CHAPTER I
INTRODUCTION

1.1 Background and problems of interest

Nuclear spectroscopy has been applied in many fields of application, for example, industries, physics and nuclear medicine. All of these activities need radiation measurement system with high-energy resolution and high counting efficiency for accurate result. Especially for nuclear spectroscopy laboratory, the Nuclear Instrumentation Module, abbreviated as NIM, is widely used because the system has high flexibility for various applications and excellent operating efficiency. The basic spectroscopy configuration consists of radiation detector, high voltage bias, preamplifier; spectroscopy amplifier with shaping network and pulse height analyzer as shown in figure 1.1

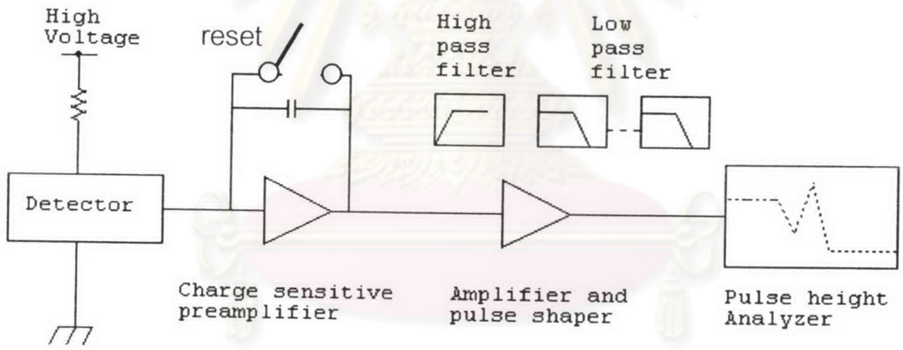

Fig. 1.1 The basic nuclear spectroscopy system

Generally, there are three categories of radiation detectors i.e. gas filled detector, scintillation counter and semiconductor detector, which produce ions or electron-hole pairs depending on its interaction with radiation. Amount of charges or electron-hole or ion pairs are proportional to the absorbed energies and vary with the type of detector. It should be noted that, the charges released per absorbed energy represent the energy resolution of each type of detector. In a measuring system, radiation detector is biased with high voltage for charges collection to produce a current pulse at detector's anode that can be represented by the equivalent circuit as a current source parallel to a capacitor (detector capacitance, C_d). This inherent capacitance of some category like semiconductor detector is not stable. It fluctuates due to the variation of reverse biasing high voltage during current pulse generating. This situation affects the signal pulse height, having the same amount of charges (V_d=Q/C_d). For this reason, the charge sensitive preamplifier configuration with charge active reset technique is preferred. Preamplifier works by integrating the amount of charge on to the feedback capacitor thus produces a step voltage which grows in the stair case fashion at the output and resets the signal before pile up saturation level to ground. The feed back capacitance is very large when compared to the detector capacitance. This condition will inhibit the unwanted effect. The designed preamplifier is sophisticated circuit. Therefore, carefully choosing the components is a subject to keep noises as low as possible. Nevertheless, the signal amplitude is corrupted through unwanted noises within circuit and external sources. It is known, this is the major source of the amplitude error and thus the energy resolution degradation of nuclear radiation spectroscopy [1-11].

A function of spectroscopy amplifier is designed to improve signals to noise ratio by eliminating noises and gains the signal as an input to Pulse Height Analyzer, PHA. The pulse height analysis will be represented as the distribution of input pulse height peaks called Energy Spectrum. With the high-energy resolution spectroscopy amplifier, peaks in energy spectrum must be clearly separated representing specific energy peaks in a spectrum, which will be needed for qualitative determination in nuclear experiment. In side a spectroscopy amplifier; the important part is wave shaping network. It can be performed by using the band pass filter with some additional circuits. Wave shaping network has narrow frequency response with adjustable corner frequency or shaping time and bandwidth, producing a new voltage-pulse shape according to the nature of detector signal and noises at the output, causing to signal to noise ratio improvement. In practice, the high energy resolution of each nuclear spectroscopy is achieved by varying shaping time then recording energy spectrum for searching the minimum Full Width at Half Maximum, FWHM, at the energy peak of interest. Actually, in spectroscopy laboratories using conventional spectroscopy

NIM, researchers familiar with NIM has an experience to do this task frequently as the quality control process.

