IIT-Bombay

Silicon Detector Caliberation

by

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Project Report of Summer Internship

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Chapter 1

Introduction

Semiconductor detectors have several advantages over other types of particle detectors. They possess unique properties that distinguishes them from others: better energy resolution, flexibility of design, tolerance to high energy radiation, fast timing response etc.

In semiconductor detector, the electron hole pair produced by the inter-action of an ionizing radiation are collected by applying an electric field to provide a signal. The signal strength is directly proportional to the total number of electron hole pairs produced i.e., the total quantity of ionization and therefore to the absorbed energy. (Since, the number of e-h pairs produced is directly proportional to the energy absorbed).

In this project, a circuit was wade which can be used to calibrate readout system of such a detector. The circuit generates a short current pulse which can be given to the readout system to simulate a particle detection by a silicon detector.

Chapter 2

Monostable Multivibrator

Monostable Multivibrators or One-Shot Multivibrators as they are also called, are used to generate a single output pulse of a specified width, either HIGH or LOW when a suitable external trigger signal or pulse T is applied.

In this project, several multivibrators were made to decrease pulse width as much as possible.

2.1 555 timer

The 555 Timer is a commonly used IC designed to produce a variety of output waveforms with the addition of an external RC network.

When a negative (0V) pulse is applied to the trigger input (pin 2) of the Monostable configured 555 Timer oscillator, the internal comparator, (comparator No1) detects this input and sets the state of the flip-flop, changing the output from a LOW state to a HIGH state. This action in turn turns OFF the discharge transistor connected to pin 7, thereby removing the short circuit across the external timing capacitor, C1.

This action allows the timing capacitor to start to charge up through resistor, R1 until the voltage across the capacitor reaches the threshold (pin 6) voltage of 2/3Vcc set up by the internal voltage divider network. At this point the comparators output goes HIGH and resets the flip-flop back to its original state which in turn turns ON the transistor and discharges the capacitor to ground through pin 7. This causes the output to change its state back to the original stable LOW value awaiting another trigger pulse to start the timing process over again. Then as before, the Monostable Multivibrator has only ONE stable state.

