Basic Electronics
SERB-TIFR

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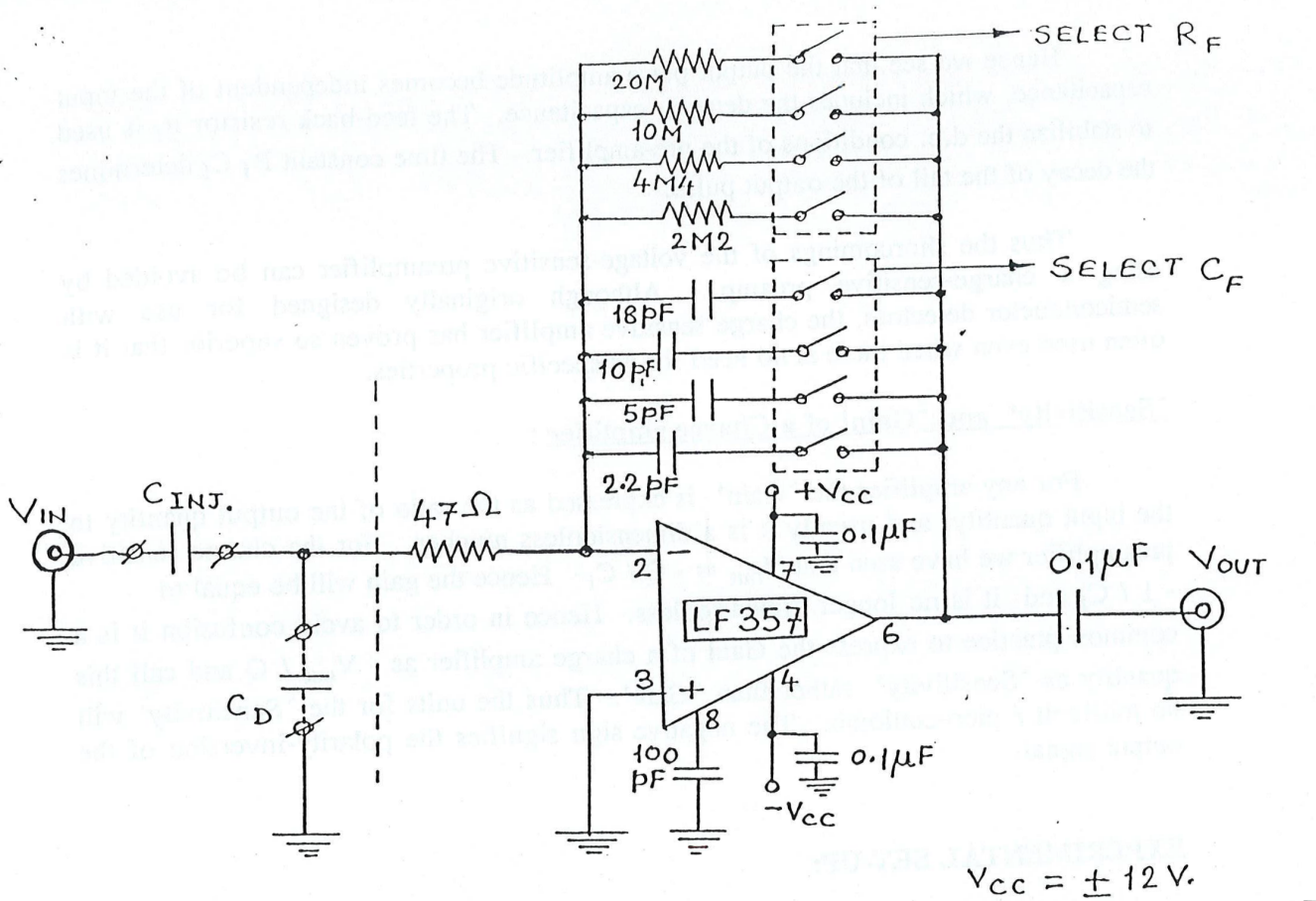
Charge Sensitive Amplifier

- Since, most of the energy information of the incident particle is quantified by the charge collected by the detector, so this is where charge-sensitive amplifiers come into play.
- It is used for amplifying the detector signal before furthur pulse processing. Sometimes it may be used just as a buffer between the detector and pulse analyzing circuits.
- Amplification with proper pulse-shaping will lead to very good S/N ratio.

