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HIGH RANGE GAMMA RADIATION METER

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Abstract

A low power meter has been constructed and tested to measure gamma fields from .1 R/hr to 1500 R/hr over the energy range of 60 keV to 1.2 MeV. The portable, battery-powered meter consists of a local display unit and remote probe. The display unit indicates gamma intensities via a 4-1/2 digit liquid crystal display (LCD) and a 50-segment bargraph LCD.

Introduction

Traditionally, measurements in the gamma range of .1 to 1,500 R/hr have been performed using either ion chambers or Geiger tubes. The difficulty with this approach for portable instrumentation is the high voltage biasing requirements of these detectors. The meter described in the following paper provides a low-cost, lower-powered substitute for previous instruments by utilizing the unique advantages of a new solid-state detector.

The Detector

Cadmium Tungstate (CdWO_4)¹ is a high Z inorganic scintillator which emits light at 530 nanometers at 40% of the efficiency of sodium iodide (NaI). The longer wavelength is a good spectral match

to silicon photodiodes and yields a current output of 1.25×10^{-7} amperes per R (roentgen) after energy compensation. The dark current of the photodiode used is less than one nanoampere at room temperature and has a temperature dependence of .6 nanoamperes per degree centigrade.

The probe detector consists of a $10 \times 10 \times 3$ mm CdWO_4 scintillator optically coupled to a silicon photodiode. The energy compensation shim is a 2.5 mm lead enclosure with a distributed low energy aperture of 12% of the surface area. The current output from the compensated detector was measured with a Co^{60} source at the Los Alamos radiation source range and found to be linear throughout this range to within 10% (Fig. 2). The energy response of the shimmed detector was also tested at the Los Alamos radiation range facilities for energies above 70 keV and was found to deviate less than 15% (Fig. 3). The directional dependence of the assembly was checked for several low energy x-rays. No dependence on incident angle was found at 114 keV but the response at 76 keV at 90 degrees was found to be 76% of that at 0 incident angle. The response at 44 keV was found to be very angle-dependent, with 75% at 60 degrees and 22% at 90 degrees.

Remote Probe Electronics

The detector is operated in the photo-voltaic mode coupled into a low input bias current, high input impedance operational amplifier operated in the transimpedance configuration to generate a voltage proportional to the input current. This voltage is coupled to a voltage-to-frequency converter with an open collector output for

driving long lines. The major considerations in the design were low power consumption, versatility of use, and cost. The probe provides a frequency proportional output which can easily be displayed on a simple frequency counter in units of R/hr. The use of a single supply amplifier and voltage-to-frequency converter (vco) minimizes power consumption, reduces the complexity of power supplies, and allows the construction of a very low cost probe. Physically, the probe is a cylinder 4 inches long and 1 inch in diameter. The only connections required are for power and signal.

The Display Unit

The local display electronics consists of a 4-1/2 digit counter updating at one second intervals scaled to display exposure in R/hr. A LCD driver for the bargraph is driven by the output of a series of decade counters to generate a linear-logarithmic bargraph display. Additional electronics allow the setting of alarm trip levels internally which generate a flashing visual alarm on four segments of the bargraph, accompanied by an audible alarm. Four more segments of the bargraph are utilized to indicate the battery voltage. Physically, the display unit is 3 x 4 x 1 inches and has a mass of 330 grams. Power consumption of the display unit is 9 MW and requires 9 volts for operation.

Conclusion

Our purpose in developing this meter was to measure high R gamma fields in a manner significantly improved over conventional ion chambers. The advantages achieved with this meter are the lack of

high voltage supplies, smaller volume, and lower power. Since the currents generated by the detector are two orders of magnitude larger than from equivalent ion chambers, the requirement for exotic electronics is reduced, and therefore cost. The device serves as a working prototype to demonstrate the significant advantages of newer solid state detectors.

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References

1. Harshaw/Filtrol Partnership, 6801 Cochran Road, Solon, Ohio 44139

Figure Captions

1. Disassembled view of instrument
2. Linearity of compensated CdWO_4
3. Energy response

Fig. 1 Disassembled view
of instrument

Energy Compensated CdWO₄ Linearity

Disco 3x10x10 mm

Fig. 2 Linearity of compensated CdWO₄

Energy Response CdWO4 Disco 3x10x10 mm