



Data Sheet

Photodiodes

Basics of photometry

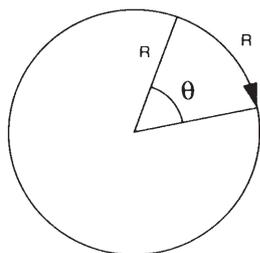
This is a brief introduction to the basics of photometry. To be able to understand this subject better a brief review of geometric principles utilised is required.

Geometric principles

Radian

In plane geometry the angle whose arc is equal to the radius generating it is called a radian. Therefore, if $C = 2\pi R$ (Circumference of a circle) $2\pi R = 360^\circ$. Radian = $180^\circ/\pi = 57.27^\circ$ (approx.).

Figure 1



Two dimensional figure

Other abbreviations used.

A_e = Area of emitting (or reflecting) surface

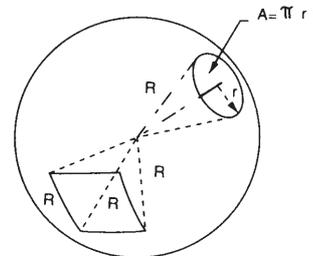
A_p = Apparent area of an emitting source whose image is projected in space and viewed at some angle, θ .

A_d = Detection area. Whether a physical target or merely a defined spatial area, it is the area of interest.

Steradian

In solid geometry one steradian is the solid angle subtended at the centre of a sphere by a portion of the surface area equal to the square of the radius of the sphere. Therefore, if $AREA/R^2 = 1 = 1$ steradian and the area on the surface of a sphere equals $4\pi R^2$, then $4\pi R^2/R^2$ or 4π steradians of solid angle ω about the centre of a sphere. The steradian is usually abbreviated as STER.

Figure 2



Three dimensional figure

Photometric Terminology

Flux (Symbol F)

Any radiation, whether visible or otherwise, can be expressed by a number of FLUX LINES about the source, the number being proportional to the intensity of that source. This LUMINOUS flux is expressed in LUMENS for visible radiation.

Luminous emittance (Symbol L)

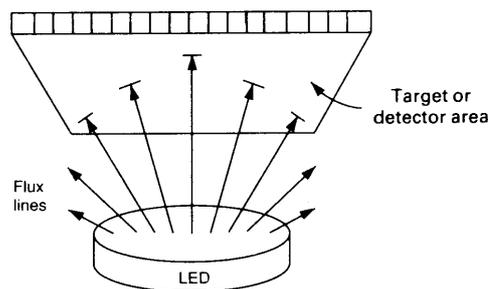
A source measurement parameter. It is defined as the ratio of the luminous flux emitted from a source to the area of that source, or $L = F/A_e$. Typically expressed in units of:

- lumens/cm² or one PHOT,
- lumens/m² or one LUX (or one METRE CANDLE),
- lumens/ft² or one FOOT CANDLE.

Illuminance (Symbol E)

This is a target or detector area measurement paragraph meter. It is the ratio of flux lines incident on a surface to the area of that surface or $E = L/A_d$. Typical measurement units are the same for LUMINOUS EMITTANCE ie. lumen/cm² = one phot, lumen/m² = one lux, and lumen/ft² = one ft candle.

Figure 3



Luminous intensity (Symbol I)

A spatial flux density concept. It is the ratio of luminous flux of a source to the solid angle subtended by the detected area and that source. The LUMINOUS INTENSITY of a source assumes that source to be point rather than an area dimension. The LUMINOUS INTENSITY (or CANDLE POWER) of a source is measured in LUMENS/STERADIAN which is equal to one CANDELE (or loosely, one CANDLA).

$$\frac{\text{LUMINOUS INTENSITY}}{A_p} = \frac{\text{LUMENS}}{A_e \cos \theta} = \frac{\text{CANDELAS}}{(\text{Sq. Unit})}$$

And depending on the units used for area:

- 1 CANDELA/cm² = 1 STILB
- 1 CANDELA/m² = 1 NIT
- 1 CANDELA/in² = } no designator available.
- 1 CANDELA/ft² = }

Also:

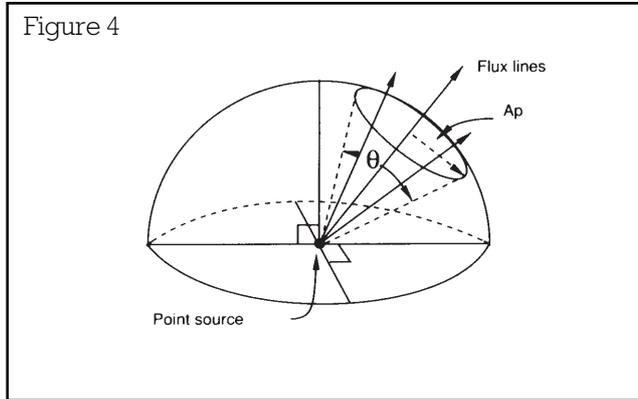
- 1/π candela/cm² = LAMBERT
- 1/π candela/m² = APOSTILB (or BLONDEL)
- 1/π candela/in² = no designator available
- 1/π candela/ft² = FOOT LAMBERT

CIE curve

Photometric quantities are related to the corresponding radiometric quantities by the CIE Standard Luminosity Function which is often called the 'standard eyeball'.

The eye responds to the rate at which radiant energy falls on the retina, ie., on the radiant flux density expressed as Watts/m². The corresponding photometric quantity is Lumens/m². The standard luminosity function is then, a plot of Lumens/Watt as a function of wavelength.

The function has a maximum value of 680 Lumens/Watt at 555nm and the 1/2 power points occur at 510 nm and 610 nm (Figure 6).



Luminance (Symbol B)

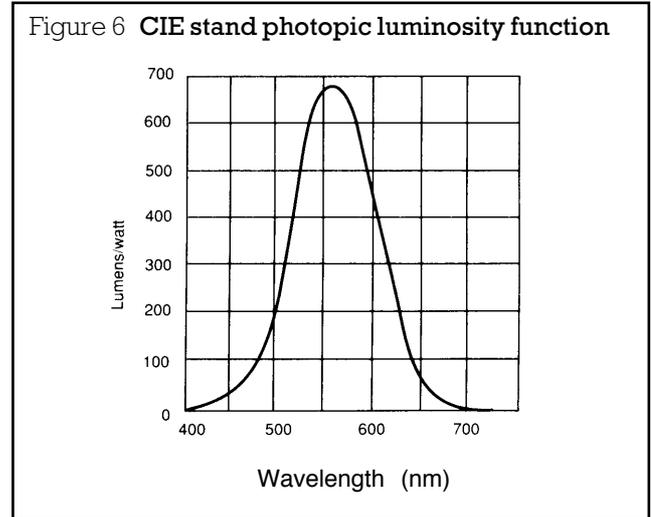
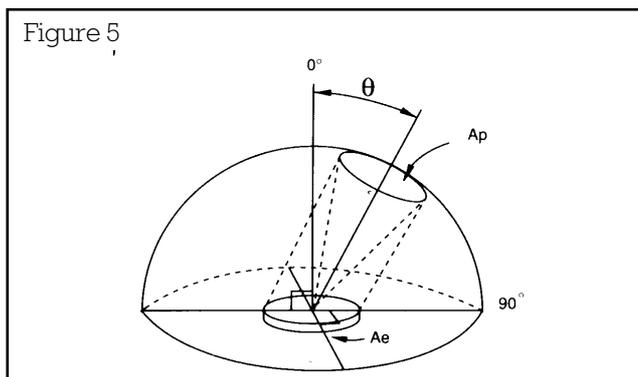
Sometimes called photometric brightness (although the term brightness should not be used alone as it encompasses other physiological factors such as colour, sparkle, texture, etc.) it is applied to sources of appreciable area size. Mathematically, if the area of an emitter (circular for example) has a diameter or diagonal dimension greater than 0.1 the distance to the detector, it can be considered as an area source. If less than this 10% figure, the source can be treated as point in nature. This one to ten ratio of source diameter to distance is offered as it MATHEMATICALLY very closely approximates results obtained when comparing an area source to its point equivalent. LUMINANCE presents itself as an extremely useful parameter as it applies a figure of merit to:

1. Apparent or projected area of the source (Ap).
2. Amount of luminous flux contained within the projected area of the source (Ap).
3. Solid angle the projected area generates with respect to the centre of the source.

Note. The projected area Ap varies directly as the cosine of theta ie. max. at 0° or normal to the surface and minimum at 90°

$$A_p = A_e \cos \theta$$

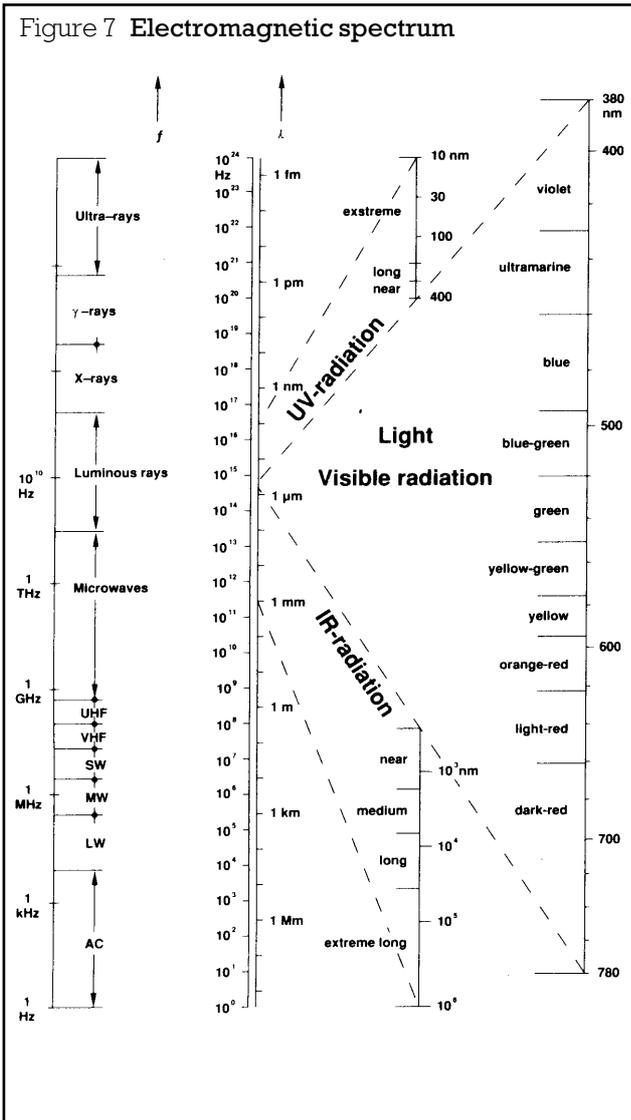
LUMINANCE is defined as the ratio of LUMINOUS INTENSITY to the projected area of the source Ap.



Electromagnetic radiation spectrum

The following range of discrete opto devices is described, each of which may be used in a variety of sensing applications.