Charge Sensitive Amplifier

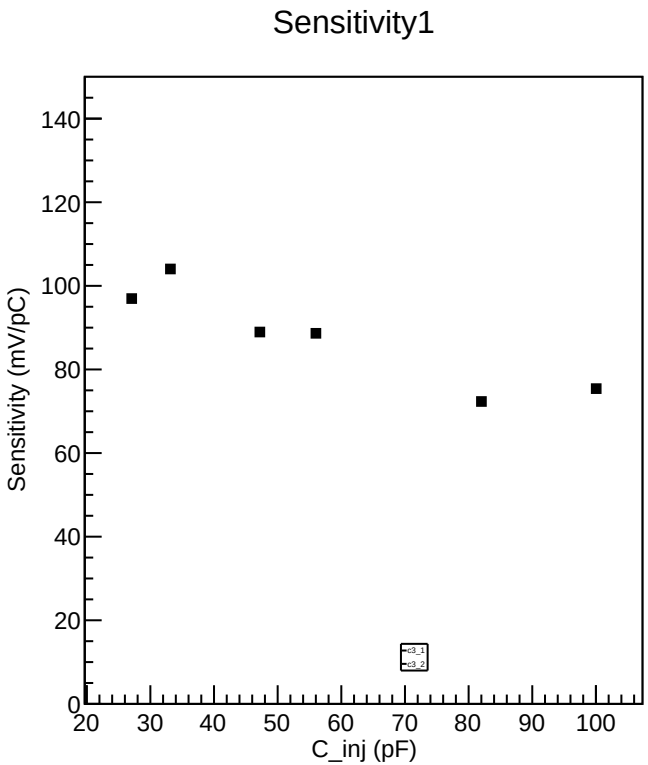
$$V_{in} = \frac{Q}{C_i + (A+1)C_f}$$

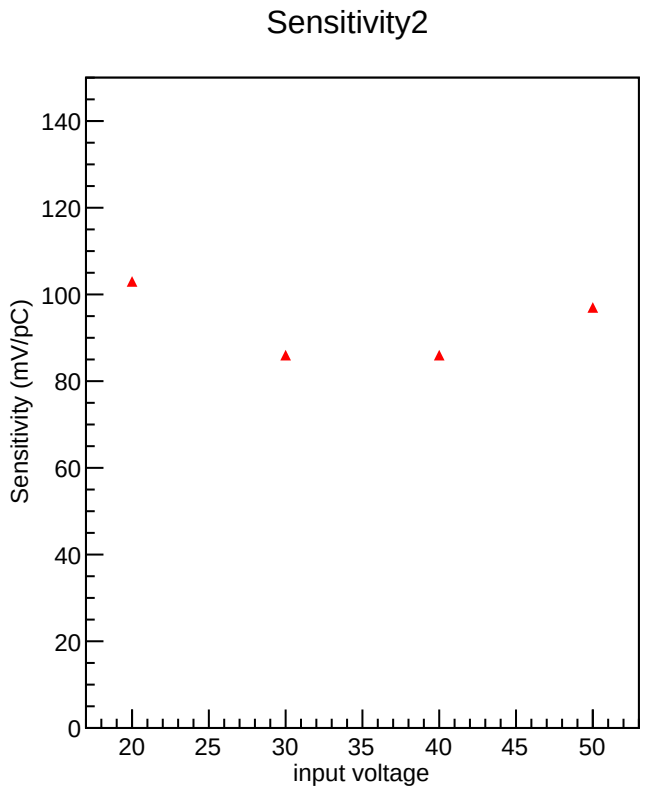
$$V_{out} = -\frac{Q}{C_f}$$



*Reference:SERB2019−BasicElectronicsManual.