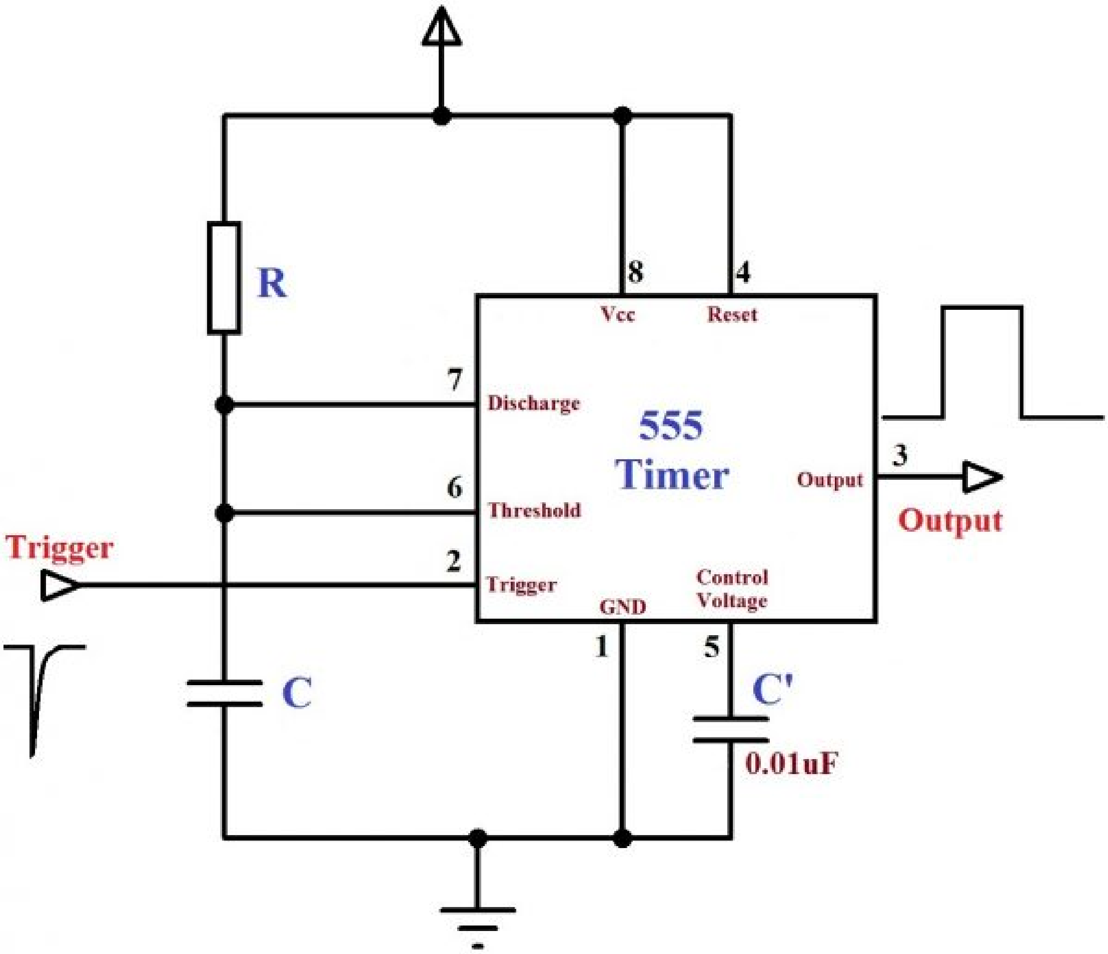

FIGURE 2.1: IC 555 monostable multivibrator circuit

The width of output pulse of an IC 555 monostable multivibrator is given by

$$\tau = 1.1R_1C_1$$

The circuit suffers from an inherent drawback. The trigger pulse should be much shorter than the output pulse, otherwise the circuit will keep firing in rapid succession. Due to limitation of human reaction time, the minimum width that can be obtained by direct trigger will be of order of 100 milliseconds.

2.2 LM 319 multivibrator

Realising that op-amp can be used as a comparator, I used a fast switching op-amp(LM-319) along with a simple RC circuit to design a faster monostable multivibrator. The circuit diagram is shown below.

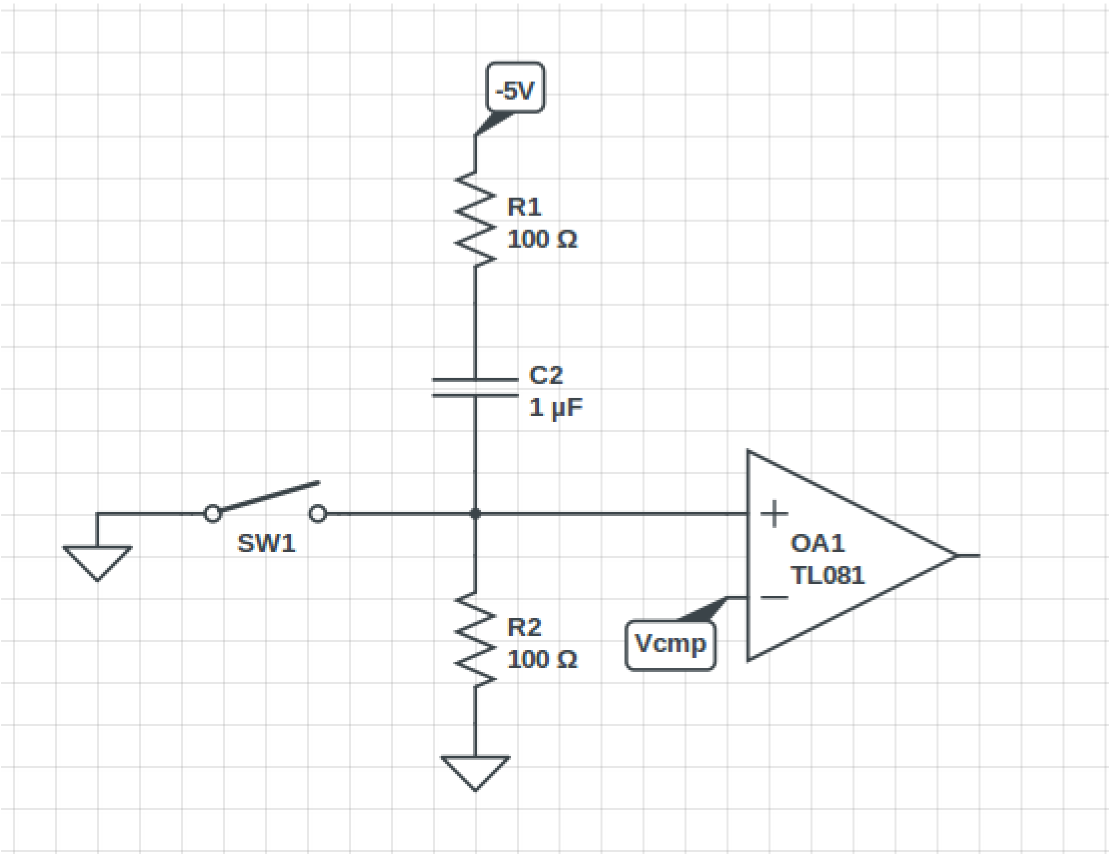

Figure 2.2: LM 319 monostable multivibrator

in the circuit, as soon as switched is closed, the capacitor starts discharging through R2, and an exponenitally decreasing voltage is seen at non-inverting terminal of op-amp. This is compared to some suitable V_{cmp} to obtain a square pulse of desired width.