Figure 7 Electromagnetic spectrum



| Product | RS stock no. |
|---------------------------------------|--------------|
| General purpose photodiode | 305-462 |
| BPX 65 high speed photodiode | 304-346 |
| BPW21 photodiode | 303-719 |
| Quadrant silicon photodiode | 652-027 |
| 15mm ² silicon photodiode | 194-076 |
| Medium area photodiode | 651-995 |
| Large area photodiode | 303-674 |
| Integral amplifier 5mm ² | 308-067 |
| Integral amplifier 100mm ² | 590-963 |
| 5.8mm ² UV photodiode | 564-021 |
| 33.6mm ² UV photodiode | 564-037 |
| 100mm ² UV photodiode | 564-043 |
| 16 element linear array | 194-060 |

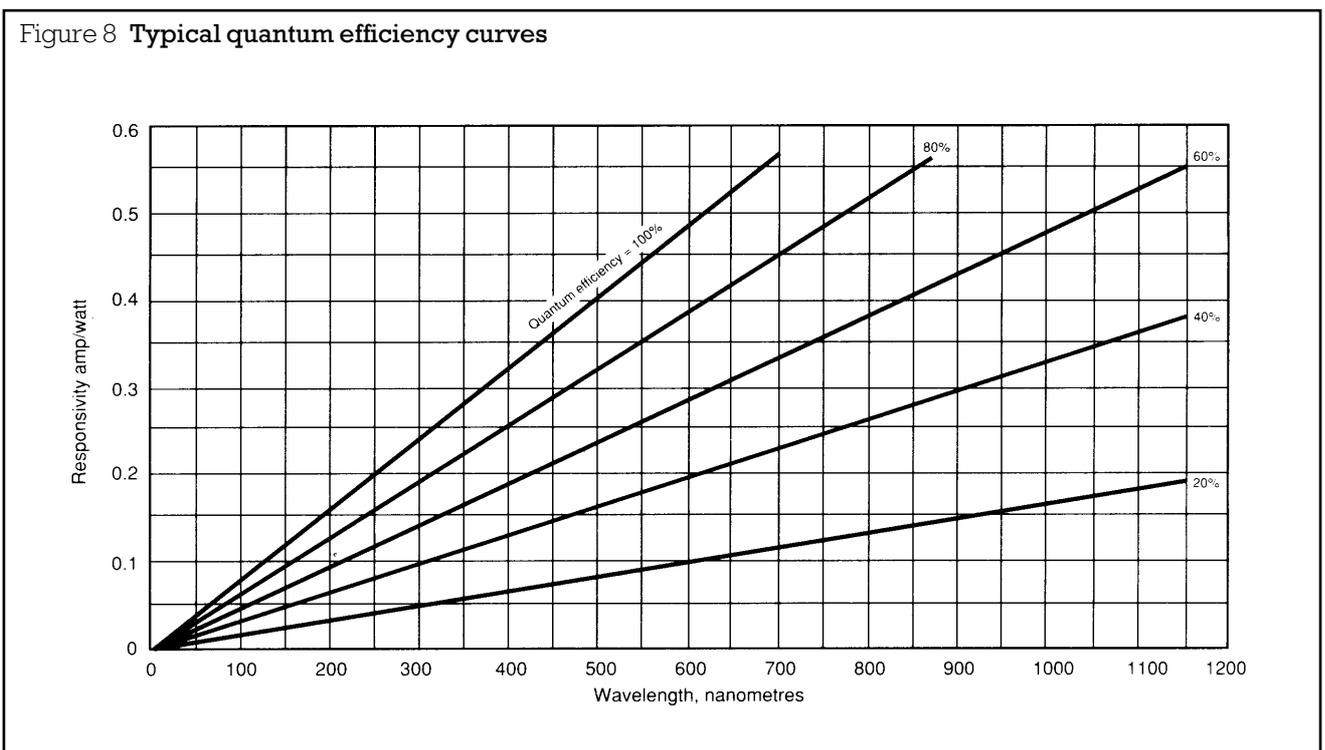
General purpose photodiode
(RS stock no. 305-462)

A planar diffused photodiode in a 2-lead TO-18 can with glass window. A very linear output of current versus light level can be obtained over a wide range of inputs. Light falling on the diode induces current in the diode, thus when the device is reversed biased thereby conducting very low leakage currents, it behaves as a current source controlled by the incident illumination.

Absolute maximum ratings

- at +25°C (unless stated)
- Reverse voltage V_R _____ +80V
- Forward current I_F _____ 100mA
- Operating temperature range _____ 0°C to +70°C
- Storage temperature range _____ -55°C to +125°C
- Power dissipation P_d _____ 200mW

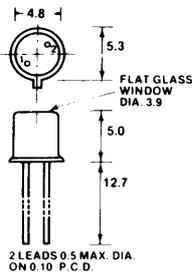
Figure 8 Typical quantum efficiency curves



Pin connections and case dimensions



Case is connected to Pin 2.
 Chip placement accuracy $\pm 0.25\text{mm}$ of can centre.
 Nominal photosensitive area 850 mils (near square)*.



*Note: 850 mils \approx 0.7mm \times 0.7mm

Electrical characteristics (at $+22^\circ\text{C} \pm 2^\circ\text{C}$ unless otherwise stated)

| Symbol | Parameter | Min. | Typ. | Max. | Units | Test conditions |
|------------|------------------------------|------|------------|------|-------------------------------------|--|
| $V_{(BR)}$ | Breakdown voltage | 80 | | | V | Dark; rev. current $10\mu\text{A}$ |
| I_D | Dark current | | 1.4 | 14 | nA | Dark; rev. bias 20V |
| R_e | Responsivity | 0.35 | 0.7 | 1.4 | $\mu\text{A}/\text{mW}/\text{cm}^2$ | Zero bias; $400\mu\text{W}/\text{cm}^2$ |
| C | Capacitance | | 12 | | pF | Dark; rev. bias 10V |
| t_R | Response time | | 4 | | ns | 10-90% levels |
| - | Temp. coeff. of responsivity | | 0.35 | | % per $^\circ\text{C}$ | 0°C to $+70^\circ\text{C}$ |
| - | Temp. coeff. of dark current | | $\times 2$ | | per 10°C rise | 0°C to $+70^\circ\text{C}$ |

Typical performance curves

Figure 9 Photo current vs. irradiation

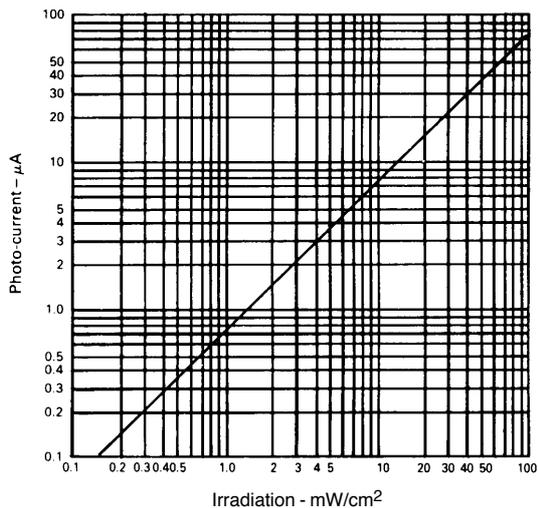


Figure 10 Open circuit voltage vs. irradiation

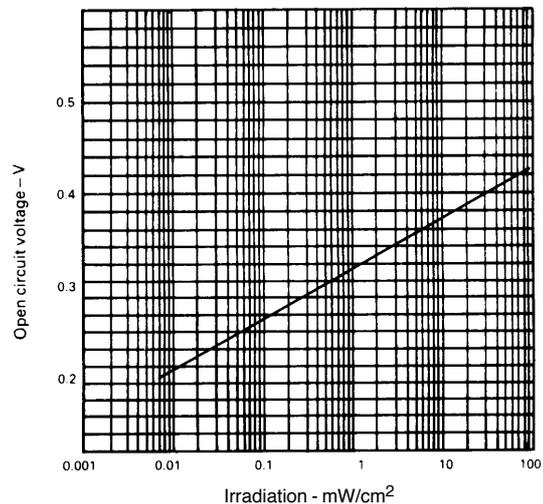


Figure 11 Normalised capacitance vs. bias voltage

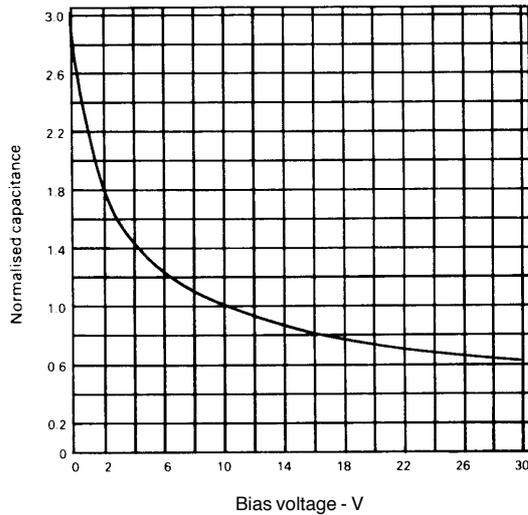


Figure 12 Photo current vs. bias voltage

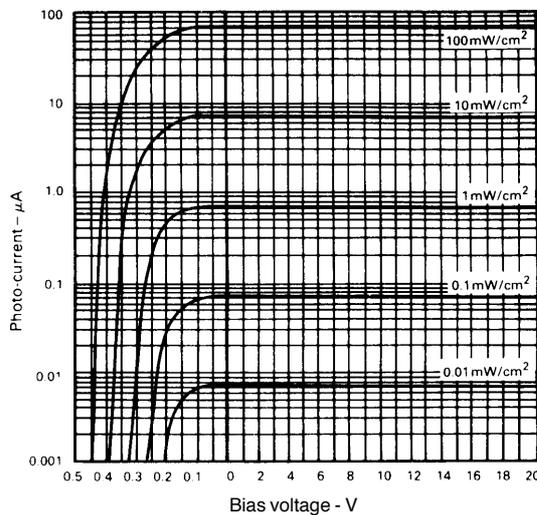
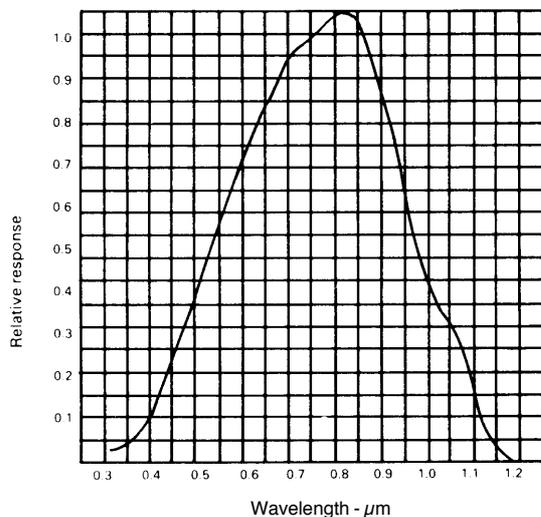


Figure 13 Normalised spectral response



Typical applications

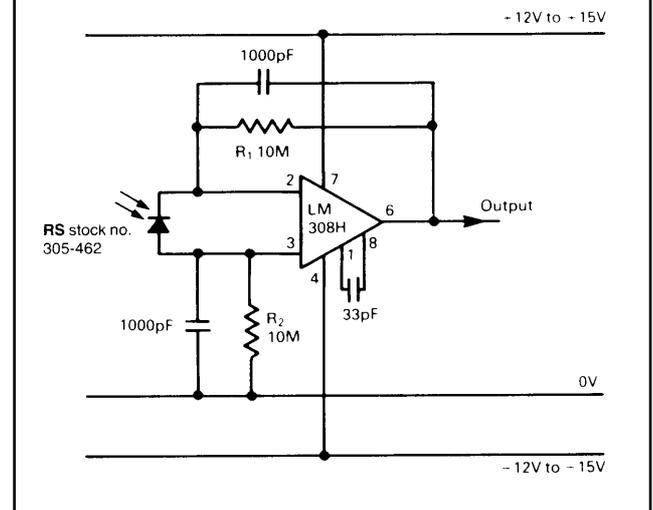
Analogue light level sensor - direct reading

Low input bias current op amps such as LM 308 or FET input types can be used to give steady dc indication of light levels as is necessary for photometric applications, photocell measurements, transmission and reflection coefficients, etc.

The values shown give approximately 14V/mW/cm² of irradiation. The value of R₁ and R₂ may be reduced for less sensitivity but should be kept equal. For values less than 100kΩ, a less sophisticated amplifier may be used, eg. μA741.

The 1000pF capacitors may be increased to reduce ripple from ac lighting or control response time accordingly.

Figure 14 Analogue light level sensor - direct reading



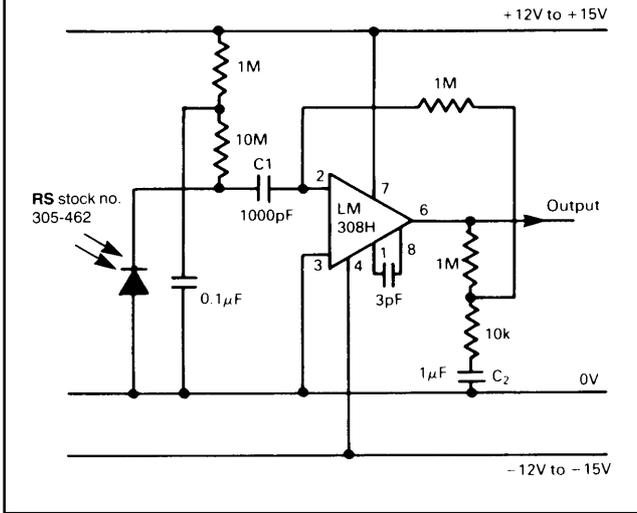
ac coupled analogue sensor for optical communications links

A stage of amplification giving the substantial gain necessary for optical communication links is implemented as shown. An op amp with low input bias currents such as LM308 or an FET input type is necessary.