Charge Sensitive Amplifier-Sensitivity





Effect of Detector Capacitance on Charge Amplifier

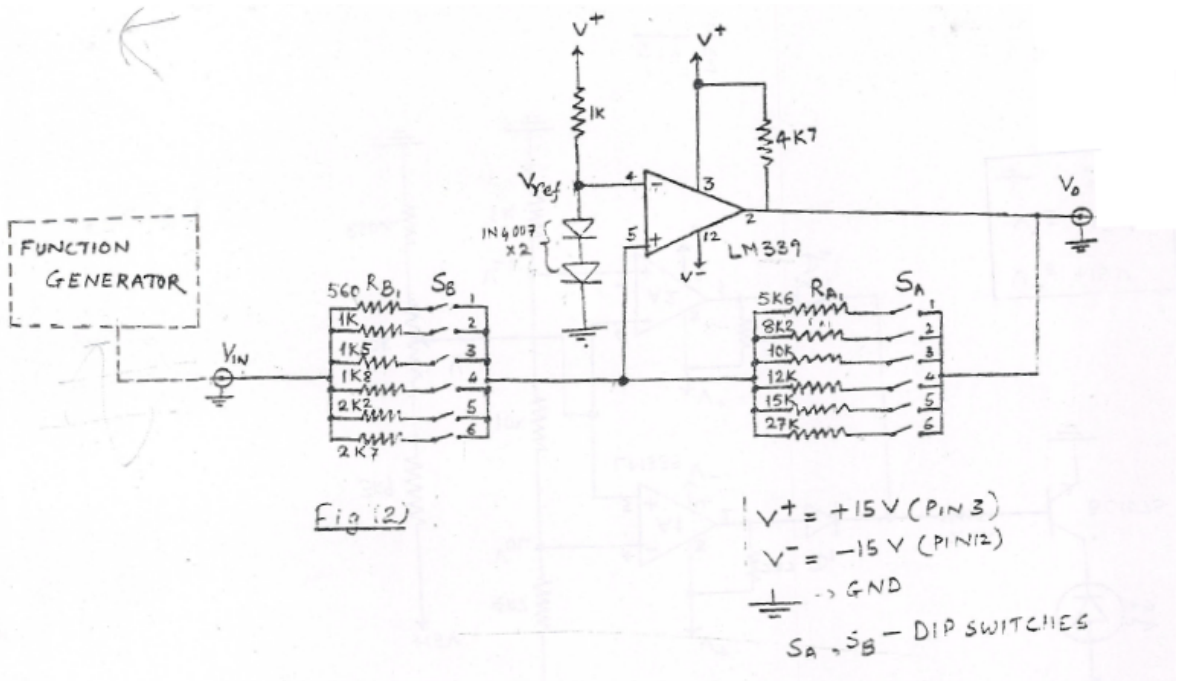
$V_{in} = 20mV$

C_f	voltage (V) Without C_d	voltage (V) With C_d
10	262	256
18	170	168
28	118	118

Schmitt Trigger

- It is often the case that we need the timing information of the incident particles. For example in the SERB school experiment for determining Muon lifetime, this was required. In such cases we prefer the incident pulse in the form of a logic pulse and comparator serves this purpose.
- It compares the input value with a preset threshold value and outputs a logic high or low pulse having width equal to the duration the input value is above the threshold.
- The Schmitt trigger further improves the comparator by employing a method for shifting the reference voltage dynamically and hence avoiding jitter in the input signal from the detector. This reduces the chances of getting false logic signals due to the jitters.

