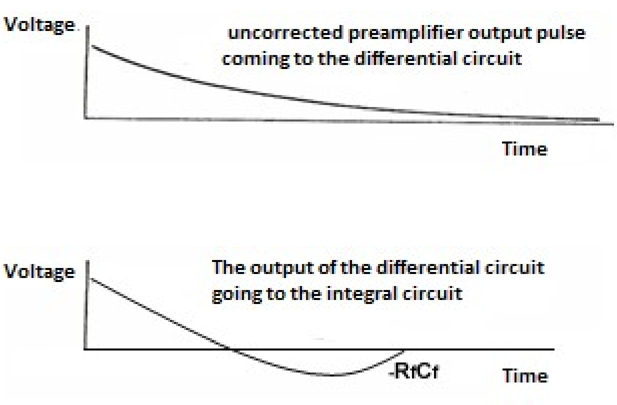
7.4. The Change In Detector Resolution With The Change Of Shaping Time And Pole Zero Cancellation

As is well known, there are several factors which can effect a nuclear counting system. Any change in one of these factors or attempting to adjust it to a new or an optimum value, it is expected that signal/noise ratio will change and this modification can cause a significant decrease in resolution(in terms of FWHM) of the measuring system. In this experiment the students familiarize with the adjustment/switches on the spectroscopy amplifier. Thus they will understand the importance of fine adjustment in the counting sytem. One of them is that the effect of shaping time on resolution will be investigated and the adjustment of the optimum selection shaping time. The electronic noise in the pre amplifiers input of a nuclear counting system causes by its specific capacitive effect and effects the resolution of the system. The selection of a suitable shaping time on the amplifier is a dominant factor on compensating that noise. Although the rise time of a pulse going through shaping is faster than 1 μs, the total time needed for collecting the whole charge is longer than the required rise time. Because of this, the effect of the charge collection in detector cannot be neglected. This effect is not that important in NaI and HPGe detectors but in CdZnTe, HgI_2 detectors which have a high atomic number, this effect is really important due to the remarkable difference in their charge mobilities. In fact, this effect completely depends on the detector characteristics. Because of incomplete charge collection, pulses will have lower amplitudes than expected and a tail on the left hand side of the peak can be seen. Hence, it is recommended to set the shaping time greater than the pulse rise time.

Pole Zero Cancellation

Adjustment/correction of pole zero is a really important factor which effects the performance of the nuclear counting systems. This adjustment provides to avoid overshooting or undershooting of the decay tail of a pulse from baseline. In resistive feedback preamplifiers output pulse is a pulse with a long decay time tail. If this pulse is fed into the amplifier, the resulted pulse shape is observed clearly on the scope if high pulse sampling rate exist, thus the tail can be seen around the baseline (Figure 2).



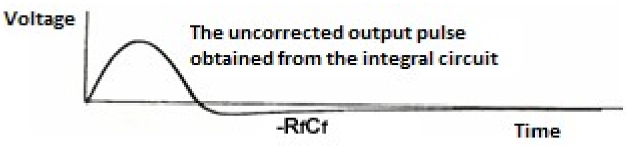


Figure 2. Pole zero cancellation

The tail of the pulse may exceed the baseline and continue to the negative and comes back to the base line in a time equal to the time constant of the feedback circuit of the preamplifier. After that this pulse is transmitted to the output pulse through the integrator. If a second pulse following the first one occurs on the negative part of the first one, its amplitude measurement will be wrong. This effect can be distinguished from the spectrum without a change in the pulse shape. Pile ups can also occur at the left and right side of the peak. In this case the net count under the photopeak will not represent the expected count. This problem may only be solved by a pole zero(P/Z) cancellation circuit. This P/Z correction shall be repeated when a change is made in the shaping time or a new module is inserted to the system. Generally, when the shaping time is changed, the pole zero settings should always be checked. After small gain adjustments on the amplifier, it is not necessary to repeat the correction. If there is a decrease in the resolution, first pole zero adjustment should be checked. If the corrected pulses are checked from the scope, it should be seen that all pulses go along the base line, also peaks on MCA display are symmetric and almost Gaussian. Pole zero adjustment is not needed on the preamplifiers which have an ability of discharging the integrator very quickly (< 2 µs), transistor reset preamplifiers or pulsed optical reset preamplifiers.

PROCEDURE

1. Place the ^{109}Cd source on a close shelf to the detector and keep it at the same place during the experiment.
2. Adjust amplifiers shaping time to 0.5 µs.
3. Acquire measurement for 600 seconds.
4. For 88 keV, calculate the FWHM in keV and channels and fill the Table 3. Use the following equation for this step.

$$\text{FWHM (keV)} = \frac{\text{Photopeak Energy (keV)}}{\text{The observed centroid channel (channel)}} \times \text{F}\mathit{WHM}\,\text{(channel)}$$

5. Adjust the shaping time to 1, 2, 4, 6, 12 µs and repeat step 4 and fill the Table 3.
6. Plot graphs of shaping time versus energy resolution in keV and channel. Comment on these graphs.

Table 3

Shaping time (τ, µs)	**FWHM (channel)**	**FWHM (keV)**
0,5		
1		
2		
4		
6		

12		

7. Make pole zero cancellation correction for every shaping time in front panel of the amplifier, and repeat the experiment and fill Table 4. Plot the same graphs for these settings.

Table 4

Shaping time (τ,μs)	**FWHM (channel)**	**FWHM (keV)**
0,5		
1		
2		
4		
6		
12		

To make the pole zero correction, connect the amplifiers output to the scope. Check the shapes of output signal. On the amplifier there is a potentiometer which can be adjusted with a suitable tool like a screwdriver. This changes the resistant on the derivation circuit (Figure 3). Correct the pulse if you see a tail under the base line.

If potentiometer is turned too much, pulse will go overshoot the base line and in this case it should turn to another way to correct that back.

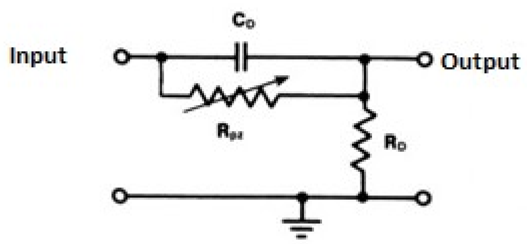


Figure 3. Pole Zero Cancellation Circuit

EVALUATION

1. Does the change on shaping time effect the noise?
2. How does shaping time change the pulse shape, explain?
3. Compare the results before and after pole zero correction and comment the results.

ANNEXES

<u>ANNEX 1</u> Gamma energies, gamma emitting probabilities and half-life of some isotopes used in experiments.

Isotope	**Gama Energy (keV)**	**Half life**	**Gamma emitting probability (%)**
^{241}Am	59,56	432,2 year	35,90
^{109}Cd	88	464 day	3,7
^{57}Co	14,4	271 day	9,5
	122,1		85,5
	136,5		10,6
^{137}Cs	661,66	30,25 year	85,20
^{54}Mn	834,843	312,3 day	99,976
^{60}Co	1173,238	5,2719 year	99,89
	1332,502		99,983