The input ac coupling C₁ gives a dc isolation of steady ambient conditions, and C₂ minimises effects of offset voltages, both such lower break frequencies are below 10Hz.

Upper frequency response is approximately 3kHz and ac sensitivity is 70V/mW/cm². A further amplifier/buffer stage is necessary to drive a headset or loudspeaker.

Figure 15 ac coupled analogue sensor for optical communications links



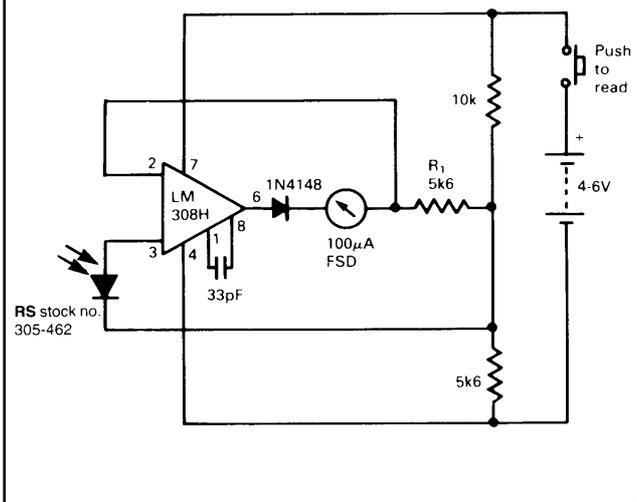
Logarithmic detector for exposure meter

Feeding the RS stock no. 305-462 into a high impedance gives a logarithmic voltage/illumination response.

The circuit shown is the basis for a simple battery-operated exposure meter. At very low light levels where the amplifier bias current may cause the output to go negative, a diode avoids the spurious state of negative indication.

The movement may be calibrated in photographic scales, one stop being approximately 7μA. Sensitivity can be trimmed by adjusting R1.

Figure 16 Logarithmic detector for exposure meter



BPX 65 high speed photodiode

(RS stock no. 304-346)

The BPX 65 is a planar silicon PIN photodiode housed in a modified TO-18 case incorporating a plain glass flat window which has no influence on the beam path of optical lens systems. The cathode is electrically connected to the case. Because the BPX 65 is capable of detecting wide bandwidth signals due to its excellent high frequency response, this coupled with its high sensitivity makes the device ideal for signal detection applications. This photodiode is outstanding for low junction capacitance and short switching times.

Absolute maximum ratings

at +25°C (unless stated)

Reverse voltage V_R _____ 50V

Forward current I_F _____ 10mA (200mA pulsed 1μs
1% duty cycle)

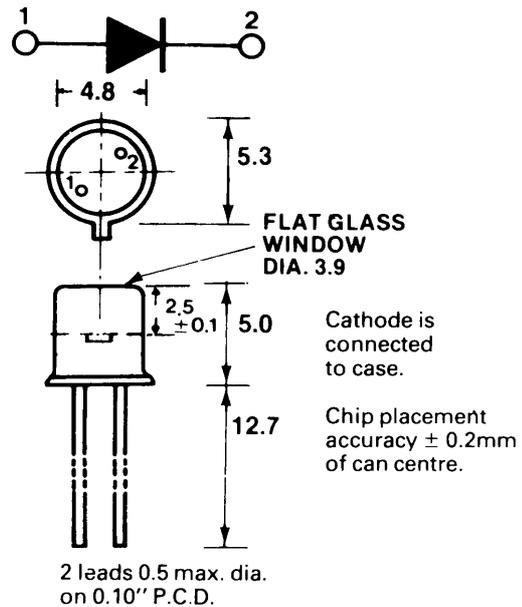
Operating temperature range _____ -25°C to +70°C

Storage temperature range _____ -55°C to +125°C

Junction temp. T_J _____ +125°C

Power dissipation P_d _____ 250mW
(derate linearly 2.5mW/°C above +25°C)

Shape and dimensions



Electrical characteristics at +25°C (unless stated)

| | Parameter | Test conditions | min. | typ. | max. | units |
|------------------|--------------------------------|--|------|-----------------------|------|-----------------------|
| A | Radiant sensitive area | | | 1 | | mm ² |
| λ_s max. | Wavelength of max. sensitivity | | | 850 | | nm |
| R_e | Responsivity | $\lambda = 450\text{nm}$ | | 0.2 | | A/W |
| | | $\lambda = 900\text{nm}$ | | 0.55 | | A/W |
| | | $\lambda = 1064\text{nm}$ | | 0.15 | | A/W |
| t_r | Response time (10-90% levels) | $R_L=50\Omega; V_R=20\text{V}; \lambda = 900\text{nm}$ | | 0.5 | 1 | ns |
| C_0 | Capacitance $V_R=0\text{V}$ | | | 15 | | pF |
| C_1 | $V_R=1\text{V}$ | | | 12 | | pF |
| C_{20} | $V_R=20\text{V}$ | | | 3.5 | | pF |
| f_g | Cut-off frequency | | | 500 | | MHz |
| I_p | Dark current | $V_R=20\text{V}$, Dark ($E=0$) | | 1 | 5 | nA |
| S | Spectral sensitivity | $V_R=20\text{V}$; see Note 1 | 7 | 10 | | nA/Lx |
| NEP | Noise equivalent power | $V_R=20\text{V}$ | | 3.6×10^{-14} | | W/ $\sqrt{\text{Hz}}$ |

Note 1. The illuminance indicated refers to unfiltered radiation of a tungsten filament lamp at a colour temperature of 2856K (standard light A in accordance with DIN 5033 and IEC publ. 306-1).

Typical performance curves

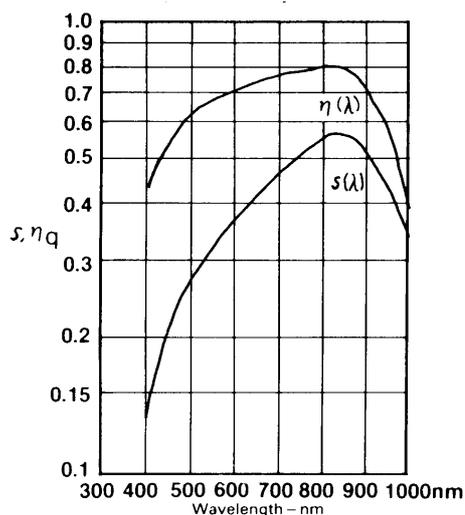
Figure 17 Normalised spectral responses (λ) and quantum yield $\eta(\lambda)$ 

Figure 19 Polar sensitivity curve

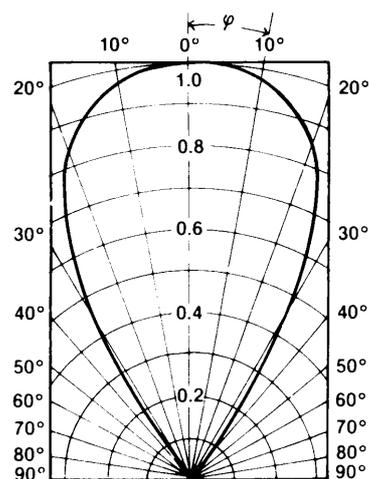


Figure 18 Variation of output current with illumination

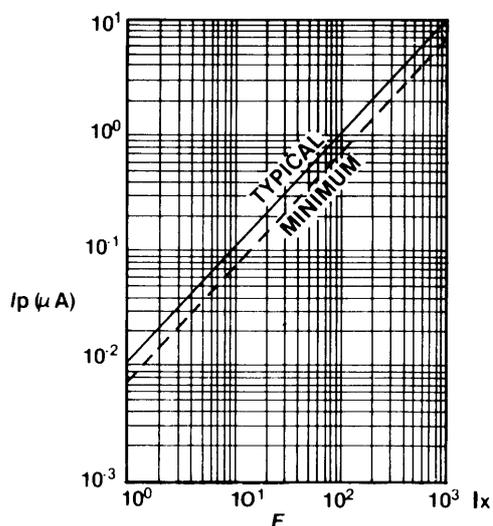


Figure 20 Variation of diode dark current with reverse voltage

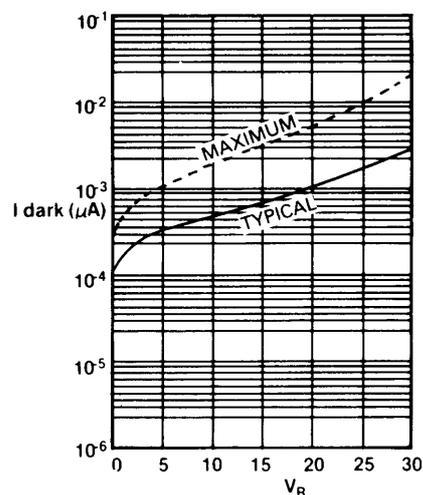


Figure 21 Variation of output current with temperature

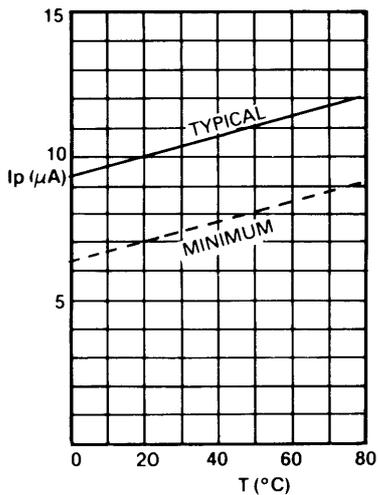


Figure 23 Permissible power dissipation

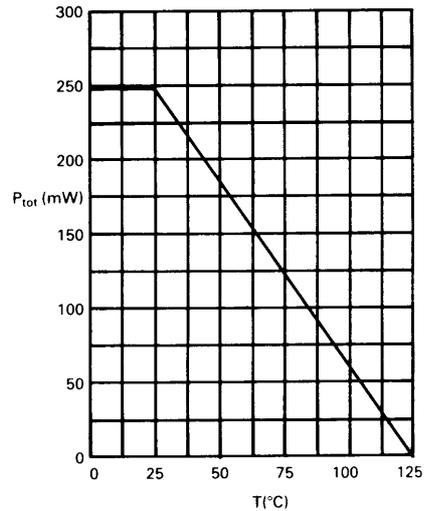


Figure 22 Variation of diode capacitance with reverse voltage

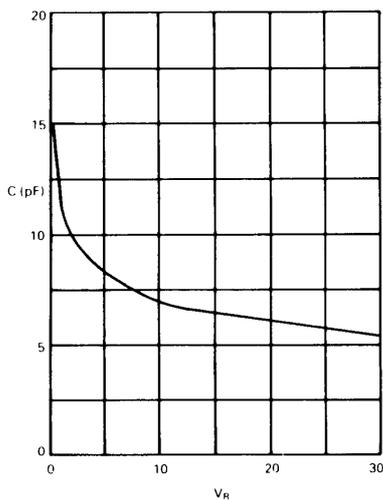
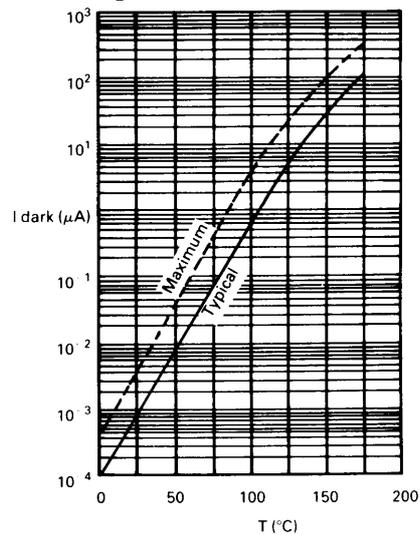


Figure 24 Variation of dark current with diode temperature



BPW21 photodiode

(RS stock no. 303-719)

A silicon photodiode housed in an hermetically sealed case with a flat window incorporating built-in colour correction. Sensitivity approximating the human eye response. Linear current (short circuit) versus illumination. Log. voltage versus illumination. This photodiode is designed for use in the photoamperic mode and is ideally suited for use in light monitoring and control, optical instrumentation and camera control.

