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# Small Signal Pulse Detection

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## Abstract

The report discusses the development of a small signal pulse detection system which is a subpart of a Partial Discharge measurement system. In electrical engineering, a **partial discharge** (PD) is a localized dielectric breakdown of a small portion of a solid or liquid electrical insulation system under high voltage stress. While a corona discharge is usually revealed by a relatively steady glow or brush discharge in air, partial discharges within an insulation system may or may not exhibit visible discharges, and discharge events tend to be more sporadic in nature than corona discharges. Once begun, PD causes progressive deterioration of insulating materials, ultimately leading to electrical breakdown. Thus, detection of partial discharge enables us to estimate the age of the insulator. When a partial discharge occurs, the event may be detected as a very small change in the current drawn by the sample under test. The use of high speed op-amps and analog components enables us to measure the net charge due to the discharge in spite of its low magnitude. The following report demonstrates the concept using relatively low speed components used for data sampling and conditioning and a microcontroller enabled data transmission to a computer via the serial port. The circuit can be similarly extended to high speed operations using relatively expensive high speed components and taking into consideration effects of high frequency operations.

## 1. Introduction

Partial discharge is primary cause of the failure of high voltage systems. Partial discharge occurs when there is a gap in the dielectric between two electrodes in a high voltage device and which cannot be bridged. Partial discharge deteriorates the insulation and hence reduces the life of the system. In this project, we aim to detect the pulses generated from a high voltage system due to partial discharge. The system superimposes these pulses on a 50 Hz AC signal and then later filters it out. The signal we get as our input is the filtered out signal. We design our device initially using normal operational amplifiers (LM 741) at lower frequencies. The pulses which occur due to partial discharge have a very high frequency, of the order of 500 MHz.  The width of these pulses is 60 – 100 nm and the amplitude is not more than 900 mV.

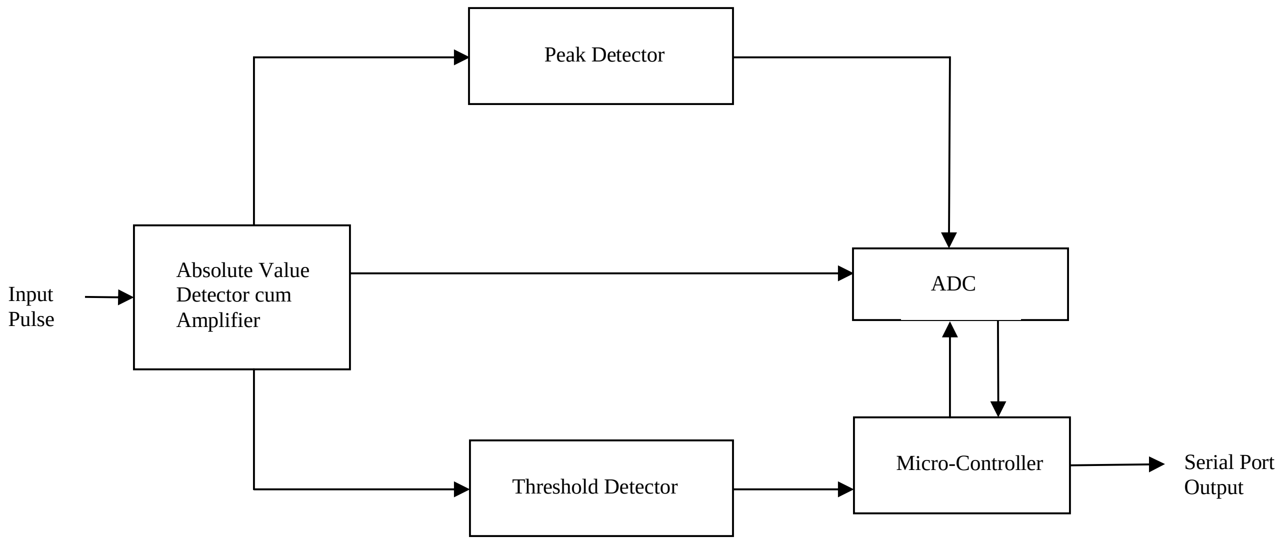



**Fig 1 – Block Diagram**

The design approach used is to partition the circuit into two parts – Analog and Digital. The analog part consists of the Absolute Value cum Phase Detector, Peak Detector and Threshold Detector from Fig 1 above. The digital part consists of the ADC and Microcontroller from the above figure. The input signal is provided to the absolute value detector acting as a precision rectifier which also acts as a preamp. The Peak detector constantly determines the peak value of the input signal, and stores it till the next maxima is obtained. The threshold detector filters out the noise from the signal. Finally, the processing and storage of data is performed by the microcontroller and ADC.