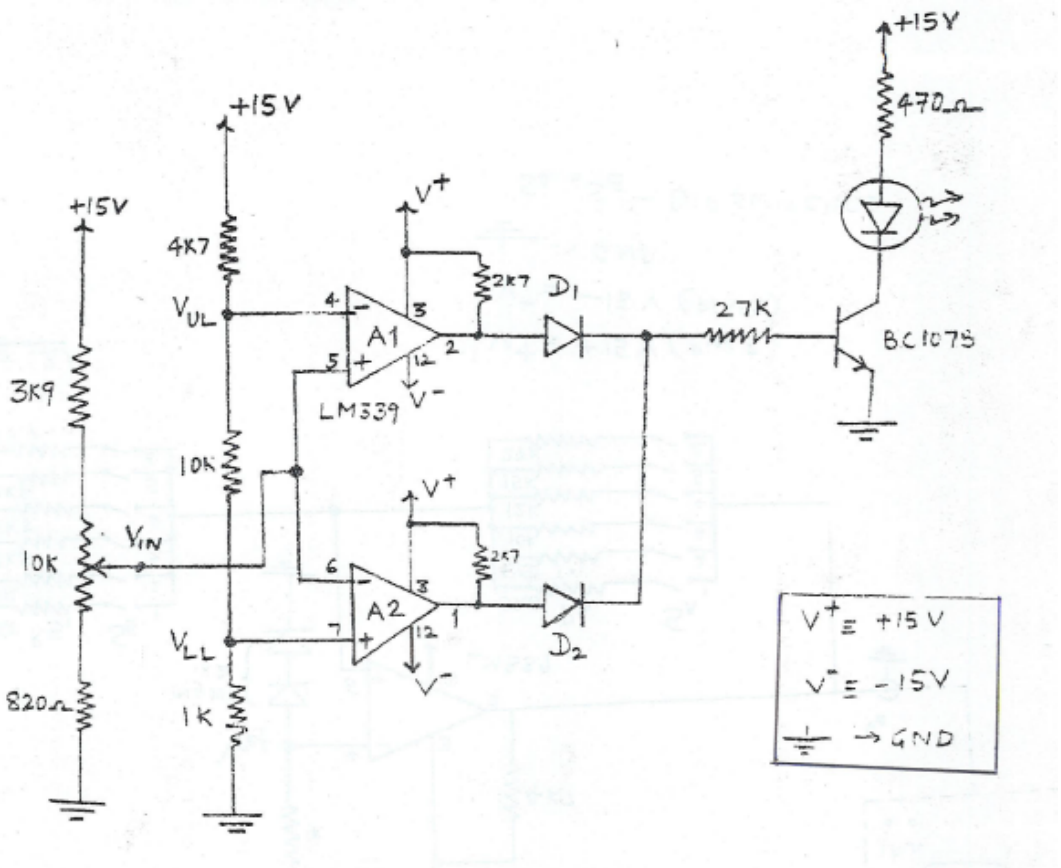
Schmitt Trigger



$$V_{UT} = \frac{R_A+R_B}{R_A}(V_{ref}) + \frac{R_B}{R_A}(V_{+sat})$$
$$V_{LT} = \frac{R_A+R_B}{R_A}(V_{ref}) - \frac{R_B}{R_A}(V_{-sat})$$

*$Reference: SERB2019-BasicElectronicsManual$.

Window Comparator



- This circuit produces a logic pulse or in this case makes the LED off when the input voltage lies within a preset range.

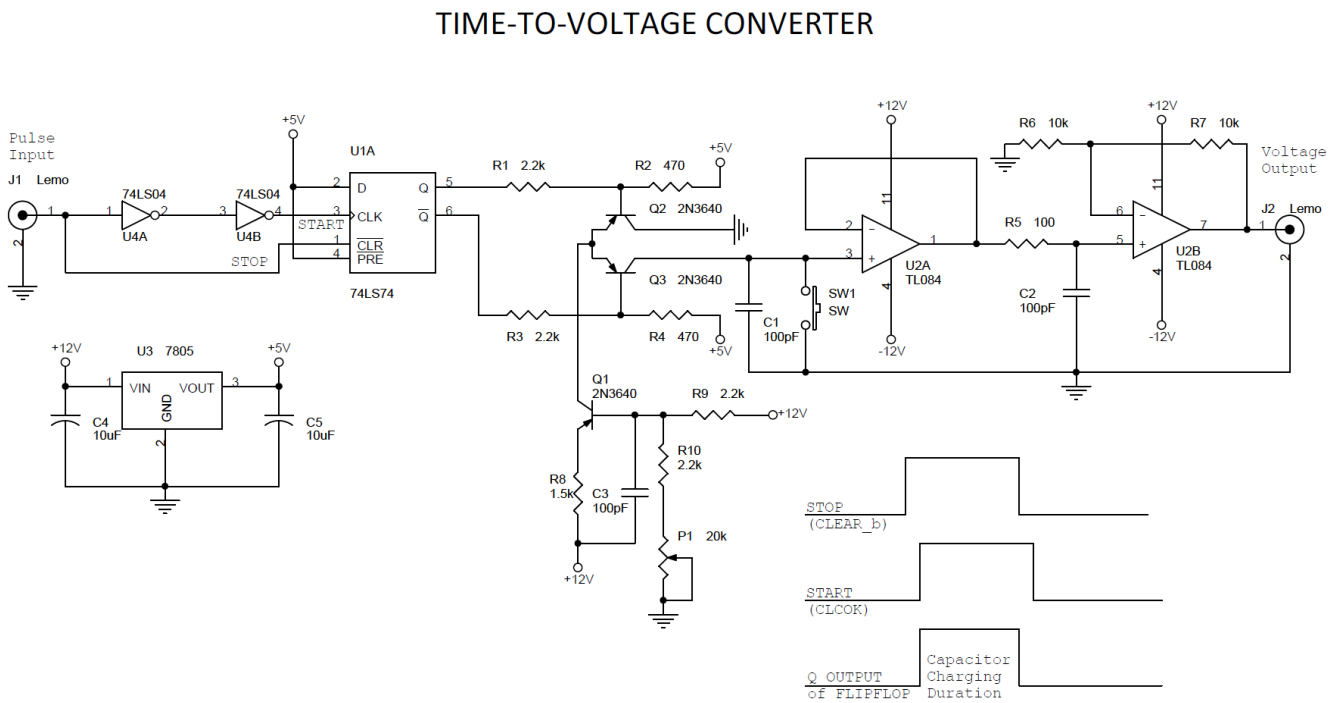
*Reference:SERB2019−BasicElectronicsManual.