Absolute maximum ratings

Ambient temperature range _____ -25°C to +100°C
 Reverse voltage, V_R _____ 10V
 Open circuit voltage _____ 650mV
 Power dissipation (at 25°C), P_d _____ 250mW
 Illuminance, E _____ 10⁵ lux

Features

- Response approximating to the human eye
- Photovoltaic cell operation
- Linear output current versus illumination
- Hermetically sealed TO5 case.

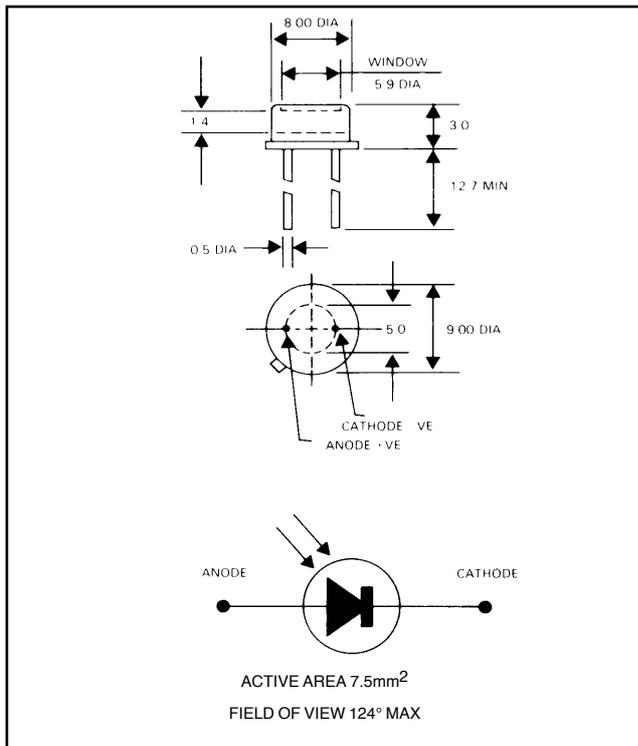
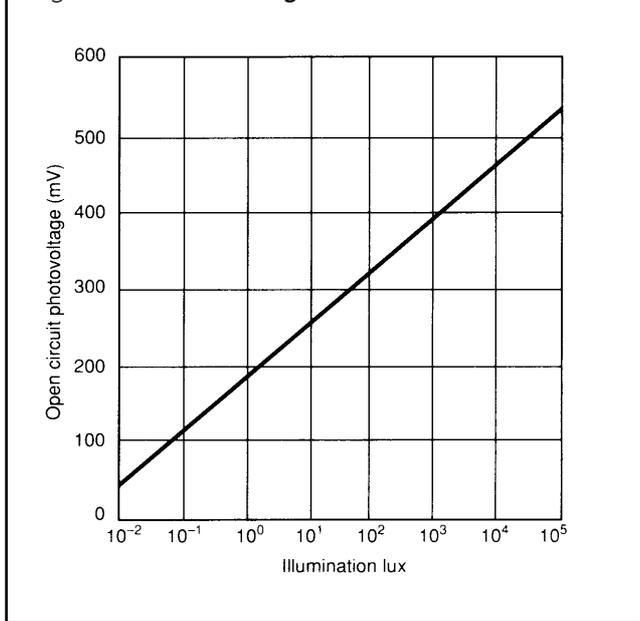


Figure 25 Photovoltage vs illumination



(For standard illuminant A, 1000 Lux = 4.75mW/cm²)

Electrical characteristics at 25°C

| | Parameter | Conditions | Min. | Typ. | Max. | Unit |
|--------------|---------------------------------------|--|------|----------------------|------|------------------|
| S_k | Sensitivity (short circuit) | $R_L = 100\Omega$. $E_A = 10^{-2}$ to 10^5 lux* | 4.5 | 7 | | nA/Lux |
| V_{ph} | Photovoltage (open circuit) | $E_A = 1$ Lux* | | 250 | 350 | mV |
| $T_k I_{SC}$ | Temp. Coeff. of short circuit current | $E_A = 1$ K Lux* | | -0.05 | | %/°C |
| $T_k V_{ph}$ | Temp. Coeff. of open circuit voltage | $R_L = 100\Omega$. $E_A = 1$ K Lux* | | -2 | | mV/°C |
| λ_p | Peak wavelength sensitivity | | | 560 | | nm |
| | Spectral bandwidth | 50% sensitivity upper limit | | 680 | | nm |
| | | 50% sensitivity lower limit | | 440 | | nm |
| | Junction capacitance | $V_R = 0V$ | | 490 | | pF |
| t_r | Rise time | $R_L = 1K\Omega$. $V_R = 5V$ | | 1.0 | | μs |
| I_D | Dark current | $R_L = 1K\Omega$. $V_R = 5V$ | | 2 | 30 | nA |
| NEP | Noise equivalent power | $V_R = 5V$ | | 1.4×10^{-5} | | Lux/ \sqrt{Hz} |

*The illuminance indicated refers to unfiltered radiation of a tungsten filament lamp at a colour temperature of 2856°K (standard Light A in accordance with DIN 5033 and IEC publ. 306-1).

Figure 26 BPW21 and human eye spectral sensitivity

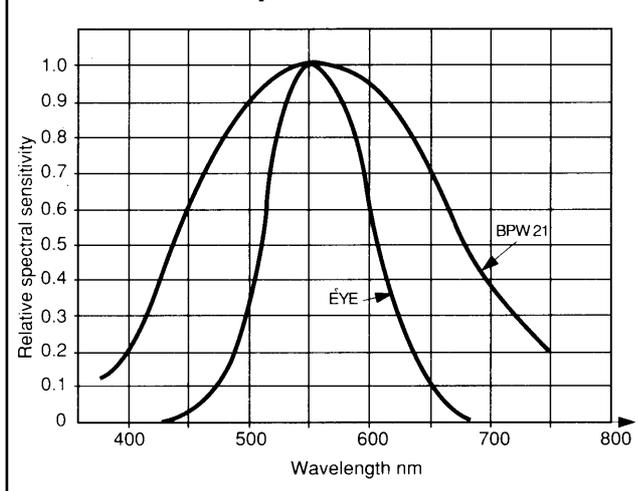
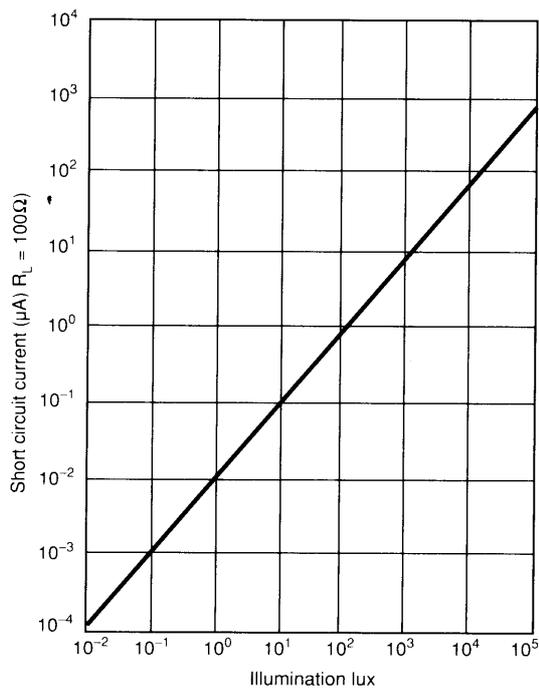
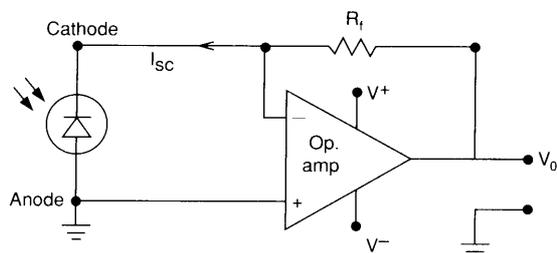


Figure 27 Photocurrent vs illumination



Typical photovoltaic connection

Figure 28



$$V_0 = R_f I_{SC}$$

$$I_{SC} = E_V S_k$$

$$V_0 = R_f E_V S_k$$

where
 V_0 = Signal output voltage, V
 R_f = Feedback resistance, Ω
 I_{SC} = Photodiode short circuit current, A
 E_V = Incident illumination, Lux
 S_k = Photodiode sensitivity, A/Lux

Quadrant silicon photodiode

(RS stock no. 652-027)

A silicon photodiode containing four separate sensing elements (with commoned cathodes) arranged one per quadrant. The output voltage of each quadrant is available separately enabling null conditions to be detected with equal degrees of shading. The device is hermetically sealed in a TO5 package which incorporates the pcb pin connections.

Absolute maximum ratings

dc reverse voltage _____ 15V
 Peak pulse current (1 μ s, 1% duty cycle) _____ 200mA
 Peak dc current _____ 10mA
 Storage temperature range _____ -45°C to +100°C
 Operating temperature range _____ -25°C to +75°C
 Lead temperature soldering (5s) _____ +200°C

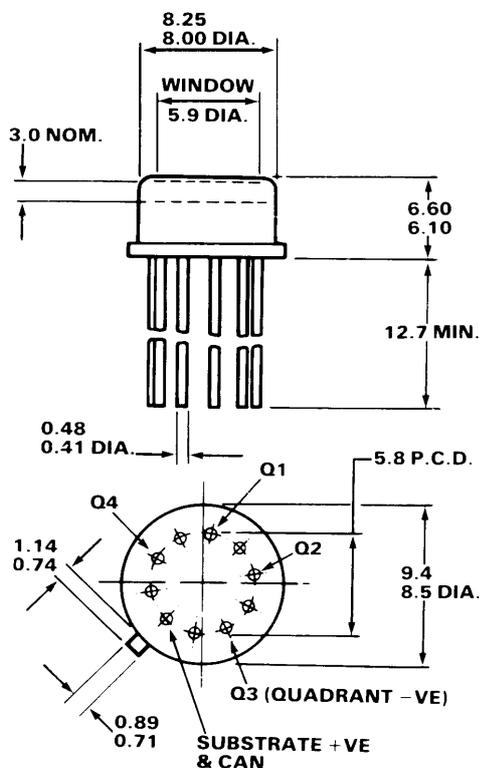
Features

- High blue sensitivity and shunt resistance
- Suitable for low light level applications
- T05 package incorporating pcb pin connections.

Applications

- High accuracy position sensing
- Alignment
- Optical surveying.

Pin connections and dimensions

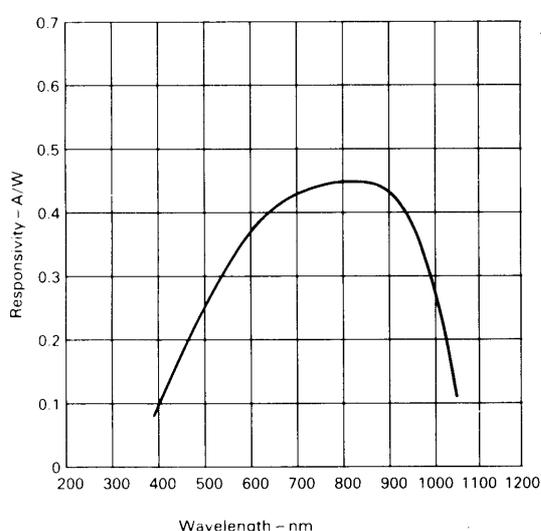


NOTE:
 DIMENSION* REFERS TO
 DISTANCE BETWEEN WINDOW AND ACTIVE
 AREA. NO CONNECTION SHOULD BE MADE
 TO UNSPECIFIED PINS.

