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High Speed Peak Detection

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Abstract— peak-detector circuits are used in many applications such as amplitude measurement, automatic gain control, and data regeneration in Electronics. We can build a simple and fast peak detector from a serial diode and a shunt capacitor, but it suffers from serious inaccuracy due to the diode's forward-voltage drop. The peak detector monitors a voltage of interest and retains its peak value as its output. The circuit gives a DC output voltage that is the peak input voltage over a wide frequency range, with a very low ripple voltage and low harmonic distortion. In this paper peak detector is used to detect the maximum magnitude of a signal over a period of time.

For high frequency circuits we require to know the peak value of an input voltage waveform to compare it with reference value to improve the accuracy of the circuit. Simple peak detector circuits can miss the peak of sharp-peaked signals, which gives inaccurate value of the peak. These limitations are removed in the high speed peak detection circuit. The proposed solution improves both linearity and accuracy without compromising speed. This is accomplished by properly combining the output signal of simple peak detector and comparator. Results show the improvement in detection accuracy.

Keywords—Peak Detection, voltage drop, Analog switch, Reverse capacitance, depletion region, negative saturation, feedback

INTRODUCTION

High speed peak detection function is one of the important requirements in many applications, such as instrumentation and measurement. Peak detection circuits are mostly used in nuclear instrumentation. Peak detectors can be used to improve the effective conversion time of a high resolution spectroscopy ADC without compromising any other performance. Peak detectors also used to hold the value of the detected peak long enough for the quantization process [10]. The Multichannel Pulse-Height Analyser is the primary tool used in nuclear science to record the energy or time spectra available from nuclear radiation detectors. For pulse height analysis of various signals, no assumption can be made on the shape or on the timing of the pulses and therefore there is a requirement to detect and store the true amplitude of the peak. Peak detector circuits are also used in biomedical applications such as X-ray imaging where X-ray photon energy is determined by the detected peak amplitude. Peak detectors are used to obtain the peak voltage of the rapidly changing AC input signals.
Fast peak detectors requires amplifiers with high slew rate. This condition causes either a long overload, or DC accuracy errors. To support the high slew rate at the output, the amplifier must deliver large currents into the capacitive load of the detector which can results in amplifier instability with a large capacitive load, as well as change in the accuracy of the output voltage.

Peak Detector Circuit

1. Theoretical Peak Detector

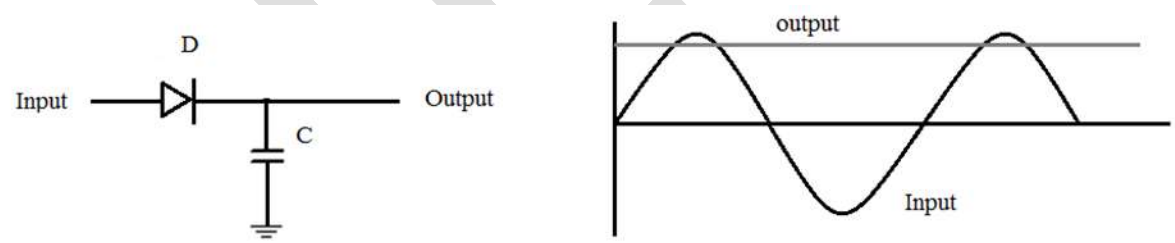
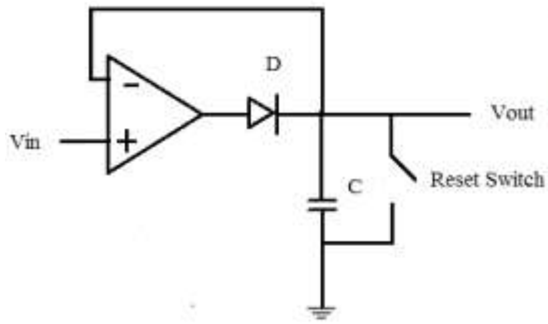


