Photodiode and op amps form wideband radiation monitor

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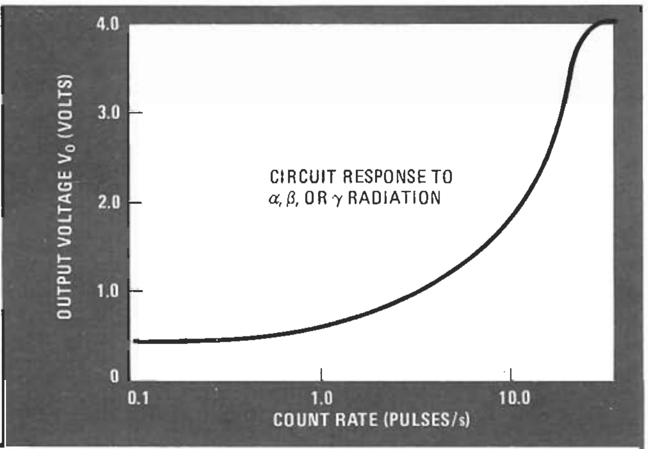
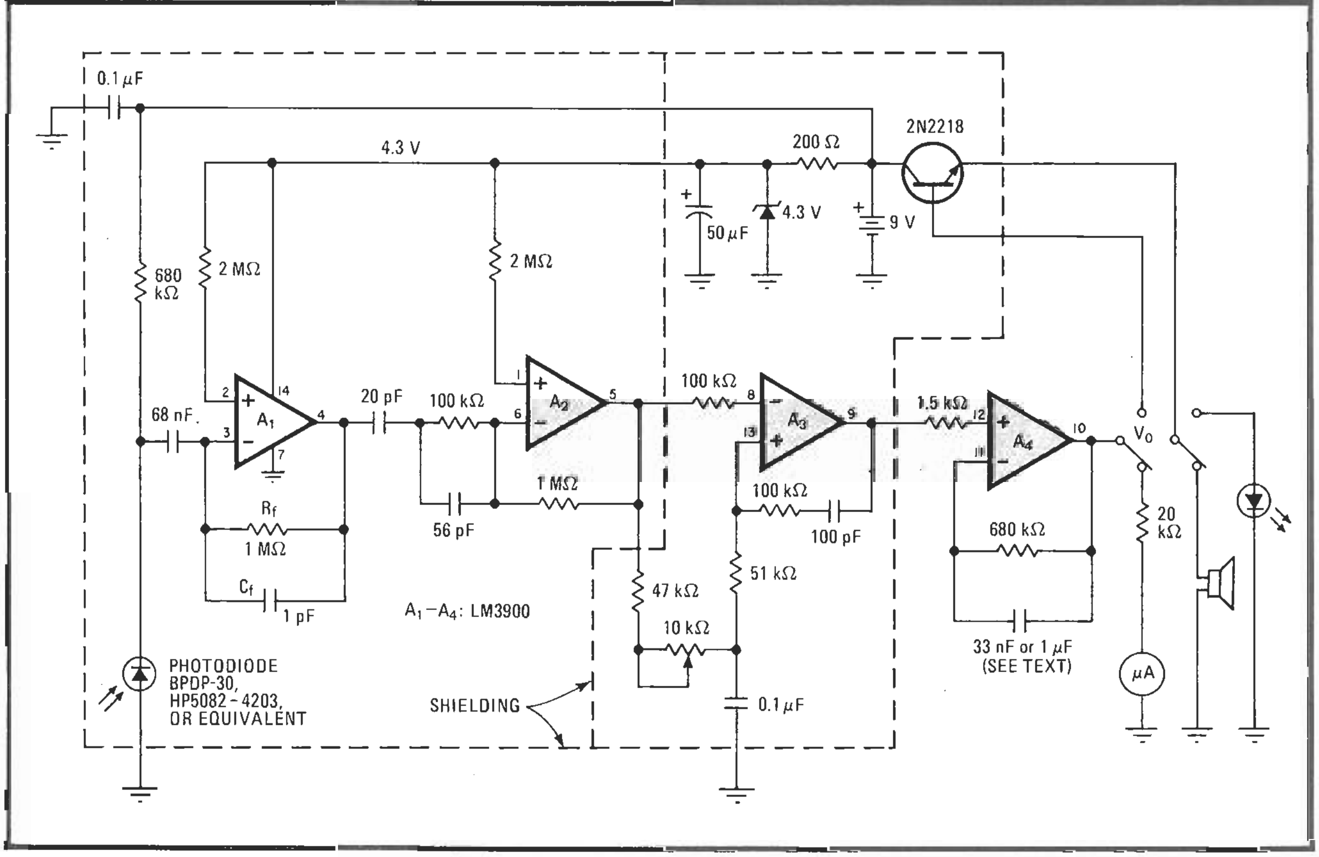
A sensitive radiation monitor may be simply constructed with a large-area photodiode and a quad operational amplifier. Replacing the glass window of the diode with Mylar foil will shield it from light and infrared energy, enabling it to respond to such nuclear radiation as alpha and beta particles and gamma rays.

The general circuit is shown in Fig. 1. The HP-5082-4203 device is a p-i-n photodiode, called that because there is a thin layer of undoped, or intrinsic, material between the p and n type regions of the diode. The intrinsic material acts to lower junction capacitance, so that the device has a higher frequency response than a standard photodiode, making possible the detection of beta particles and gamma rays (alpha particles could be detected with a standard photodiode).