Time to Voltage Converter

- This circuit is essential for doing time analysis of incident pulses. A similar circuit for example was used to find out the time interval between the muon and electron pulses when determining the lifetime of the muon.
- The circuit employs a constant current source to charge a capacitor across which the output voltage is measured.

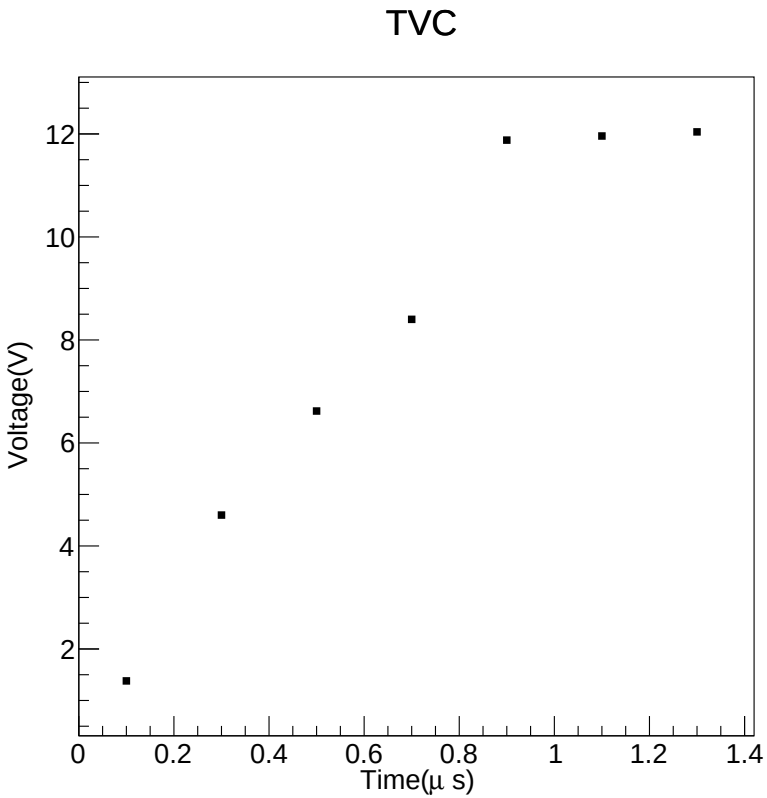
Time to Voltage Converter

$$V = \frac{i*t}{C}$$



*Reference: SERB 2019 – Basic Electronics Manual.