Fig 1. Typical peak detector circuit with input and output waveforms

Typical peak detector circuit is a series connection of a diode and a capacitor which gives a DC voltage equal to the peak value of the applied AC signal. An AC voltage source applied to the peak detector, charges the capacitor to the peak of the input. The diode conducts in positive half cycles, charging the capacitor to the waveform peak. When the input waveform falls below the DC "peak" stored on the capacitor, the diode is reverse biased, blocking current flow from capacitor back to the source. Thus, the capacitor retains the peak value even as the waveform drops to zero. Fig 1 graph shows that the output peak voltage is lower than the input peak voltage by approximately 0.7V. This represents the voltage drop across the diode

2. Practical peak detector circuit



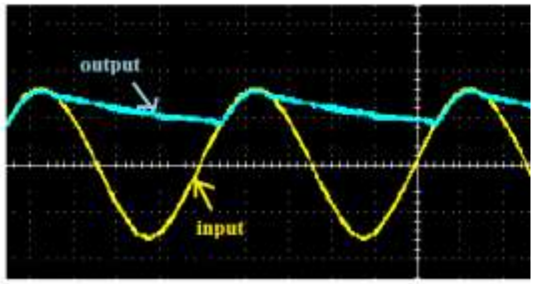


Fig 2.Practical peak detector circuit with input-output waveforms

Fig2 shows more advanced version of a peak detector that eliminates the voltage drop across the diode discussed above. In this circuit op-amp is used with peak detect diode in the feedback loop of op-amp. Fig 2 graph shows that we eliminate the voltage drop across diode. This circuit will work well for slow signals. However, it does not work well for fast signals.

Working of the practical peak detector circuit:

The diode conducts in the positive half cycles, charging the capacitor to the waveform peak. When the input waveform falls below the peak stored on the capacitor, the diode is reverse biased, blocking current flow from capacitor back to the source. Thus, the capacitor retains the peak value even as the waveform drops to zero. Therefore we require the reset switch to discharge the capacitor. When switch is closed capacitor can discharge through this path. The switch can be operated such that, the peak is held for some time before it discharges, so as to make sure that the system does not miss out any peak and detects its amplitude with greater accuracy.

There is, however, a fundamental problem with this simple circuit is that when the input signal is less (more negative) than the voltage being held on the capacitor, the diode will be reverse biased and the output of the op amp will be disconnected from the inverting input terminal. The op-amp in this case have no negative feedback and causes its output to saturate at the negative supply rail. When the input voltage again becomes more positive than the voltage held on the capacitor, the output moves out of saturation to detect next peak so the response time of the amplifier will be affected. The circuit may not respond properly to fast, for short duration positive peaks in the input signal.

This limitation comes from the op-amp going into saturation during negative cycles of the signal. This can be overcome by tracing the input voltage while the op-amp remains in the active region, without going into saturation during negative cycles of the signal.

Modified peak detector circuit

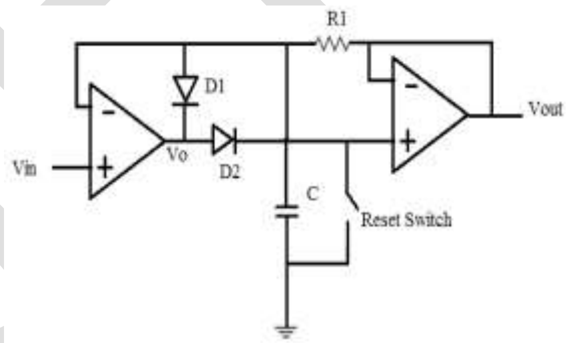


Fig3: Modified peak detector

The limitation of the practical peak detector can be removed by the modified peak detector. The operation of Diode D1 and Buffer Op-amp prevents First Op-amp from going into negative saturation and allows Op-amp to always operate in the active region, which allows peak detection of fast signals.