Specification

| Parameter | Conditions | Min. | Typ. | Max. | Unit |
|--------------------------|---|------|---------------------|------|-----------------|
| Operating voltage | | | | 12 | V |
| Dark current | $V_R = 1V$ | | 0.03 | 3 | nA |
| Capacitance | $V_R = 0V$ | | 80 | 100 | pF |
| Responsivity | 900nm, $V_R = 1V$ | 0.42 | 0.45 | | A/W |
| Rise time | 0-70%, 864nm, $V_R = 10V$, 100 Ω load | | | <15 | ns |
| Peak wavelength | | | 820 | | nm |
| Spectral response range | | 430 | | 900 | nm |
| Noise equivalent power | 900nm | | 1×10^{-13} | | W $H^{-1/2}$ |
| Active diameter | | | 3 | | mm |
| Total active area | | | 7 | | mm ² |
| Metallurgical separation | | | 200 | | μ m |

Figure 29 Typical spectral response



15mm² silicon photodiode

(RS stock no. 194-076)

A 15mm² silicon photodiode housed in an hermetically sealed TO5 package. This device is ideal for low light level applications where a very high signal to noise ratio is important such as light monitoring and control applications.

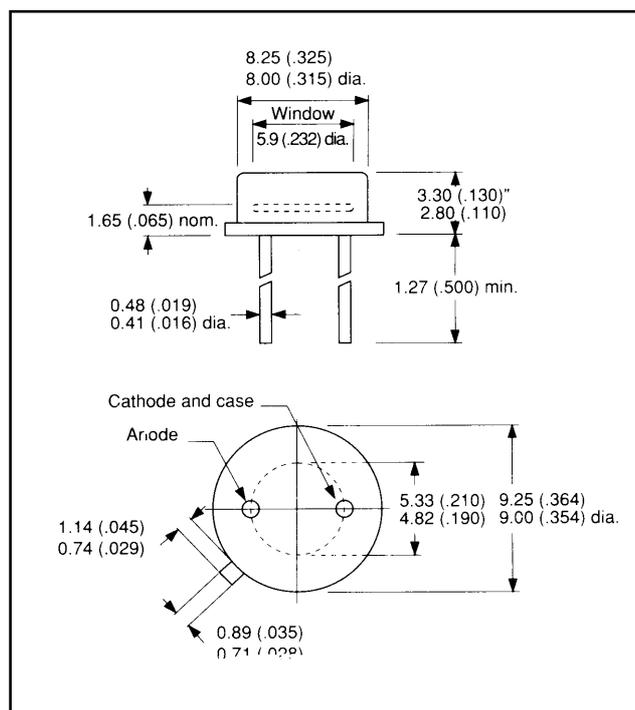
It may be operated photovoltaically or with a reverse bias of up to 12V where lower capacitance is needed.

Electrical/Optical specifications

Characteristics measured at 22°C (± 2) ambient, and a reverse bias of 12 volts, unless otherwise stated. Shunt resistance measured at ± 10 mV.

Absolute maximum ratings

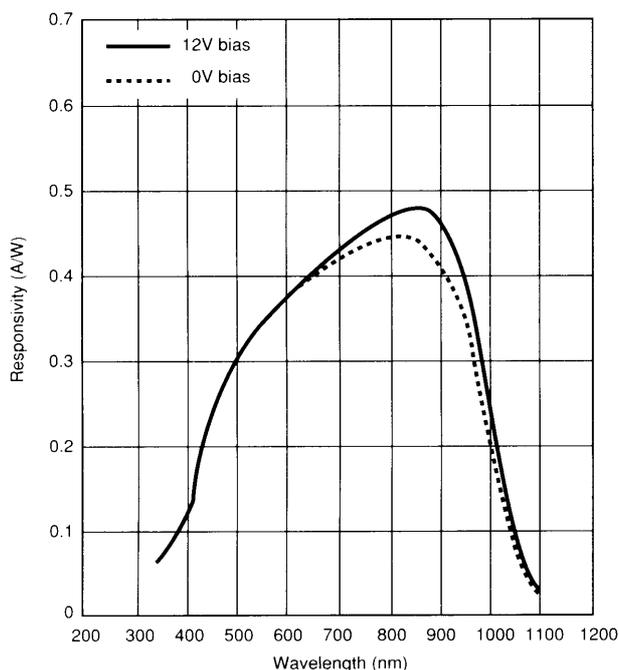
| | Max. rating |
|--|-----------------|
| dc reverse voltage | 15V |
| Peak pulse current (1 μ s, 1% duty cycle) | 200mA |
| Peak dc current | 10mA |
| Storage temperature range | -45°C to +100°C |
| Operating temperature range | -25°C to +75°C |
| Soldering temperature for 5 seconds max. | 200°C |



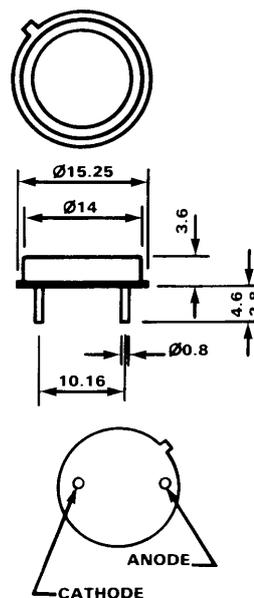
Single elements

| | | | |
|---|-------------------|-------------------------|-------------|
| Active area | 15mm ² | | 3.8 × 3.8mm |
| | Min. | Typ. | Max. |
| Responsivity A/W λ = 436nm | 0.18 | 0.21 | |
| Dark current | | 3nA | 10nA |
| NEP WHz λ = 436nm V _r = 0V | | 8.8 × 10 ⁻¹⁴ | |
| Capacitance pF V _r = 0V | | | 390 |
| Capacitance pF V _r = 12V | | | 80 |
| Shunt resistance megaohm | 25 | 200 | |
| Risetime ns λ = 820nm R _L = 50Ω | | 12 | |

Figure 30 Typical spectral response



Pin connections and dimensions



Medium area photodiode

(RS stock no. 651-995)

The RS stock no. 651-995 is a high speed, medium area, silicon photodiode mounted in an hermetically sealed TO5 package. The device is ideal for reduced light applications including brightness control, edge detectors, colour grading etc.

Absolute maximum ratings

Reverse voltage _____ 60V
 Operating temperature range _____ -40°C to +70°C
 Storage temperature range _____ -55°C to +125°C
 Lead temperature soldering (5s) _____ +200°C

Electrical characteristics at +22°C ±2°C unless otherwise stated

| Parameter | Conditions | Min. | Typ. | Max. | Unit |
|---|---|------|------|------|-----------------|
| Radiant sensitive area | | | 41.3 | | mm ² |
| Wavelength of maximum sensitivity | | 760 | 800 | 880 | nm |
| Peak responsivity | 800 nm | 0.4 | 0.5 | | A/W |
| Dark current | V _R = 1V | | 4.0 | 20 | nA |
| | V _R = 20V | | 40 | 200 | nA |
| Capacitance | V _R = 0V | | 325 | 400 | pF |
| | V _R = 10V | | 91.5 | 113 | pF |
| | V _R = 20V | | 71 | 87.5 | pF |
| Response time | V _R = 10V, R _L = 100R | | 25 | 40 | ns |
| Temperature coefficient of responsivity | (0°C to +70°C) | | 0.35 | | %/°C |
| Temperature coefficient of dark current | (0°C to +70°C) | | ×2 | | per +10°C |

Typical performance curves

Figure 31 Normalised capacitance vs bias voltage

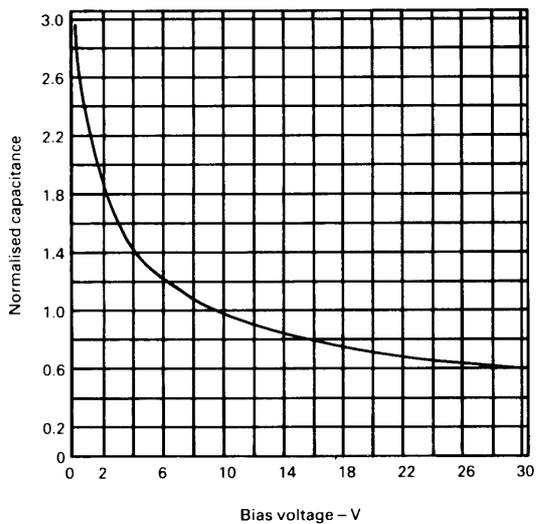


Figure 32 Open circuit voltage vs irradiation

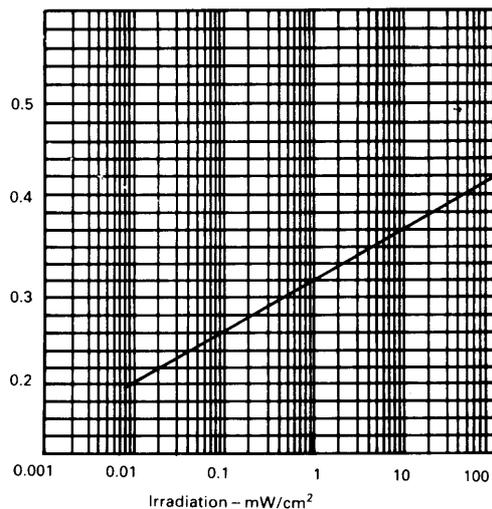
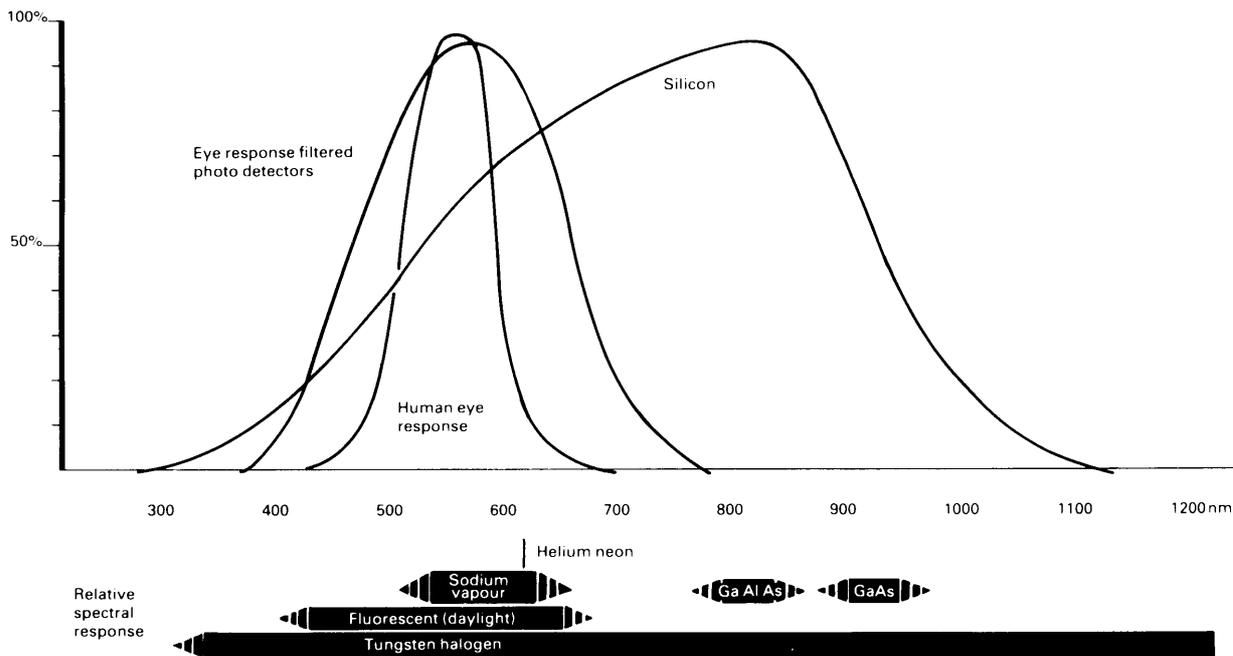


Figure 33 Relative spectral response



Large area photodiode

(RS stock no. 303-674)

A high speed, large area, silicon photovoltaic detector housed in a 26.2mm diameter case. Its large active area, 1cm², and peak spectral response at 900nm make the device suitable for use as a calibration device in optical instrumentation, and for other optical measurements. Spectral response range (5% points): 350 to 1150nm.