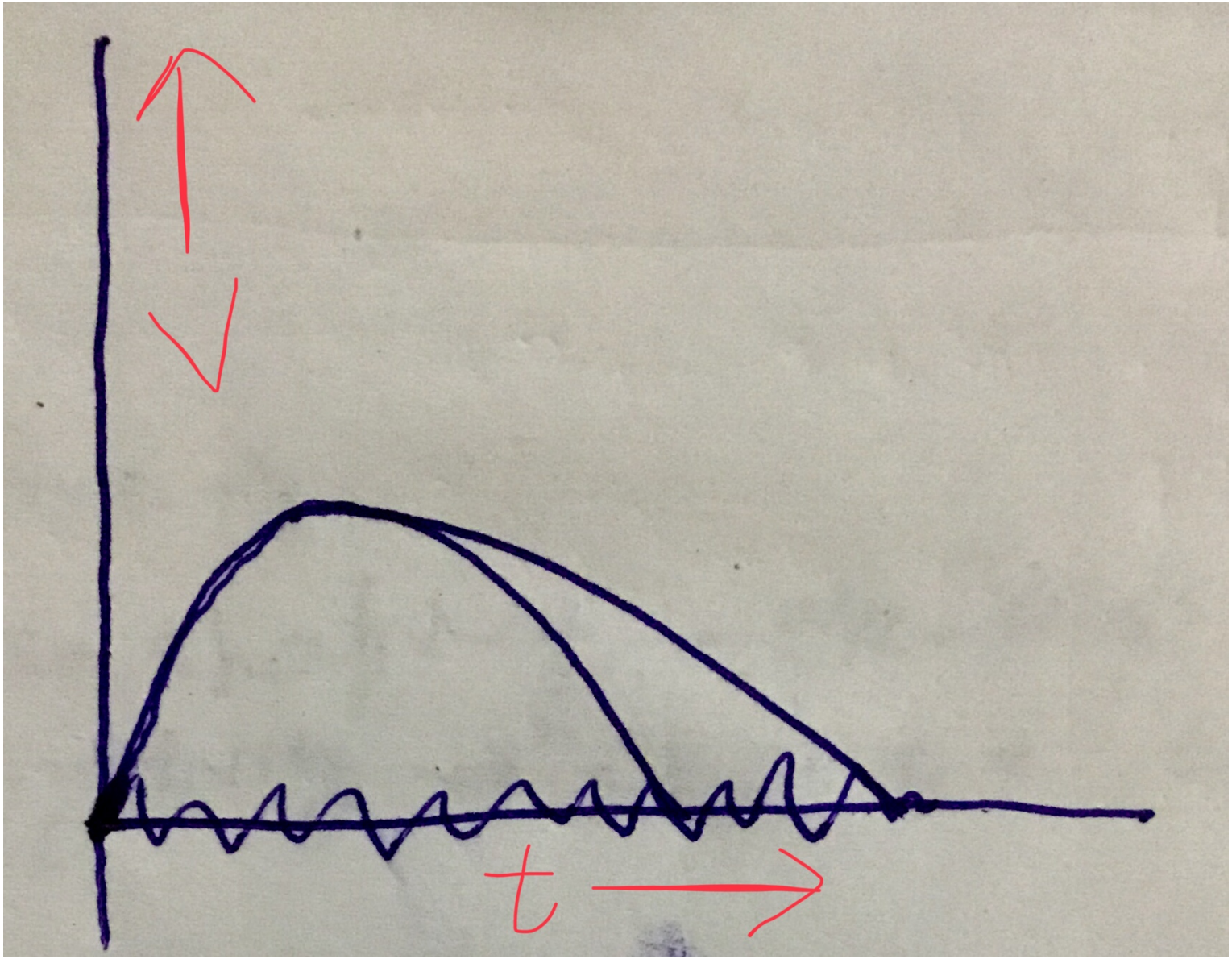
Time to Voltage Converter



Pulse Shaping

- To reduce background to noise ratio.
- To reduce the Pile-up in high event rates.