The issue with this circuit is that because of op-amp, the output signal has lot of noise, even at base level.

2.3 74121 multivibrator

74121 multivibrators feature dual negative-transition-triggered inputs and a single positive-transition-triggered input any of which can be used as a trigger. In the circuit shown, positive trigger at pin 5 is used, while negative trigger pins 3 and 4 are grounded. Complementary output pulses are provided.

The 74121 monostable multivibrator is non-retriggerable, i.e. a new trigger during a pulse will not restart the pulse time, and thus does not affect the current pulse. This is useful property because a push button suffers from debouncing effect, which will then be nullified by the circuit.

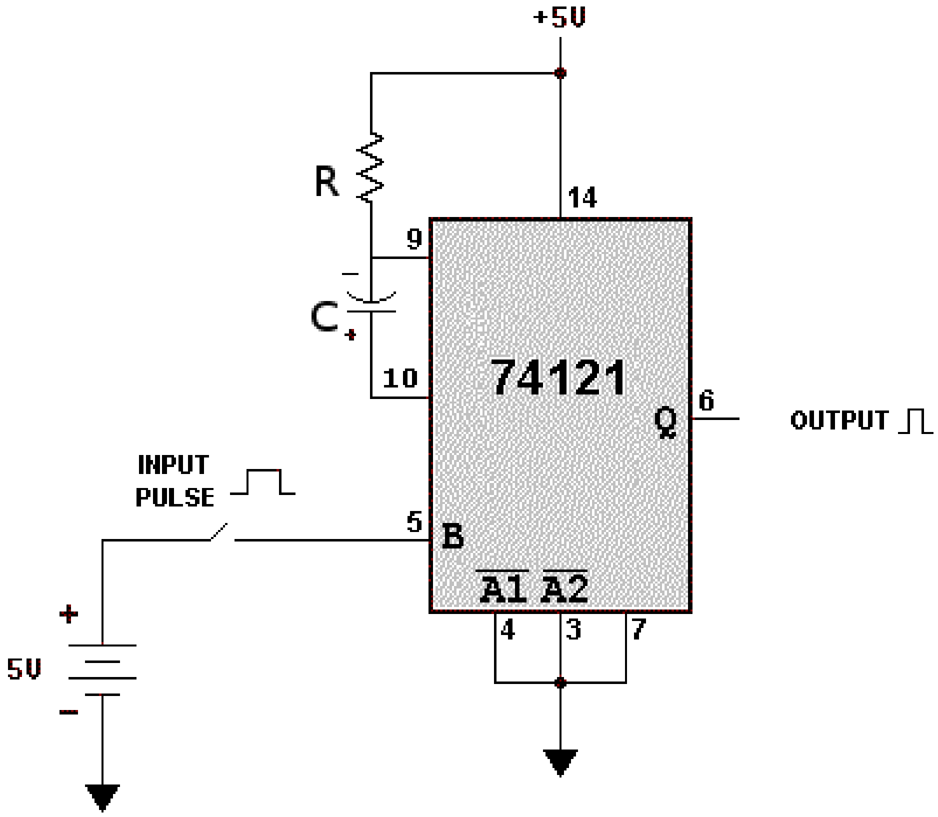

FIGURE 2.3: 74121 monostable multivibrator

By varying R and C, the width of the pulse can be controlled according to the relation.

$$\tau = 0.69RC$$

For $R = 50\Omega$ and $C = 4.7nF$, pulse f width $\tau = 4.7ns$ was obtained.

The circuit was later made in EAGLE, and was printed on the PCB. The Eagle Schematic and Board design is shown below.

IC 7805 was used to obtain 5V supply from a 9V battery. SVG2 pin header was used to connect the switch, with $R_2 = 5k\Omega$. R_1 and C_1 are the circuit elements which determine the width of the pulse. The output signal is divided into two halves, one of which was sent to an Operational Transconductance Amplifier for obtaining a current pulse, while other signal could be analysed using a DSO.