Absolute maximum ratings

at +25°C (unless stated)

Reverse voltage V_R _____ 50V

Operating temperature range _____ -55°C to +70°C

Forward current I_F _____ Limited by Pd and bias voltage

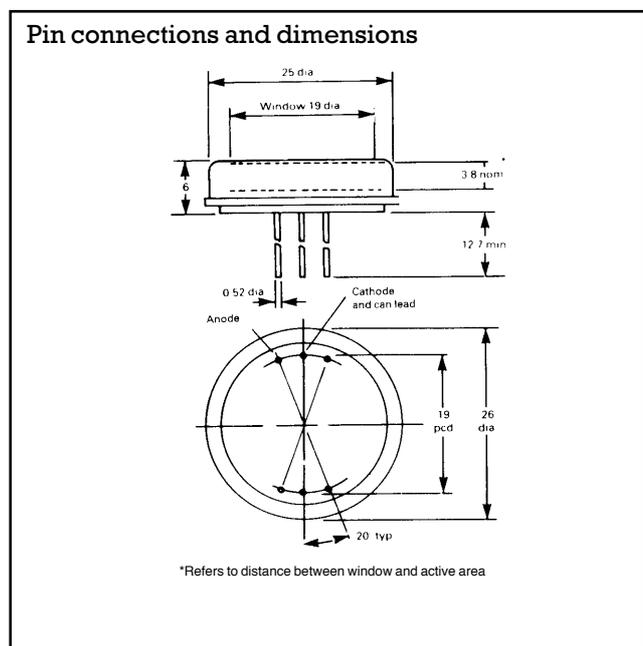
Power dissipation Pd _____ 100mW

Features

- Photovoltaic operation or low-bias photoconductive operation
- High sensitivity over wide spectral range
- Circular active area (1cm²)
- Low noise
- Fast response
- Long term stability
- Low capacitance for a photovoltaic detector.

Applications

- ▲ Optical instrumentation
- ▲ Laser detection
- ▲ Optical communication.

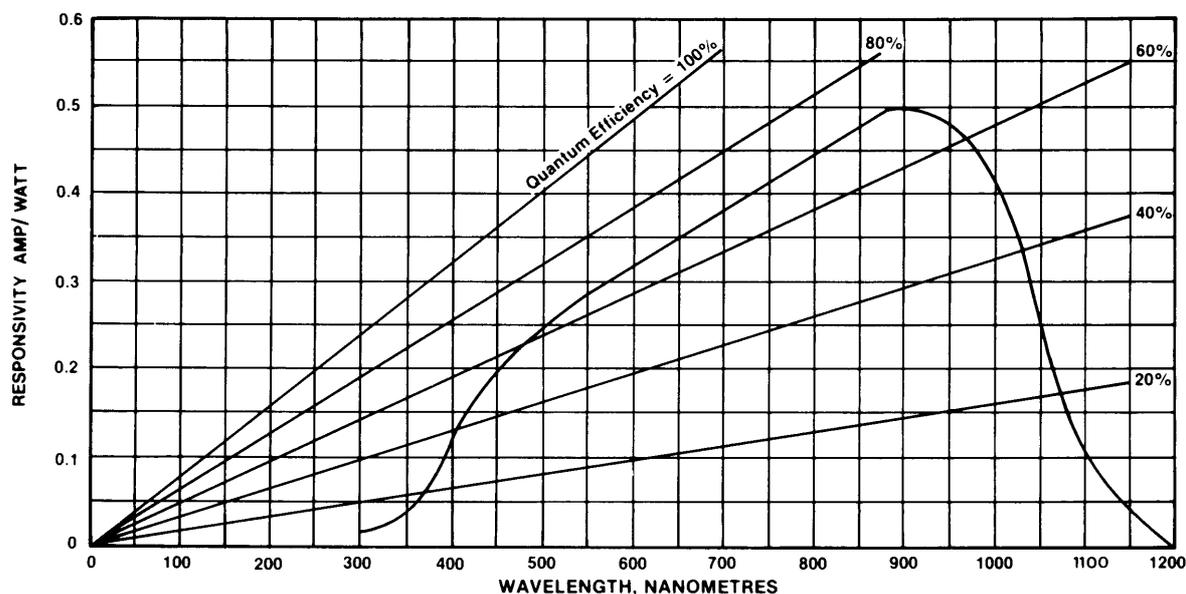


Electrical characteristics at +25°C (unless stated)

| | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|------------|--|--|------|------|------|-------------|
| $V_{(BR)}$ | Breakdown voltage | $I_D = 100\mu A$ | 50 | | | V |
| I_D | Dark current | Dark, rev. bias 10V | | 0.5 | 1.5 | μA |
| R_e | Responsivity @ 450nm 633nm 900nm 1064nm | | | 0.2 | 0.22 | A/W |
| | | | | 0.35 | 0.4 | |
| | | | | 0.5 | 0.55 | |
| | | | | 0.15 | 0.16 | |
| C | Capacitance | at 0V | | 1500 | | pF |
| | | at 10V rev. bias. | | 350 | | |
| t_r | Response time (10% to 90%) | at 0V $R_L 50\Omega$ | | 0.5 | | μs |
| | | at 10V $R_L 50\Omega, \lambda < 910nm$ | | 50 | | ns |
| R_S | Shunt resistance | at 0V $\pm 0.1V$ | | 5 | | M Ω |
| I_n | Noise current | at 0V $f = 1kHz$ | | 0.1 | | pA (rms) |
| | | at 10V rev. bias $f = 1kHz$ | | 0.4 | | \sqrt{Hz} |
| NEP | Noise equiv. power (at $f = 1kHz$) | 450nm at 0V | | 0.5 | | pW |
| | | 450nm at 10V rev. bias | | 2 | | \sqrt{Hz} |
| | 900nm | at 0V | | 0.2 | | pW |
| | | at 10V rev. bias | | 0.8 | | \sqrt{Hz} |

Typical performance curves

Figure 34 Typical spectral response.
 Responsivity: 0.2A/W at 450nm, 0.35A/W at 633nm,
 0.5A/W at 900nm, 0.15A/W at 1064nm, 7.9mA/Im (2850K source)



5mm² photodiode with amplifier

(RS stock no. 308-067)

The RS stock no. 308-067 consists of a high performance silicon photodiode combined with a high gain low noise amplifier in a TO5 package. It is designed particularly for use where accurate measurements are needed of low light levels, and medium speed variation in such light levels. Its small size and excellent temperature coefficients make it ideally suited for use under adverse conditions.

Any supply voltage between $\pm 2.5V$ and $\pm 18V$ may be used. A single output line gives a voltage with respect to earth (Pin 1) proportional to the input light level, up to a maximum only slightly less than the power rail. Correction for dark level output is not normally required due to its extremely low value. The output may be short circuited to ground or either power rail without risk of damage. Changes in ambient temperature also cause only minimal variation in signal level, typically $150\mu V/^\circ C$.

Absolute maximum ratings

Supply voltage _____ $\pm 18V$

Output short circuit duration _____ Indefinite

Storage temperature _____ $-65^\circ C$ to $+100^\circ C$

Operating temperature _____ $0^\circ C$ to $+70^\circ C$

Connecting details

1. Earth
2. Output
3. V+
4. V- (Connected to can)

TO5 can with 4 leads

Gold-plated leads:

Active light sensitive area:

12.7mm length

5mm²

Features

- Very high responsivity
- Linear response
- Low output impedance
- Low noise
- Rugged construction
- Excellent temperature characteristics
- Short circuit proof
- Excellent power supply noise rejection
- TTL compatible
- Simple to use

Applications include

- Light intensity measurements
- Light fluctuation detection
- Optical spectroscopy
- Pollution monitoring
- Alarm systems
- Optical shaft encoders
- Automated inspection and control
- Flow monitoring.

CONNECTION DETAILS

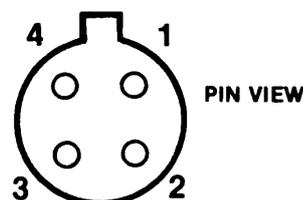
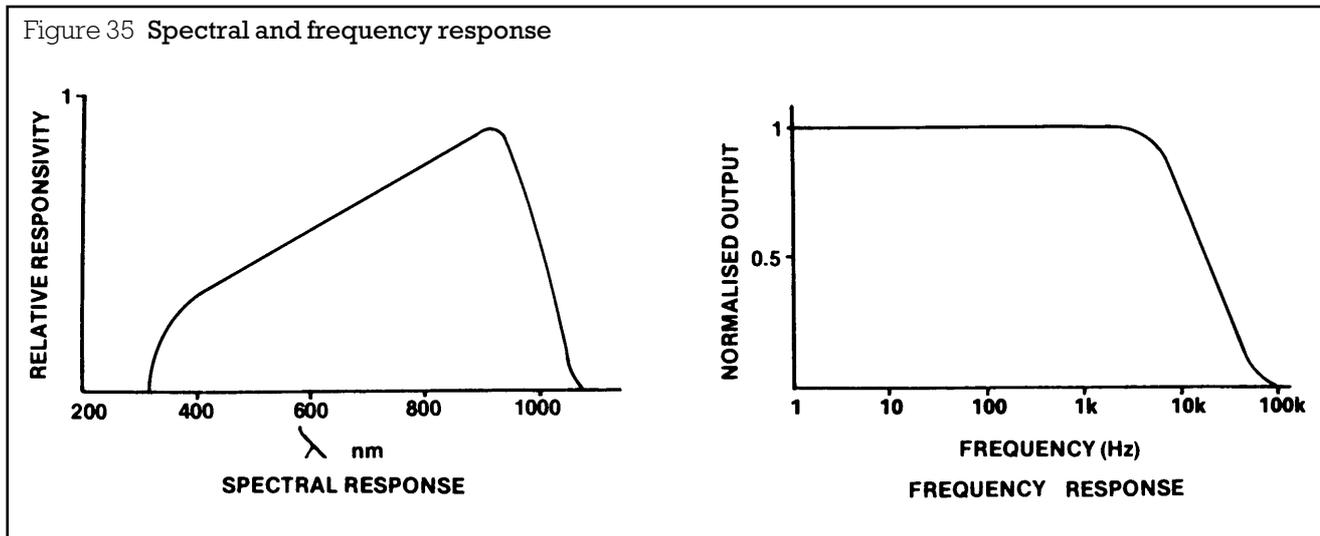


Figure 35 Spectral and frequency response



Electrical specification All at $V_S \pm 15V$ and $25^\circ C$ unless otherwise stated

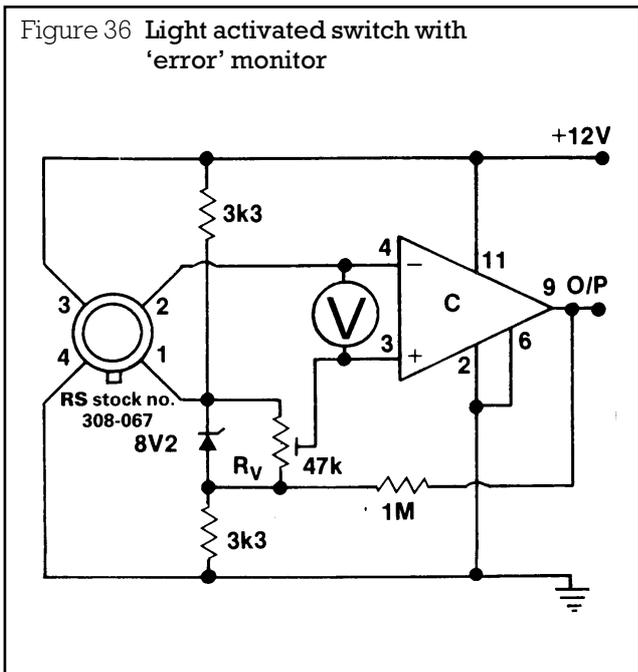
| Parameter | Conditions | Min. | Typ. | Max. | Units |
|------------------------------------|---------------------------------------|------|------|------|------------------|
| O/P dark level | | | +20 | +60 | mV |
| O/P saturation level | $R_L \geq 2k\Omega$ | -9 | -12 | | V |
| O/P resistance ¹ | | | 75 | | Ω |
| O/P short circuit current | | | 6 | | mA |
| O/P noise voltage | $V_O = \leq 1V$ | | 1 | 3 | mV/rms |
| Responsivity | 430nm | 30 | | | mV/ $\mu W/cm^2$ |
| | 630nm | 160 | | | |
| | 900nm | 250 | | | |
| Supply voltage (V+) | | 2.5 | 15 | 18 | V |
| Supply voltage (V-) | | -2.5 | -15 | -18 | V |
| Supply current | $R_L = \infty$ | | 0.5 | 1.3 | mA |
| Supply voltage rejection ratio | | 150 | 50 | | $\mu V/V$ |
| Bandwidth | Upper 3dB point | 3 | 5 | | kHz |
| Rise time ² | $C_L = 0$ | | 30 | 50 | μs |
| Fall time ² | $C_L = 0$ | | 30 | 50 | μs |
| Dark level temperature coefficient | $20^\circ C \leq T_A \leq 50^\circ C$ | | 150 | 500 | $\mu V/^\circ C$ |

Notes:

1. At 5kHz. Drops to 0.01 at dc.
2. Time for output signal to reach 90% of true reading after application of a step change in light intensity.

