Thallium Doped Sodium Iodide Scintillation Detector Parameter Study with Multi channel Analyzer

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Introduction

NaI (Tl) detector has an excellent light yield. A typical inorganic scintillator shows a small but measurable non proportionality of its scintillation response with deposited electron energy. A measure of the efficiency of the scintillation process follows from a simple energy calculation. For a wide category of materials, it takes on the average about three times the band gap energy to create one electron hole pair. In NaI (Tl), this mean that 20eV of charged particle energy must be lost to create one electron hole pair. For 1MeV of particle energy deposited in scintillator, about 5×10^4 electron hole pairs are thus created. From the various experiments we know that the absolute scintillation efficiency of NaI(Tl) is about 12%, so absorption of 1MeV of energy should therefore yield about 1.2×10^5 eV in total light energy or 4×10^4 photon with an average energy of 3eV [1]. The Multichannel Pulse-Height Analyzer is used to record the energy or time spectra available from nuclear radiation detectors. In these experiments we have studied the various parameter of the pulse height spectrum.

Experimental Setup

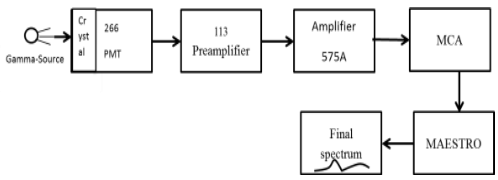


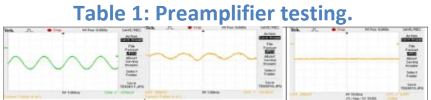
Figure 1: Experimental Setup.

The setup is shown in Figure 1. Consider the case where a detector, offering a linear response to the energy of gamma rays, produces a pulse of electrical charge for every gamma-ray photon that is detected [2]. In simple terms, the amount of charge in the pulse produced by the detector is proportional to the energy of the photon. The preamplifier collects that charge, while adding as little noise as possible, converts the charge into a voltage pulse, and transmits the result over the long distance to the supporting amplifier. The amplifier applies low-pass and high-pass filters to the signal to improve the signal-to-noise ratio, and increases the amplitude of the pulse. At the output of the amplifier, each pulse has duration of the order of microseconds, and an amplitude or pulse height that is proportional to the energy of the detected photon. Measuring that pulse height reveals the energy of the photon. Keeping track of how many pulses of each height were detected over a period of time records the energy spectrum of the detected gamma-rays. Firstly we have tested the amplifier. For this an input of 1 volt has been fed into test pulse connector of preamplifier and while increasing the capacitance of preamplifier we have observed the output with oscilloscope. Secondly we have studied the effect of varying gain of the amplifier on the photo peak. In third exercise we have studied the effect of photo peak on increasing the distance of the source from the detector with Cs-137 and in fourth experiment we have calculated the detection efficiency of scintillation detector.

Result and discussion

On testing the preamplifier we have found that that on increasing the capacitance amplitude of the output pulse decreases constantly which shows that the capacitance of the preamplifier is inversely proportional to the amplitude of the analog test pulse of preamplifier as shown in table 1. In the second exercise we have increased the gain of the amplifier continuously and observed the effect on the photo peak and found that on increasing the gain of amplifier, the pulse height spectrum starts broadening with respect to a reference peak position but the area under the peak remains unchanged. Table 2 shows the spectrum and results on increasing gain. In the third exercise we have increase the distance of the source from the detector, from 20 to 40 cm and the result conclude that on increasing the distance between source and detector, intensity goes down exponentially but there is no effect on peak position as can be seen in table 3. The graph between intensity of photo peak and distance is shown in figure 2. In fourth exercise we have find out the detection efficiency of the scintillation detector by using different gamma ray sources. Detection Efficiency of the detector is given by D.E.= D/N, where D= no. of photon counted in the detector, N=no. of photon emitted by the source, D=P/R, P = no. of counts in photo peak, R= peak to total ratio, N= BF×BR×T×A, BF= branching fraction, BR=branching ratio, T = total counting time interval in second, A= activity in disintegration per second [3]. The relation between the ratios R of the area under the full energy peak A_p to the area of full spectrum A_t with respect to the energy of gamma ray (integrated no. of counts) under full energy peak is shown in figure 3. Table 4 shows the detection efficiency of the detector for different sources calculated by the spectrums.

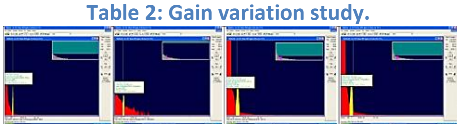
Table 1: Preamplifier testing.



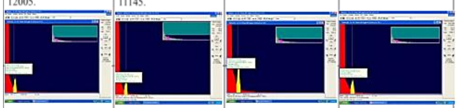
Test pulse of 1volt.	Output pulse of 216 mV when capacitance is 0 pF.	Output pulse of 68 mV when capacitance is 100 pF.

Output pulse of 40 mV when capacitance is 200 pF.	Output pulse of 32 mV when capacitance is 500 pF.	Output pulse of 26 mV when capacitance is 1000 pF.

Table 2: Gain variation study.



Gain= 2.5, peak position = 684, Peak Area= 12005.	Gain= 2.8, peak position = 750, Peak Area= 11145.	Gain= 3.0, peak position =808, Peak Area= 11941.	Gain= 3.2, peak position = 833, Peak Area= 11382



Gain= 3.4, peak position = 869, Peak Area= 11014.	Gain= 3.6, peak position = 935, Peak Area= 11816.	Gain= 3.8, peak position = 971, Peak Area= 11859.	Gain= 4.0, peak position = 1025, Peak Area= 11271.

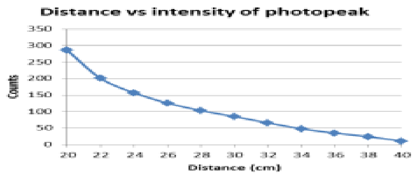


Figure 2: Distance vs. intensity of photo peak.

Table 3: distance variation study

Distance (cm)	Peak position	Intensity
20	631	286
22	632	207
24	643	156
26	632	126
28	632	103
30	641	85
32	632	66
34	641	48
36	631	35
38	641	24
40	635	11

Table 4: Efficiency determined for thallium doped sodium iodide detector for different sources.

Sources	Energy	Full spectrum area A_t	Full energy peak area A_p	Ratio (A_p/A_t)*100
Cs-137	0.662 MeV	81666	8477	10.4%
Co-60	1.33 MeV	92156	2271	4.0%
	1.17 Mev	92156	3725	2.46%
Ba-133	0.384 Mev	165190	2271	1.6%
	0.437 Mev	165190	8150	4.9%

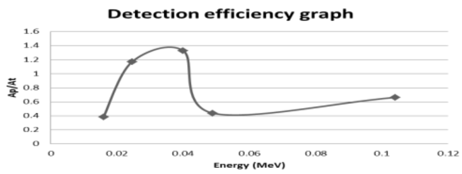


Figure 3: Detection efficiency graph.

References

[1]. Glenn F. Knoll, Radiation Detection and Measurement, 3rd Edition, John Wiley & Sons, New York, 1989.
[2]. Easy MCA - 2k/8k, ORTEC, AMETEK Advanced measurement technology, 2006.
[3]. Bircon Crismetic, Efficiency calculation for Selected Scintillators, 2004.