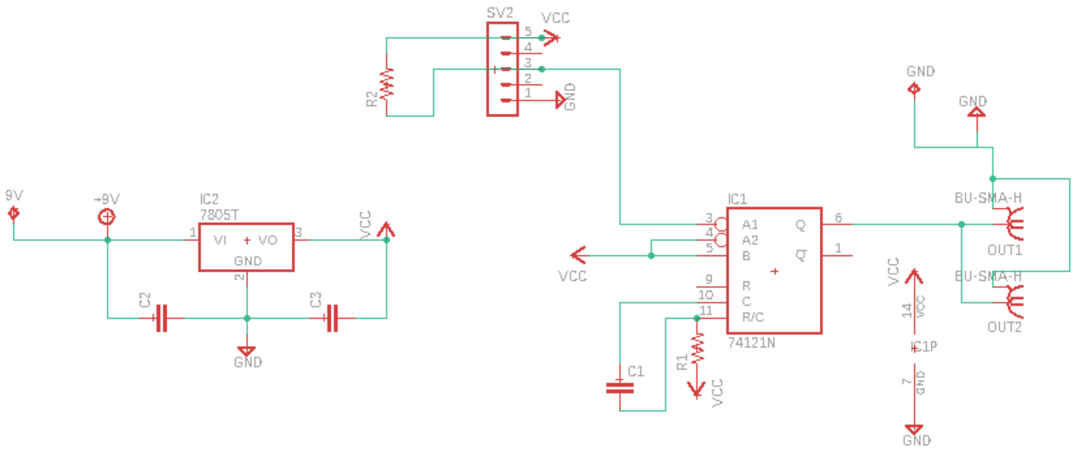

Figure 2.4: 74121 schematic

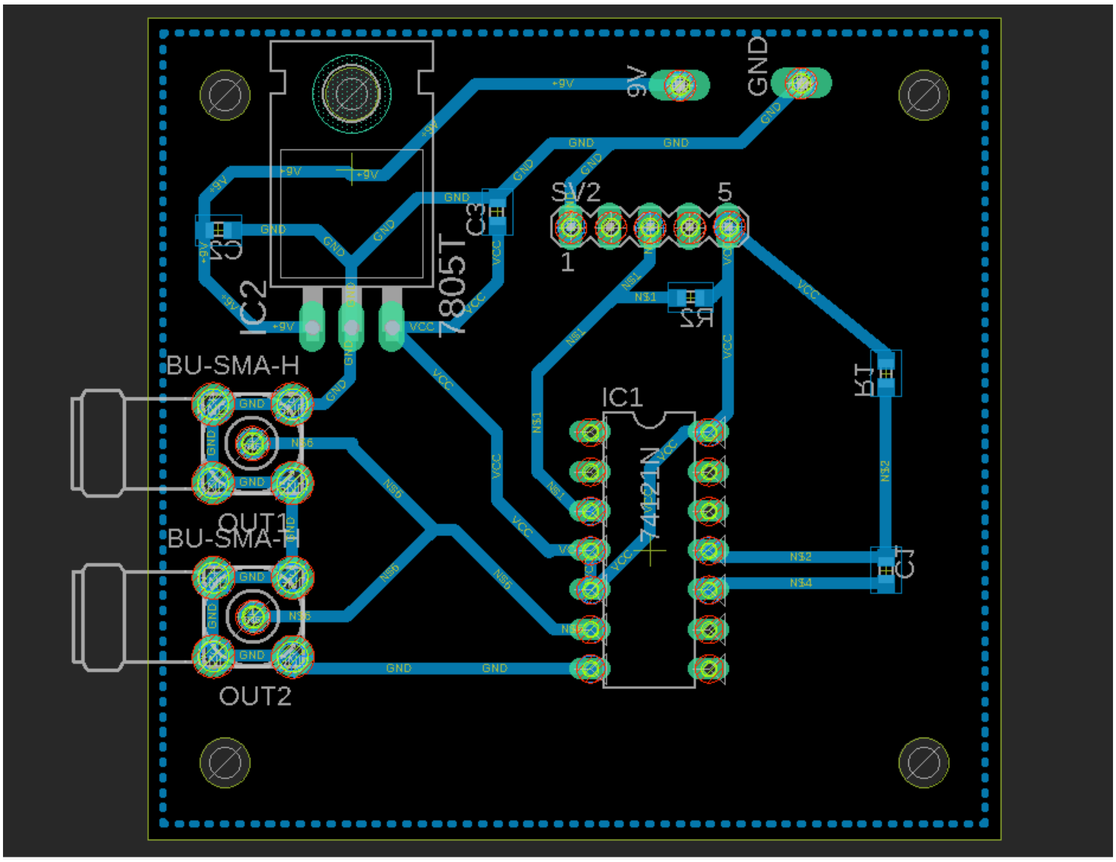

Figure 2.5: 74121 board