Application examples

Figure 36 Light activated switch with 'error' monitor

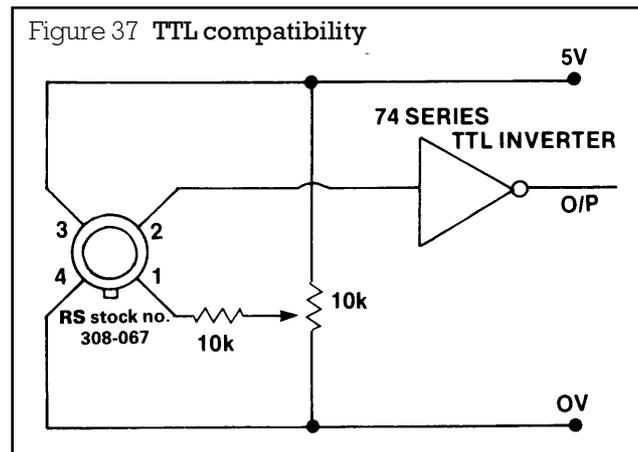


Linear interfacing

In Figure 36, the comparator (eg. RS stock no. 308-843) will switch its output state when the light intensity increases above a pre-set level, determined by R_v . The centre zero voltmeter registers the difference between the switching threshold intensity and the actual intensity received by the RS stock no. 308-067. Since the threshold is determined with respect to pin 1 of the RS stock no. 308-067 supply voltage variations have no effect on the operation of the circuit.

Note: Centre zero voltmeter (RS stock no. 259-628) requires a series resistor (RS stock no. 167-967).

Figure 37 TTL compatibility

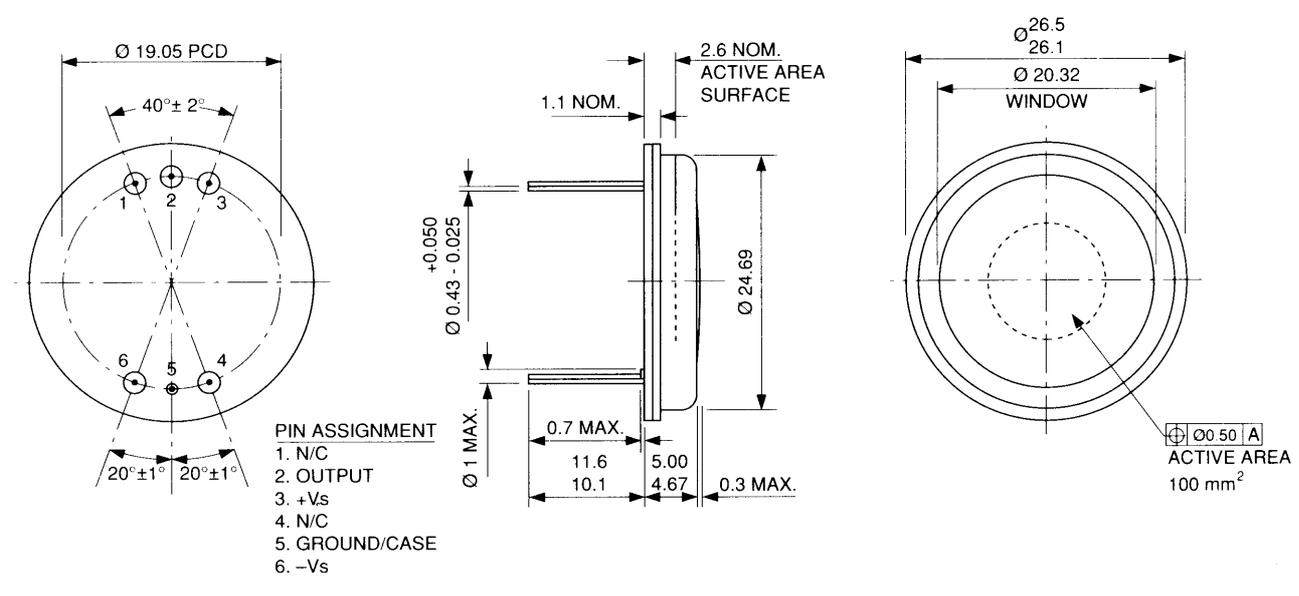


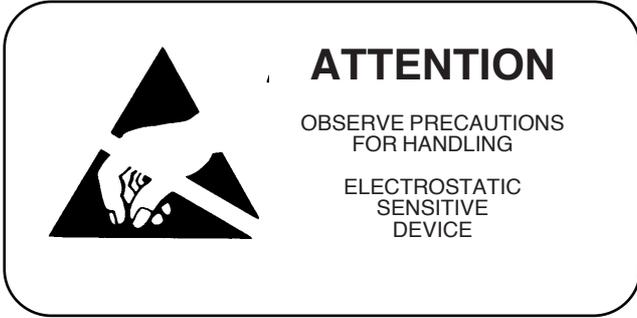
Large area photodiode + amp

(RS stock no. 590-963)

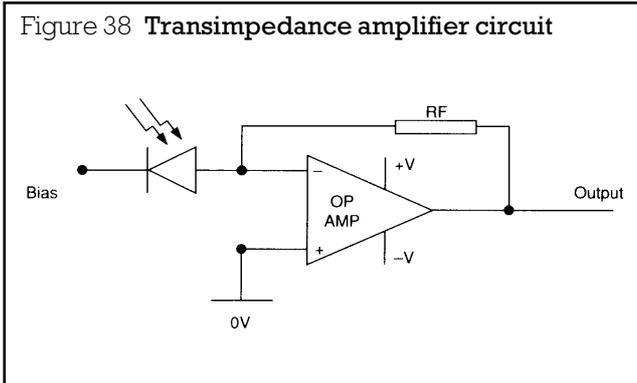
This silicon photodiode has an active area of 100mm² and an integral transimpedance amplifier. This device is ideal for use in electrically noisy environments because the length of the highly sensitive input line to the amplifier is very short and is also screened by the metal can package.

Pin connection and case dimensions





The transimpedance configuration provides high noise immunity and high amplifier signal saturation levels.



In this circuit the op amp is used with negative feedback so that the current generated by the photodiode is converted via the resistor into an output voltage.

Gain is defined only in terms of the feedback resistor.

UV enhanced photodiodes

(RS stock nos. 564-021, 564-037 and 564-043)

A range of ultra-violet sensitive silicon photodiodes with enhanced responsivity in the 190 to 400nm range. The devices high shunt resistance and enhanced responsivity make them ideal for light measurement photometry and fluorescence applications.

The 5.8mm² is housed in a metal can package while the 33.6 and 100mm² devices are housed in ceramic packages. All packages incorporate a quartz window for enhanced spectral response.

Electrical characteristics

(Ta = 25°C, ±15V supply)

| Parameter | Min. | Typ. | Max. | Units |
|----------------------------|-----------------------|------|------|-------|
| Operating wavelength | 400 | - | 950 | nm |
| Peak wavelength | - | 800 | - | nm |
| Responsivity @ 530nm | 1.3 × 10 ⁵ | - | - | V/W |
| Supply voltage | ±5 | - | ±18 | V |
| Supply current | - | - | 250 | µA |
| Transimpedance gain | - | 500k | - | - |
| Output resistance | - | 1 | - | Ω |
| Dark output offset voltage | - | - | ±5 | mV |
| Rise time | 77 | - | - | µs |
| Bandwidth | - | 5 | - | kHz |
| Dark output noise level | - | - | 400 | µVrms |
| Temperature range | 0° | - | +70 | °C |

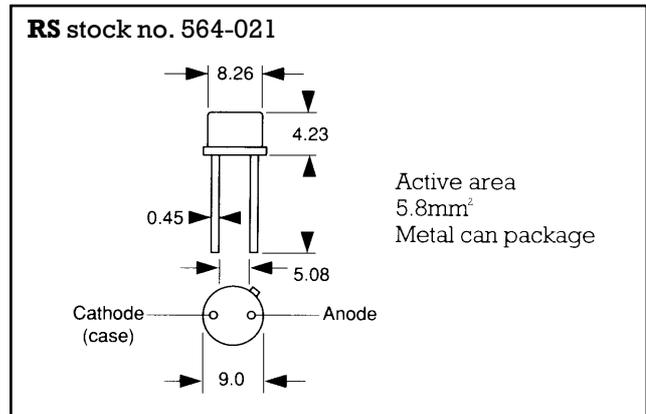
Solder temperature 300°C for 15 seconds.

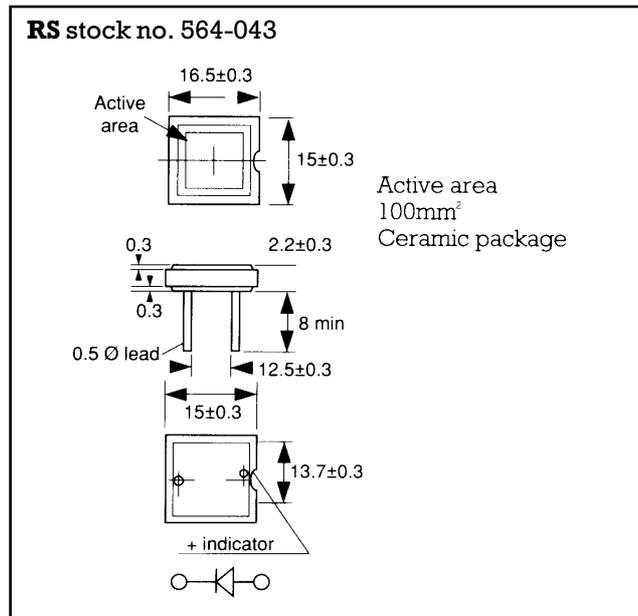
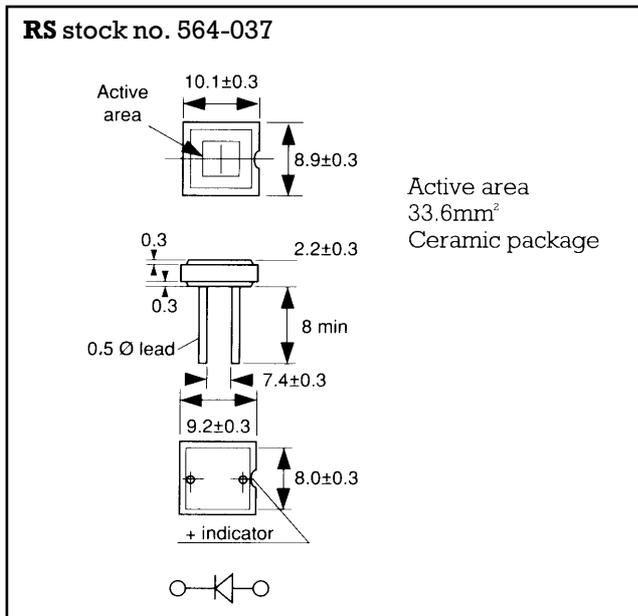
To eliminate unwanted oscillation it is recommended that a 10nF or 100nF disc ceramic capacitor in parallel with a 1µF tantalum decoupling capacitor be used between supply and 0V close to the device.