## 2. <u>Circuit Design</u>

### 2.1 Absolute Value Detector cum Preamplifier circuit:

PD pulses can be either positive or negative. However, the negative PD pulses need to be inverted since the rest of the circuit is unipolar. This is done by the absolute value detector implemented using OPAMP LM341. It provides a gain of +4 to positive pulses and -4 to negative pulses. Thus, the output of this circuit is unipolar. (Positive)

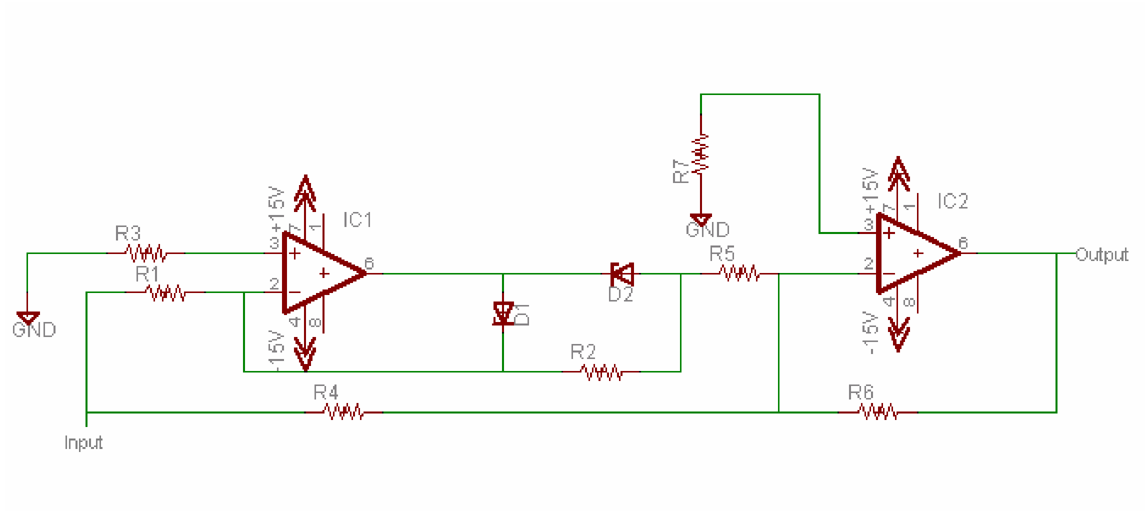
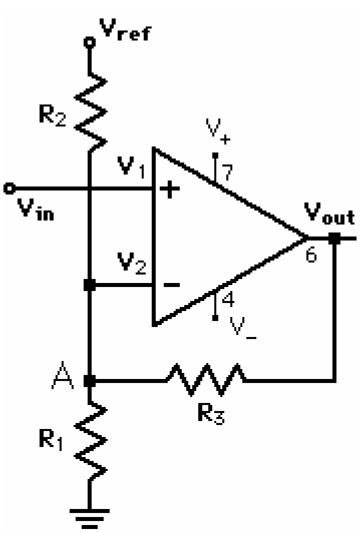



**Fig 2.1 – Absolute value circuit**

**Threshold Detector:**




$$v_2 = \frac{R_{123}V_{ref}}{R_2} + \frac{R_{123}V_{cc}}{R_3}$$

$$v_2' = \frac{R_{123}V_{ref}}{R_2} - \frac{R_{123}V_{cc}}{R_3}$$

**Fig 2.2 Threshold value detector**

The Schmitt trigger circuit given in Fig 2.2 acts as a threshold detector and qualified the pulses above the noise margin for detection. The noise margin is determined by varying the resistor values as shown in the figure. The comparator output is positive whenever the magnitude of the pulse appearing at its non inverting terminals is greater than the preset at its inverting one. This circuit also enables the microcontroller to provide a trigger to the ADC to start performing conversion. Some typical input output waveforms of the comparator are as follows:

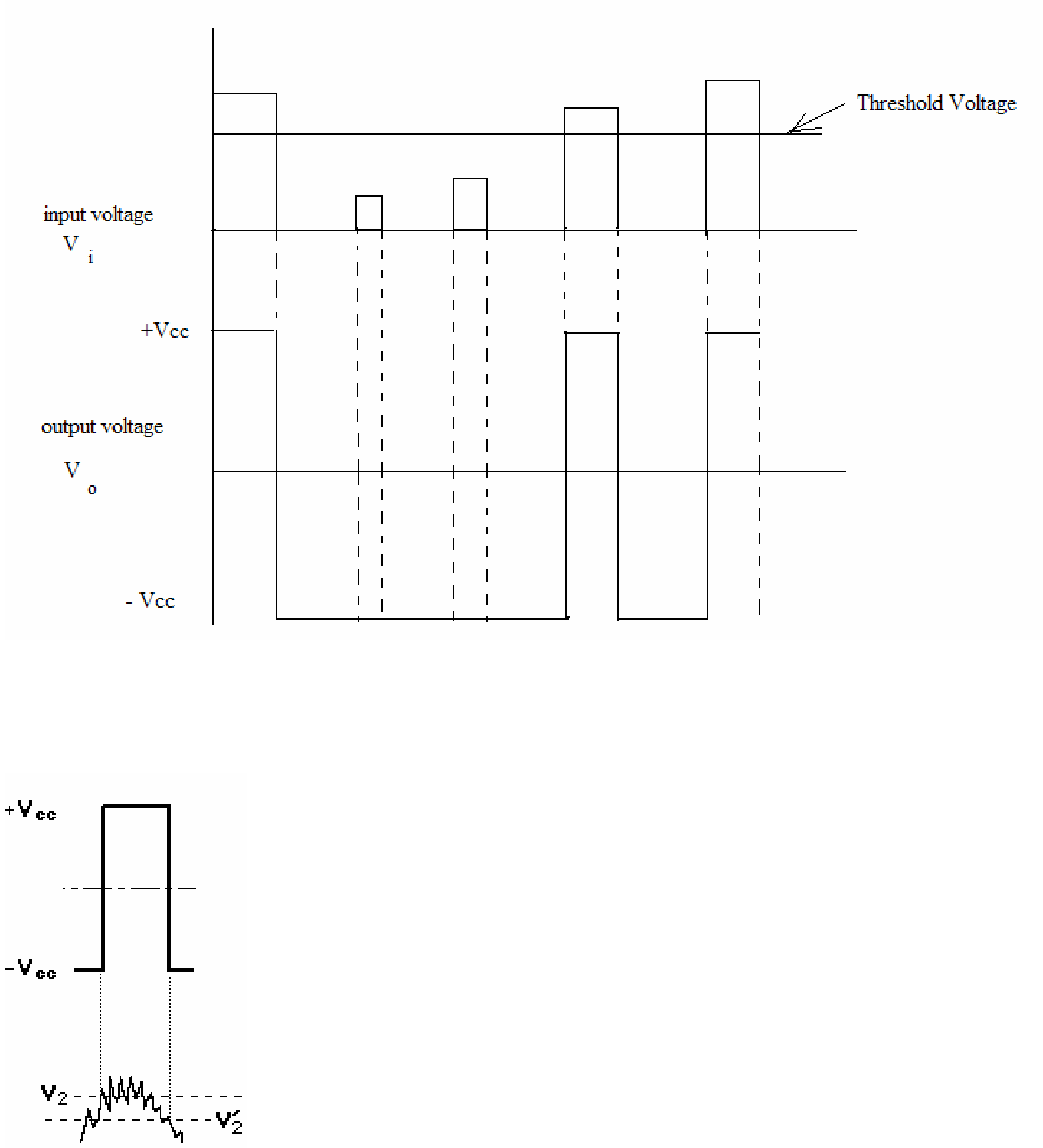



**Fig 2.3 Threshold detector waveforms**

**Peak Value Detector:**

The peak value detector circuit constantly determines the peak of the waveform and keeps it stored till the next peak is obtained. After sampling every pulse; once the threshold value is crossed again, the ADC samples this peak value and stores it in the microcontroller.