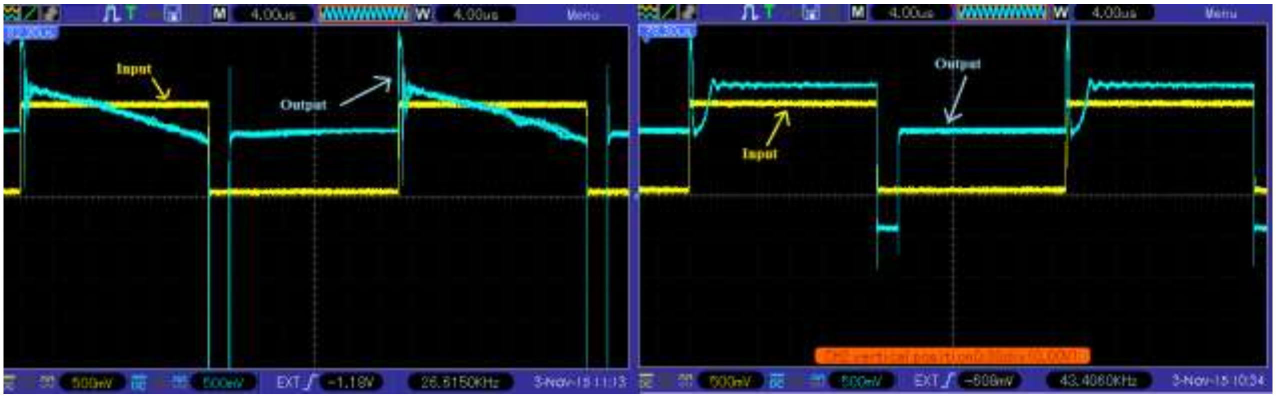


Fig4: Negative saturation of the Practical peak detector and Modified peak detector

Working of modified peak detector:

The diode D2 conducts in the positive half cycles and D1 becomes reverse biased, charging the capacitor to the waveform peak. When the input waveform falls below the peak stored on the capacitor, the diode D2 becomes reverse biased and D1 becomes forward biased, here diode D1 prevents the op-amp going into negative saturation by feedback path and diode D2 prevents the capacitor from discharging.

When switch is closed the capacitor start discharging through the closed path of switch and diode D2. This leads to diode D2 acts as a capacitor (reverse capacitance), due to the presence of reverse biased voltage. The reverse capacitance of the diode arises when the D2 is in reverse biased condition causes the majority charge carriers to move away from the junction, so the thickness of the depletion region increases with the increase in reverse bias voltage. Increase in reverse biased voltage causes increase in reverse capacitance. To solve this problem we need to reduce the reverse biased voltage across the diode D2.

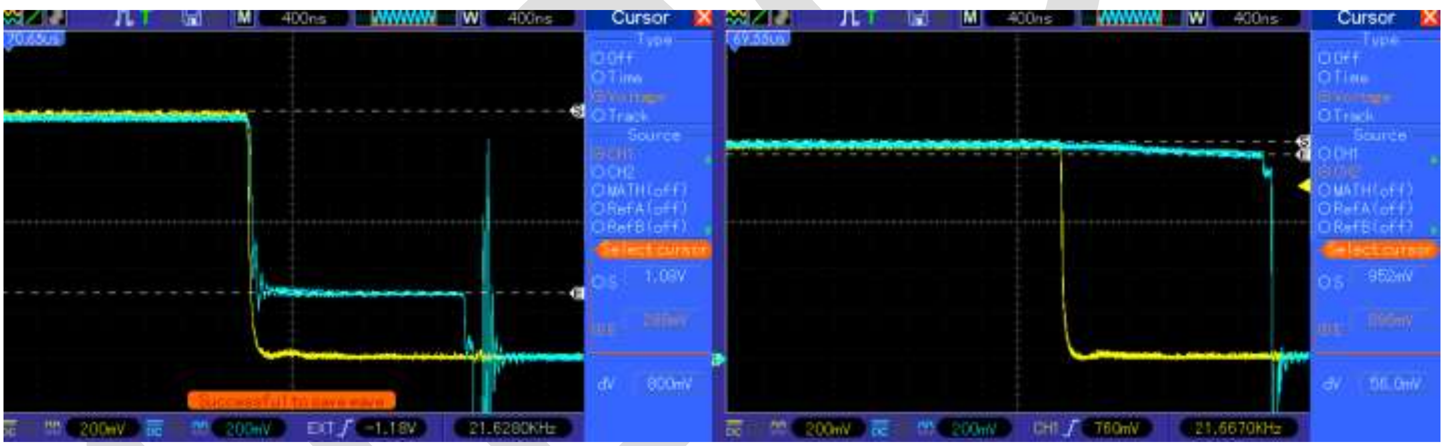
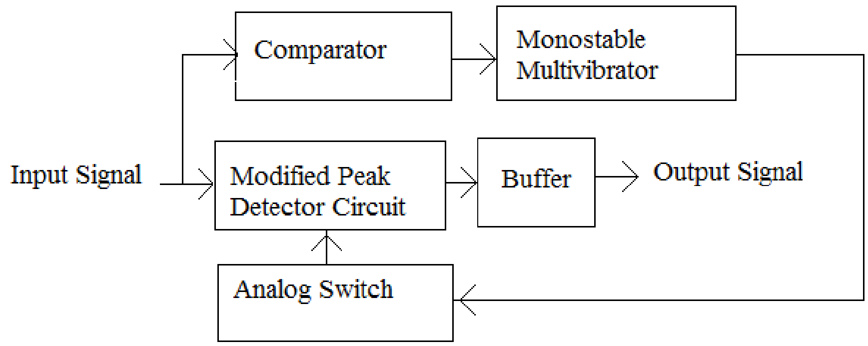