Absolute maximum ratings (Ta = 25°C)

- Reverse voltage _____ 5V
- Peak current (1µs, 1% duty cycle) _____ 200mA
- Peak dc current _____ 10mA
- Storage temperature range _____ -55°C to +125°C
- Operating temperature range _____ -55°C to +70°C
- Soldering temperature _____ 260°C

Pin connections and case dimensions

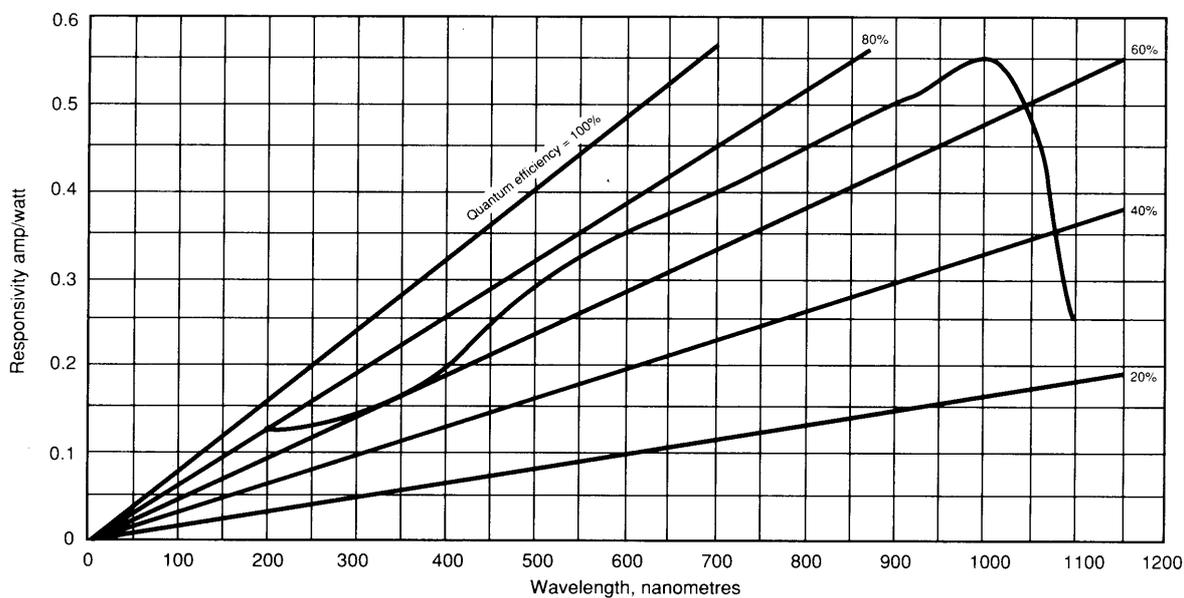




Electrical characteristics (T_a = 25°C)

| Active area | | Responsivity a/w (typical) | | | Peak Responsivity (typical) | Dark current @V _r = 10mV (typical) | Noise equivalent power (typ.) @900nm | Capacitance typical | Rise time V _L = 0Ω R _L = 1kΩ typical | Shunt resistance @V _r = ± 10mV min. typical | |
|-----------------|-----------|----------------------------|---------|---------|-----------------------------|---|---|---------------------|--|--|---------|
| mm ² | mm | @ 190nm | @ 245nm | @ 340nm | | | | | | min. | typical |
| 5.8 | 2.4 × 2.4 | 0.12 | 0.14 | 0.19 | 950nm | 3pA | 6 × 10 ⁻¹⁵ w/Hz ^{1/2} | 170pF | 0.4μs | 0.5GΩ | 3GΩ |
| 33.6 | 5.8 × 5.8 | 0.12 | 0.14 | 0.19 | 950nm | 20pA | 1.5 × 10 ⁻¹⁴ w/Hz ^{1/2} | 1000pF | 2.0μs | 0.5GΩ | 0.5GΩ |

Figure 39 Typical spectral response and typical quantum efficiency curves

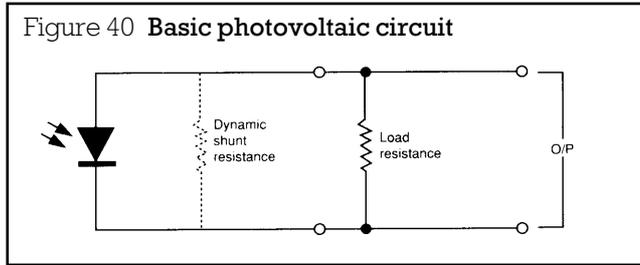


Typical applications

Photovoltaic mode

In the photovoltaic mode, as the light level increases, photocurrent induced in the device develops a voltage across the dynamic shunt resistance. However, this resistance then decreases exponentially, therefore the photogenerated voltage is a logarithmic function of the incident light intensity.

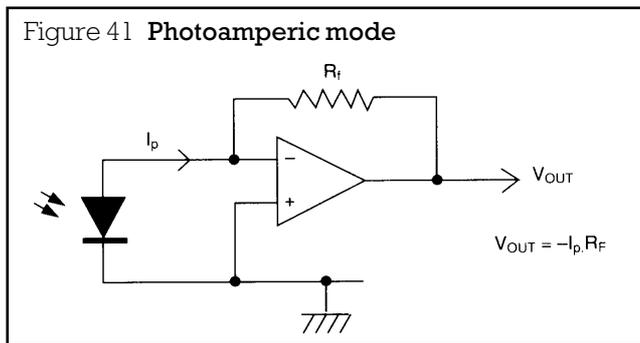
Typically this mode of operation is most useful in simple comparator applications, Figure 40 shows the basic photovoltaic circuit.



Photoamperic mode

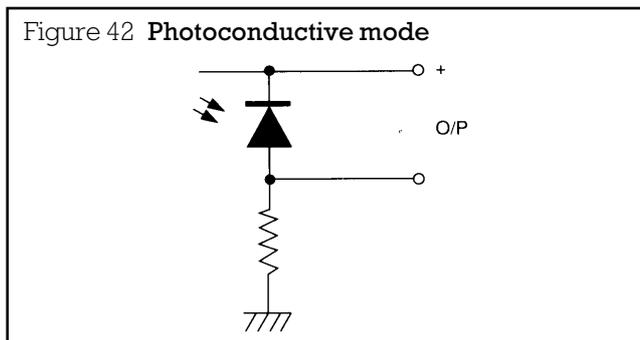
If the photodiode is connected to a low value of load resistance the effect on the dynamic resistance is negligible and the output current is linearly related to light level.

The usual method of providing a low load resistance with subsequent amplification is to connect the diode to the virtual earth of an operational amplifier. This circuit as shown in Figure 41 is a current to voltage converter.



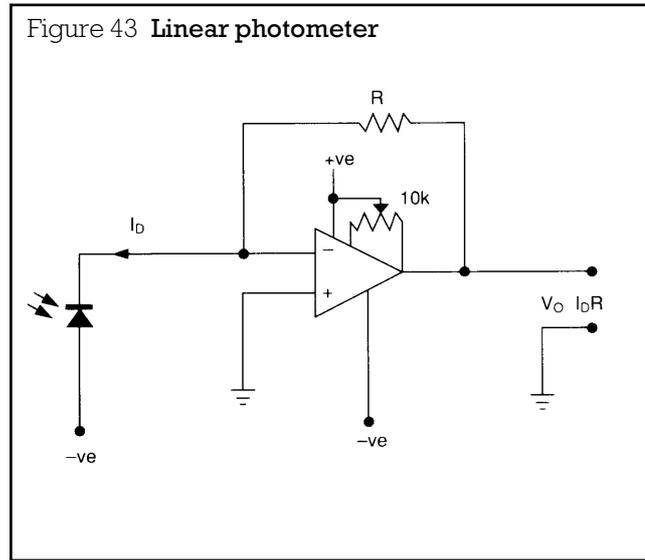
Photoconductive mode

The dynamic resistance of a reverse biased photodiode is constant, and a high value of load resistance can be used to give a voltage output that is linearly related to the light level incident on the device. Because the diode junction capacitance decreases with increasing reverse bias voltage, diodes operated in this mode will have the fastest response times. However, noise levels will also increase in this mode as leakage current increases with bias voltage. Figure 42 shows the basic circuit.



Linear photometer

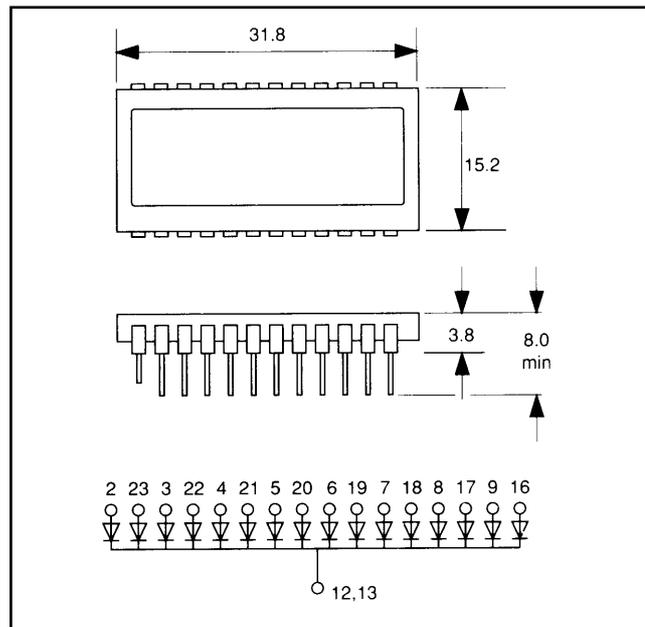
Figure 43 illustrates a photometer circuit using an FET operational amplifier RS stock no. 307-058. Diode current I_D varies with light level from 1nA to 1mA type. Resistor R is chosen to give required output-typ. value 1MΩ.



16 element linear array

(RS stock no. 194-060)

A 16-element linear silicon PIN photodiode array housed in an hermetically sealed 24 pin ceramic d.i.l. package. This high speed device consists of 16 individual elements arranged on a 1mm pitch in common cathode configuration. This array is ideal for linear position sensing, wide aperture detection and edge and hole detection in strip materials.



| Package type | Peak responsivity per diode A/W at λ nm | Number of diodes | Pitch of diodes mm | Active area of each diode mm ² | Dark current per diode nA (VR = 1V) | Capacitance per diode pF (VR = 0V) | Response time per diode nS (VR = 10V RL = 100R) |
|--------------|---|------------------|--------------------|---|-------------------------------------|------------------------------------|---|
| 24 pin | 0.6 900 | 16 | 1.0 | 0.66 | 0.1 | 9 | 4 |

Figure 44 Spectral response

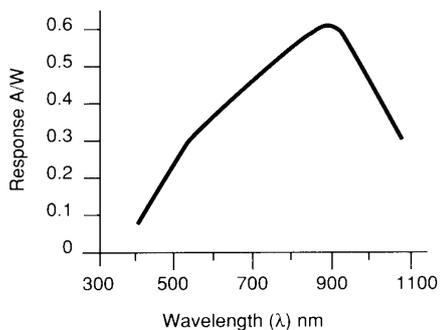


Figure 46 Open circuit voltage vs irradiation

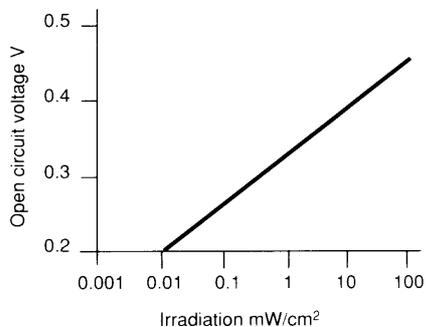
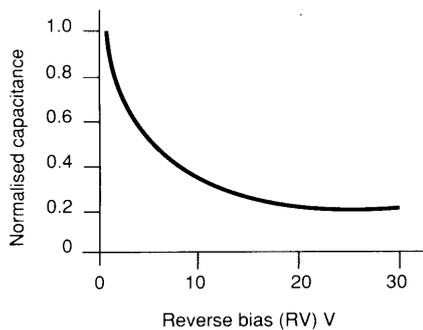


Figure 45 Normalised capacitance vs reverse bias



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