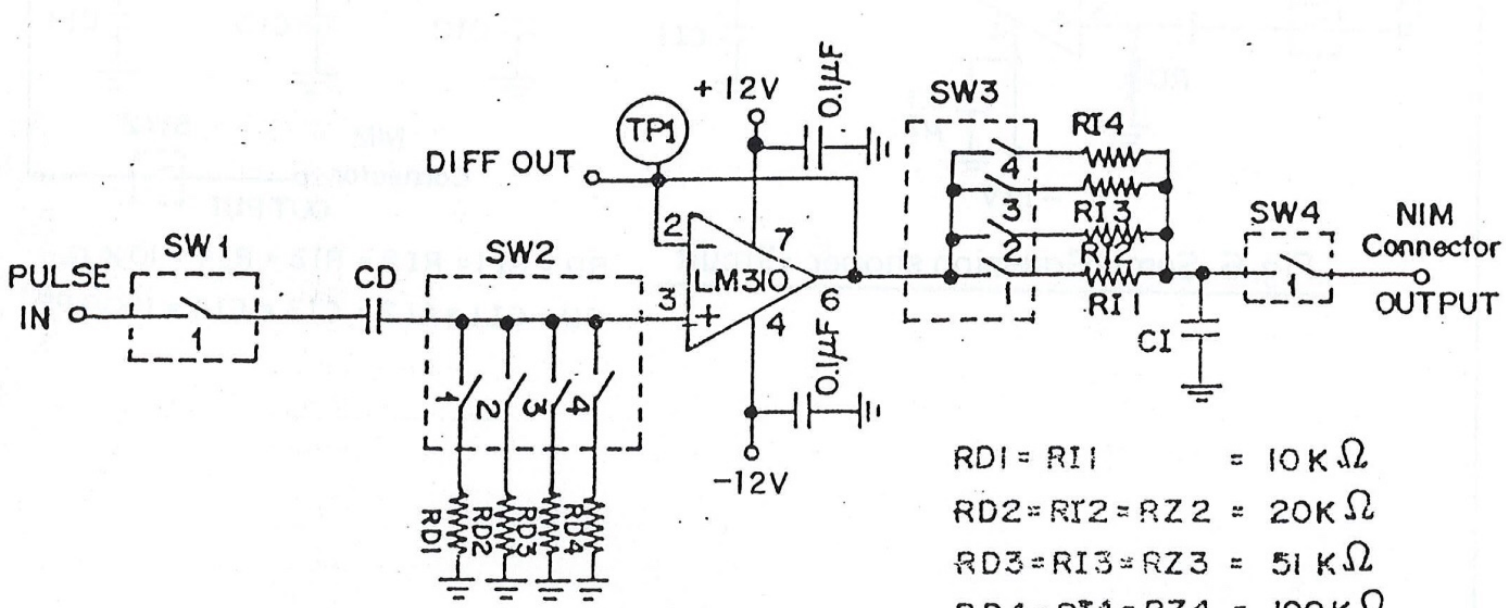
Background to Noise Ratio



Comparison of CR-RC and CR-RC4

- Sharply pointed top makes subsequent pulse height analysis difficult because the maximum pulse amplitude is maintained only for a short time period.
- the differentiaon allows all high-frequency components of any noise mixed with the signal to be passed by the network.
- For equal time constants throughout
  CR-RC4 = 4x peaking time CR-RC.(that is undesirable).
- If time constants are adjusted such that rise times are roughly equal then the more symmetric shape of gaussian pulse results in faster return to the base line.

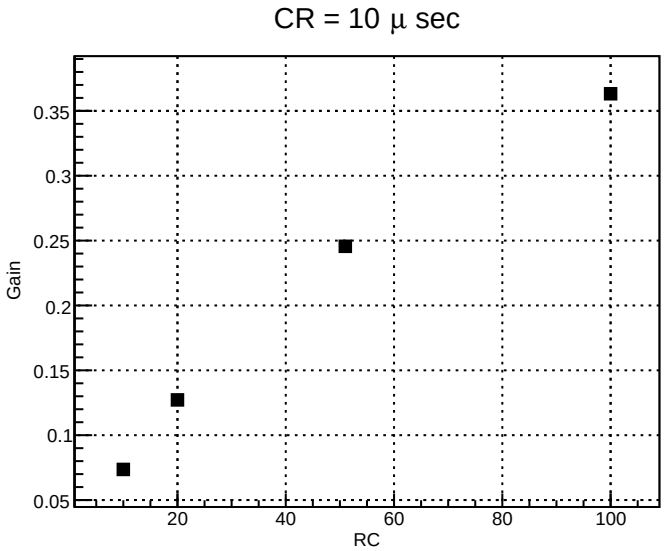
Pulse shaping CR-RC

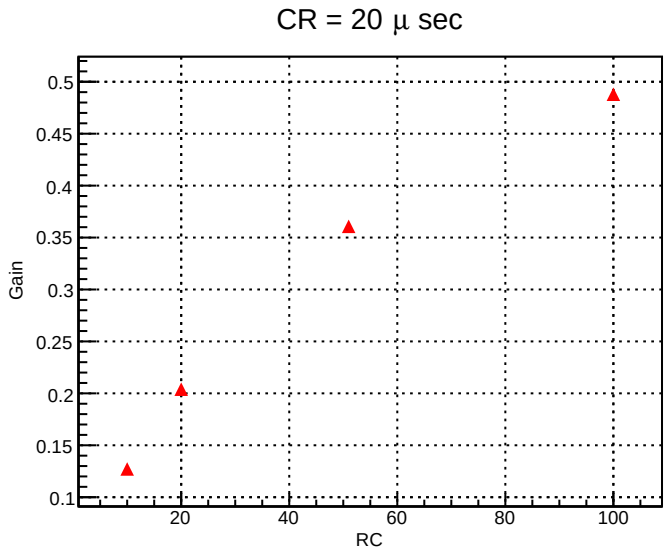


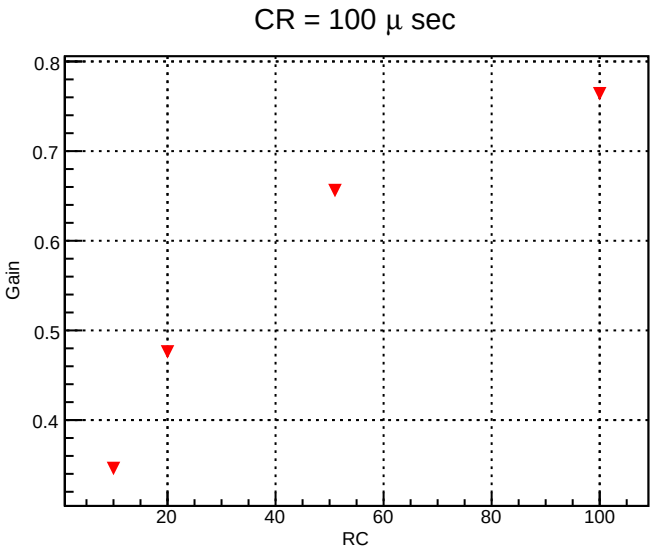
CR-RC Shaper Circuit

*Reference: SERB 2019 – Basic Electronics Manual.

