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Performance of avalanche photodiodes for the detection of Terrestrial Gamma-ray flashes

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Terrestrial gamma-ray flash (TGFs) are gamma-ray from the earth, which have a duration of about 1 msec and hard spectrum up to 20 MeV. BATSE on board CGRO firstly observed TGFs and found the photon energy extends above 1 MeV. Recently, RHESSI observe TGFs more frequently than BATSE, a few tens of TGFs a month. A summed spectrum of TGFs observed with RHESSI is roughly reproduced by isotropic thin-target bremsstrahlung from 35 MeV electrons. It is suggested that most of the electron that produce the gamma-rays have energies on the order of 20 - 40 MeV. This most energetic photon phenomena in the natural world on Earth are thought to be caused by upward beams of runaway electrons accelerated by thundercloud fields.

In order to study TGFs, we are developing gamma-ray detector, which can be used on a small satellite. We have an interest in an accurate time observation because it is important to see if the TGFs are observed simultaneously with a lightning discharge or any other phenomena. For the detection of gamma-rays, scintillation detectors which have high detection efficiency for gamma-rays, are applied. We utilize avalanche photodiodes (APDs) for readout of the scintillation. An APD is a silicon semiconductor device with an internal gain of 10 - 100. Its small size and low power consumption are suitable for small-satellite borne experiments.

In this work, APDs with an area of 1 cm x 1 cm are tested for the readout of CsI scintillator. Noise components such as leakage current and capacitance are measured at several temperature. Total performance combined with a CsI scintillator is reported. We also discuss the detection efficiency in the limited size and weight for the small satellite use.