Frequency domain multiplexing of multiple organic scintillator detectors

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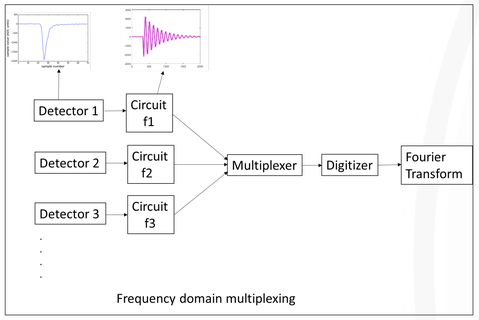
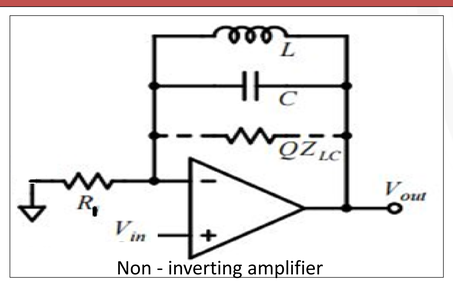
Introduction

- In this work, we present a technique to combine the anode pulses from multiple organic scintillators into a single digitizer channel.
- Each detector pulse is converted into decaying sinusoidal waveform at a particular characteristic frequency.
- The frequency – domain analysis on the ringing pulse is performed to extract the following information about the original anode pulse.
  - time – of – arrival
  - charge collected
- The frequency associated with the waveform reveals the detector from which the pulse originated.



Frequency domain multiplexing

Circuit

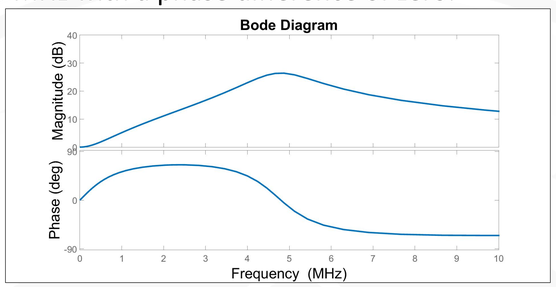


Non - inverting amplifier

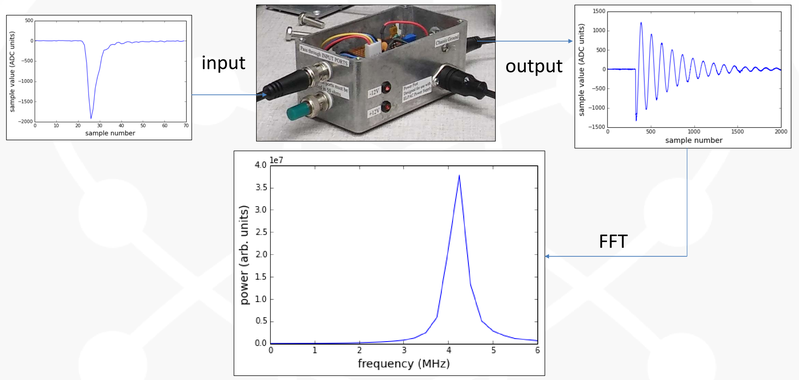
- The gain, G of the circuit is give by –
-

$$G = 1 + \frac{Z_{LC}/R_1}{j\left(\frac{\omega}{\omega_{LC}} - \frac{\omega_{LC}}{\omega}\right) + \frac{1}{Q}} \qquad Z_{LC} = \sqrt{\frac{L}{C}}\ ,\ \omega_{LC} = \frac{1}{\sqrt{LC}}$$

- The non – inverting circuit produces an output with a phase difference of zero with respect to input.
- The Bode diagram shows the gain is maximum at the frequency of ***4.75*** MHz with a phase difference of zero.

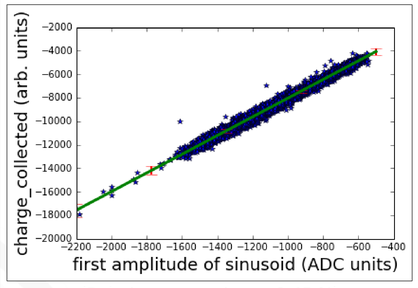


Analysis

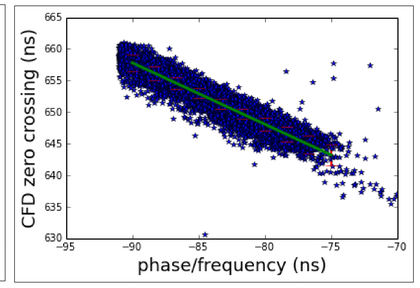


Results

- Charge collected under the anode pulse and its time – of – arrival were calculated using the first amplitude and phase of the ringing waveform respectively.
- The anode pulses from organic scintillator, generated using a Co – 60 source were used as an input to the circuit.
- A linear relationship between the charge collected under the anode pulse and the first amplitude of the sinusoidal waveform is established.
- A linear relationship is also established between the time – of – arrival of the anode pulse and phase of the sinusoidal waveform.

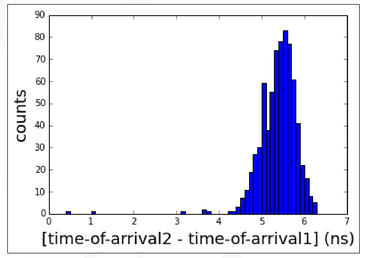


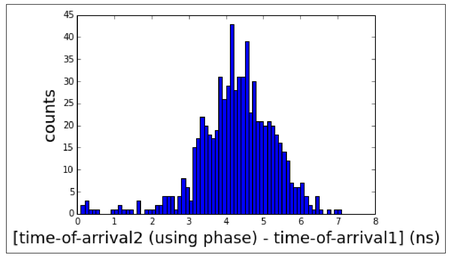
(Relative uncertainty = 3.45 %)



(uncertainty = 1.5 ns)

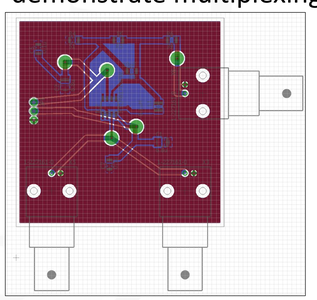
- Coincidence measurements were done using Na – 22 source where phase of the ringing waveform was used to calculate time – of – arrival of the coincident pulse.



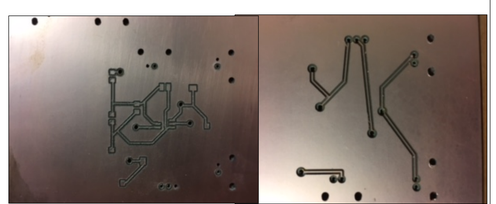


Future work

- Another circuit is being designed to ring at different frequency to demonstrate multiplexing of two detector pulses.



Two – sided printed circuit board layout
Courtesy – Eagle7.6.0



Two – sided Printed circuit board

- Perform coincidence measurements where phase of the ringing waveform will be used to calculate time – of – arrival of the coincident pulse for both the detector pulses.
- Obtain pulse – height spectrum of a radioactive source using the ringing pulse.

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National Nuclear Security Administration