Pulse shaping CR-RC







*Reference:SERB2010 *BasicElectronicsManual*

Effect of Detector Capacitance on Charge Amplifier

$E_{in} = 5V$ Square wave

CR $= 10$ μsec

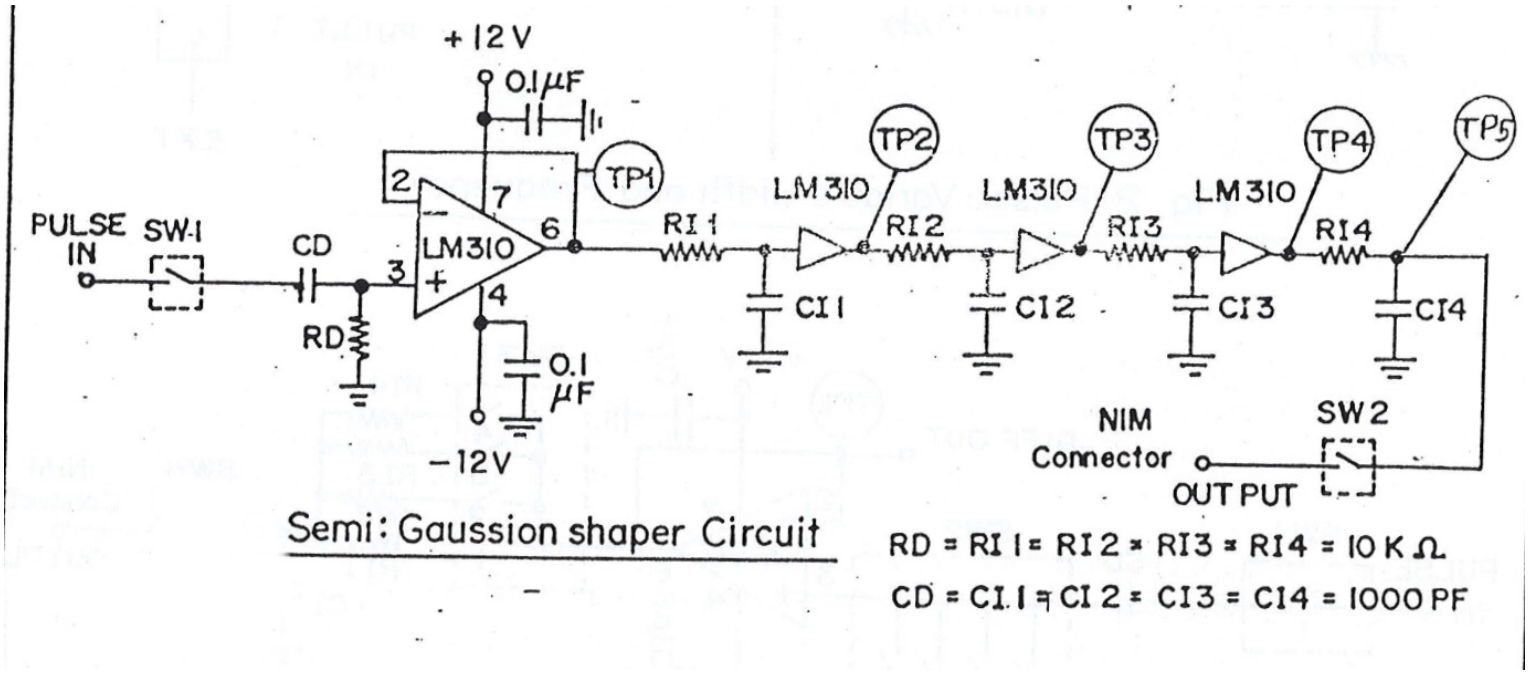
$RC(\mu sec)$	Rise time(μsec)	Pulse total time(μsec)
10	26.0	249
20	20.4	234
51	14.4	125.6
100	10.0	89.2

CR $= 20$ μsec

$RC(\mu sec)$	Rise time(μsec)	Pulse total time(μsec)
10	40.0	298
20	30.8	248
51	20.0	175.6
100	14.4	127.6

Pulse shaping CR-RC^4

$$E_{out} = E\left(\frac{t}{\tau}\right)^4 e^{-\frac{t}{\tau}}$$



*Reference: SERB 2019 − Basic Electronics Manual.