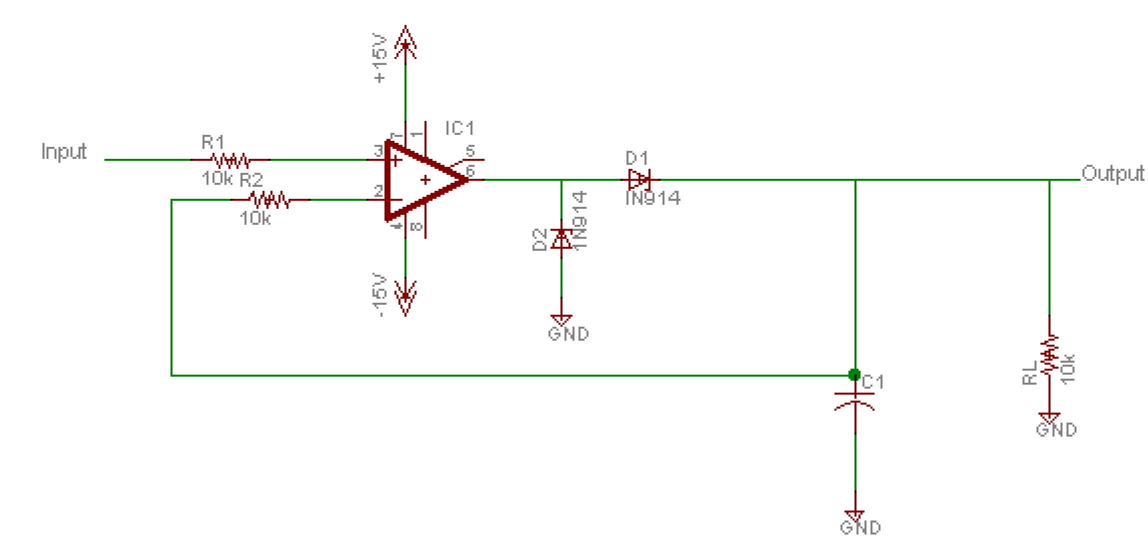



**Fig 2.4 Peak Value Detector**

### Analog to Digital conversion

The circuit makes use of the ADC 0809 IC to perform the task of analog to digital conversion. The ADC has 8 input channels, which are multiplexed internally using 3 address pins, viz. address A, B and C pins. The ADC requires an ALE signal to be given in order to enable the channel given by the address pins to be considered for conversion. This is followed by a start pulse for beginning conversion (SOC). The ADC then gives an EOC pulse when conversion has been completed and the data has been stored on the 8 latches connected internally to the 8 output pins ($2^{-1}$ through $2^{-8}$). This is then followed by waiting for the next SOC pulse, at which conversion as per the address stored in the address bits begins. The two channels used in the circuit are from the peak detector circuit (used to sample the peak value) and from the absolute value detector (used to sample the signal).

### Microcontroller role

The microcontroller used at the heart of the circuit is Atmel 89C52. This is an 8 bit microcontroller belonging to the 8051 architecture. The microcontroller begins by initially setting P2.0, P2.1, P2.2 high, which are connected to the address bits A,B and C of the ADC. This is followed by a high at P2.6, which is the Address Latch Enable (ALE) for the ADC. Then, the microcontroller continuously polls the input from the Threshold detector, and the ADC. Once the threshold has been crossed by the input signal to the analog part of the circuit, the pin P2.3, which is connected to the output of the threshold detector, becomes high, and this transition causes the microcontroller to give the start pulse to the ADC via the P2.4 pin, connected to the start terminal of the ADC. Then, the microcontroller continuously polls for a high at pin P2.5, which is in turn connected to the EOC pin of the ADC. This is followed by giving a high at P2.7, which is the Output Enable to the ADC. The 8 bit digital form of the input sample is then imported from port 1 of the microcontroller. The peak is sampled when the threshold detector output goes low. Suitable delay is provided to compensate for the 8 clock periods needed for approximation.

### 2.6 RS232 transmission

After every signal is sampled, the samples along with the peak are then to be transmitted to a Computer. This is achieved via the serial port. To avoid memory overflow, data is transmitted after every 200 samples in case the pulse has not ended in such a scenario (threshold detector is not low yet). Every pulse data is preceded by a header “FF 00 FF 00” (hex), followed by the count, say n; which is followed by [n-1] samples and the peak as the $n^{th}$ sample. Footer may also be included in the data if needed.

## 3. Status of report

The circuit has been conceptually implemented. Future scope for working on the project, involves scaling the model for a higher speed of operation, and real time processing of data to calculate the required partial discharge.

## 4. Acknowledgement

We would like to thank Prof. S. V. Kulkarni and Mr. Chetan Kulkarni for their constant guidance all throughout the project.

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