Fig5: Output of the Practical peak detector and Output of the Modified peak detector

On comparison of these outputs we can see the modified peak detector gives more precise output.

Block Diagram of High Speed Peak Detector

Occurrence of the pulse is detected by the comparator. Comparator compares input signal with reference voltage and its output drives monostable multivibrator. Using monostable multivibrator switch is operated. When pulse is detected switch will be open, diode will be in the forward bias and capacitor starts charging until its peak value. The diode conducts in the positive half cycles, charging the capacitor to the waveform peak. When the input waveform falls below the peak stored on the capacitor, the diode is reverse biased, blocking current flow from capacitor back to the source. Thus, the capacitor retains the peak value even as the waveform drops to zero. Therefore it is required to reset switch to discharge the capacitor. When switch is closed capacitor can discharge through this path. Another view of the peak detector is that it is the same as a half-wave rectifier with a filter capacitor added to the output.



Block diagram of high speed peak detector

EXPERIMENTAL SETUP

The designed peak detector has been experimentally characterized and the performance has been evaluated. The Fig shows experimental setup of the Peak detector circuit.

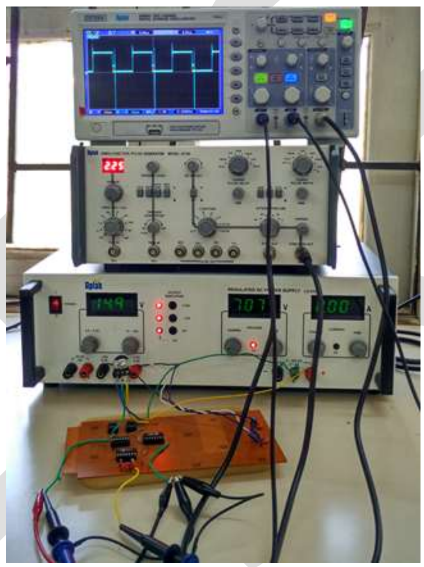


Fig.6 Experimental setup

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CONCLUSION

Peak detector circuits are important to obtain the peak value of the rapidly changing AC input signal. In this paper a comprehensive and systematic overview of the basic peak detector circuit is presented. By using the basic peak detector circuit design different setups are designed and their outputs are observed. Experimental setups are made on general purpose PCB and the outputs are observed on digital storage oscilloscope.
In this paper, the main limitations of traditional peak detectors have been theoretically analyzed and discussed. The reduction of negative saturation voltage gives a beneficial effect on its accuracy. This is accomplished by properly combining the output signal of simple peak detector and comparator. Results showed significant improvement in detection accuracy and linearity, for a wide class of input waveforms.

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