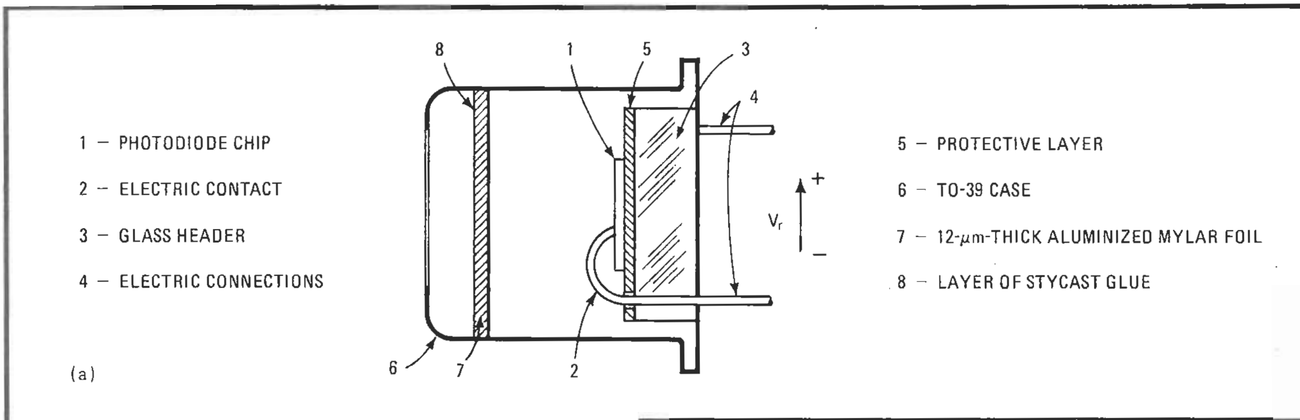
As a consequence of the p-i-n semiconductor structure, the device bandwidth is large. Hole-electron pairs, and thus charge (Q), can be accumulated across the photodiode by all forms of ionizing radiation. When the junction is shielded from visible and infrared light, the photodiode output is a function of the nuclear-type radiation only.

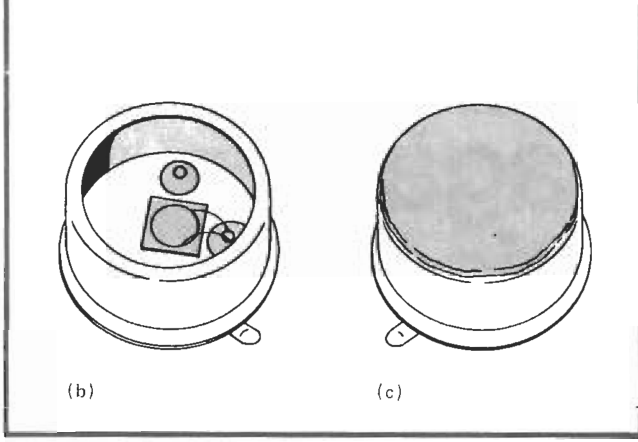
The junction charge generated by the ionizing radiation is $Q=\Delta E/\epsilon$, where ϵ is the ionizing constant of





1. Energy count. Broadband characteristics of p-i-n photodiode enables it to respond to α, β, and γ radiation when pn junction is shielded from visible and infrared wavelengths. Op-amp circuit amplifies and integrates pulses for meter or loudspeaker. Circuit has uniform response to radiation, independent of energy class.





2. Adaptation. Glass window of photodiode (a) must be removed and replaced by opaque material to shield pn junction from light. Top of photodiode case is first cut out (b) by turning lathe, then layer of aluminized Mylar foil is secured in place (c) with Stycast glue.

silicon (3.66 electronvolts at 300 K), and ΔE is the energy stored across the active region of the photodiode. The output voltage from integrator A_1 is thus:

$$V = (Q/C_f)\,(1 - e^{-t/R_fC_f})$$

where t is measured from the instant ΔE appears across the junction and R_fC_f is the time constant of the integrating network. A_2 is a quasi-Gaussian filter that shapes the pulse in order to inprove the signal-to-noise ratio of the small output signal at A_1. A_3 generates a rectangular pulse with a width proportional to the input amplitude for every signal that exceeds a threshold set by the user.

The threshold control is used if a radiation alarm circuit is desired (indicating maximum limits have been exceeded) or if it is necessary to discriminate against hash in high-noise environments. It should be noted that A_3 is in principle a current discriminator and that its temperature-drift coefficient is probably lower than that of conventional voltage discriminators, which are often used in radiation monitors.

A_4 integrates the output of A_3 in order to drive a microammeter. A l-microfarad capacitor is used in the integrating network. A lower value, say, 33 nanofarads, will make it possible to drive a small loudspeaker (50-hertz output signal) or light-emitting diode.

Figure 2 illustrates the procedure used to replace the photodiode's glass window with a 10-micrometer-thick aluminized Mylar foil. The photodiode shown here is the BPDP-30, a European make, but most photodiodes made in the U. S. are very similar.

As shown in Fig. 2b, the top of the TO-39 case containing the window must be cut away with a turning lathe. Care should be taken not to touch the pn junction within. Sharp edges are then filed smooth with care. The new window is then secured to the edges of the device by means of black Stycast glue (available from Emerson and Cuming Inc., Canton, Mass.). Figure 2c is a view of the completed diode.

The circuit response is seen in the upper part of Fig. 1. Note that this device is a radiation monitor, as opposed to a radiation meter, and so cannot distinguish between α, β, and γ radiation. Because of the photodiode's wide bandwidth, each energy class generates the same output voltage for a given radiation intensity. Thus the monitor is intended for use where an *a priori* knowledge exists of the type of energy to be encountered. □