The impression arising from the practical point of view and literature review shows that there is no attempt introducing signal processing method to determine or estimate the proper shaping time in nuclear spectroscopy with effect on energy resolution.

1.2 Thesis objective

To develop a signal processing method that enhances the energy resolution in nuclear spectroscopy.

1.3 Scope of work

The literatures and the popular textbooks in nuclear spectroscopy cited that the factors of energy resolution degradation in nuclear spectroscopy system could be summarized as follows.

1. Detector charge collection time causes the signal error if it is longer than processing time of wave shaping network.
2. High radiation rate causes the signal error due to pulse pile up when the time between two incoming pulses is less than processing time of wave shaping network.
3. Noise is a major cause of energy resolution degradation in nuclear radiation spectroscopy.

Energy resolution of nuclear spectroscopy can be improved through various kind of shaping network in spectroscopy amplifier with optimum processing time adjustment. Generally, the signal performance index is identified by the signal to noise ratio. Such a modern signal processing modeling technique and numerical calculation are used to determine the optimum condition of the system with consideration to the relation of signal and noise power spectral density in connection with the transfer function or frequency response of the shaping network at proper processing time. The framework of this dissertation is shown in Fig. 1.2

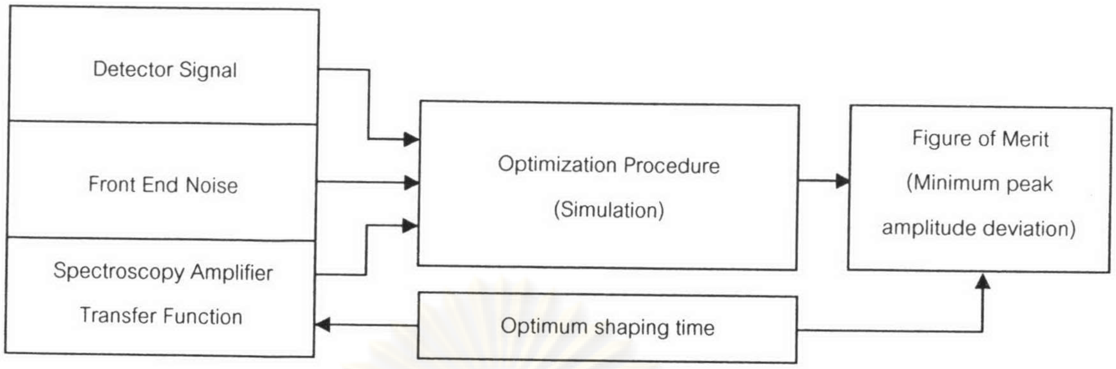

Fig. 1.2 Frame work of this dissertation

In this dissertation, the signal processing method is applied for analyzing the optimum condition to minimize noise in nuclear spectroscopy by studying the disturbance parameters in theoretical view. Thereby the signal sampling system and signal-processing program for searching and displaying the optimized index is developed with the aim to enhance the energy resolution of nuclear spectroscopy. The developed process is based on experiments with conventional manual searching on the real time nuclear spectroscopy, for example low energy x-ray spectrometer.

1.4 Expected benefit

This research work will support the idea that noise is major key energy resolution degradation in nuclear spectroscopy and the role of optimum filter that is derived from noise spectral characteristics along with detector signal. The procedure could be applied to adaptive nuclear spectroscopy, which automatically adjusts itself to the best energy resolution. Practically, it can be used as a tool replacing routine energy resolution searching in spectrometer setup and quality control, enabling better performance in nuclear instrumentation. It should be an inspection tool for nuclear spectroscopy when it faces an abnormal operating condition not only from noises but also the malfunction in spectrometer itself.