Team E.E (Electrical Engineers) Peak Detector Network

Mason Larosa, Saif Elsaady, Abriana Poola, Ean Potter, Jaden Nahoi-Baricar

Arizona State University

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Instructor Pollat

Problem Introduction

Numerous practical uses of electrical engineering exist and contribute to a better world. An example of one of the multitude of instruments built by electrical engineers is a peak detector network. Destructive testing is where the peak detector is used. Peak detector networks are employed for measuring instrumentation, mostly in amplitude modified wave telecommunications. Peak detector networks are frequently used in sound measuring equipment. An electrical circuit known as a peak detector is used to identify the peak level of an input signal. It is frequently employed in applications, such as sound processing or systems for radio communication, where it is important to ascertain the highest possible frequency of a waveform during a specific period of time. The team's creation of a peak detector network aided in the understanding of the real-world applications of the peak detector network. The team's rationale for the development of the peak detector network is shown below.

I. <u>Peak Detector Network Rationale</u>

- Be able to capture the extreme point of a voltage signal at its input.
- Be able to capture the positive point of the input signal.
- Be able to capture the negative point of the input signal.

The purpose of this final design project is the development of a peak detector network. As a team, the group was able to develop a prototype that aids in tackling real world applications. The team was able to demonstrate its importance in the use of scientific equipment and audio measuring instruments, which is particularly crucial in tackling real world applications. The need for this project is that the team wants to be able to capture the extreme value of the voltage signal at its input. The need for this is connected to real world applications and potential future implementations that this developed peak detector network can provide going forward. The peak detector generates a DC voltage that is equivalent to the peak value generated by the utilized AC signal through a series connection of diodes as well as a capacitor. This project's value lies in its ability to confidently measure numerous aspects of a signal, such as the positive, negative, and voltage input points, as well as confidently address various real-world problems (audio measuring, etc.). The contribution of each team member throughout this project is documented below:

II. Team Member Contributions

A. Saif Elsaady, led the research about real world applications and wrote and edited the final report.

B. Mason LaRosa, used the Analog Discovery to generate the waveforms and find the measured voltage values during testing.

C. Abriana Poola, researched the parts necessary to construct the prototype and final circuit as well as work on the presentation slides.

D. Ean Potter, constructed the circuit using MultiSim and built the prototype and final circuit while also helping with the testing and calculations of data.

E. Jaden Nahoi-Baricar, helped with researching background information as well as writing the final report and presentation.

Problem Statement

A peak detector network is an essential part of numerous electronic circuits, and its use is frequently necessary for accurately determining peak signal amplitudes. A peak detector network may be required in a specific application for a number of reasons. The need to precisely quantify a signal's peak amplitude is among the most popular justifications. A signal's peak level may be employed to calculate the ideal gain or volume levels in particular applications, such as audio or video machinery, where knowing the signal's peak level is critical. To collect and hold a peak signal for a predetermined amount of time is another reason why a peak detector network can be necessary. This is especially helpful in situations when it's important to determine and assess the peak signal's properties over a predetermined time frame. Team E.E (Electrical Engineers) successfully developed a peak detector network in order to determine and assess different signals properties over a particular time frame. The development of this peak detector network aided in tackling real world applications concerning signal processing.

I. Development Reasoning

A. To precisely quantify the peak of a signal.

B. To maintain the peak signal for a predetermined amount of time, enabling a more thorough examination of the signal's properties throughout time.

C. To clean out undesired noise or imperfection from signals in order to optimize them.

D. To have more design latitude when modifying the circuit to satisfy certain application needs.

E. In order to prepare the signal for further processing, such as filtration, amplification, or conversion.

Team E.E. (Electrical Engineers) created a peak detector network and now has a useful tool for various electrical applications that require precise detection of peak signal amplitudes and analysis. It allowed Team E.E (Electrical Engineers) to adapt it to their particular requirements and have more control regarding the circuit's performance. The scope of this project is to be able to develop a peak detector network that functions efficiently under different constraints such as a deadline and limited budget. The project was deemed successful as the peak detector network was able to monitor particular signals under particular constraints and deadlines. The magnitude of the project is shown below.

II. Magnitude

Item	Quantity	Price
Operational Amplifier	2	Provided
LED Pack	1	Provided
Batteries	2	Provided
Wires (big sized)	1	Provided
Resistors Pack	1	Provided
Peralta Lab Briefcase	1	Provided

Table 1. Project Magnitude

Engineering Goals

In order to successfully build the peak detector network, the team had to understand and develop particular goals to set a standard of success. The goals that the team came up with are significant because they offer an unambiguous blueprint for the creation of a peak detection network system. Without explicitly stated technical objectives, it is challenging to guarantee that the final peak detection network system will match the specified performance and operational criteria. By specifying precise performance and operational needs and guaranteeing these goals are accomplished, these goals assisted to improve the quality of the finished product. Additionally, it helped in anticipating potential problems early in the process of construction and design and taking proactive measures to address them.

I. Engineering Goals

   A. To be able to develop a peak detector network that performs well under a variety of constraints, including a strict deadline and a limited budget.

      1. Project delivered by April 25, 2023.

      2. Operation with resources illustrated in *Table 1*.

   B. To be able to precisely identify and determine the input signal's peak voltage, guaranteeing that it offers a reliable demonstration of the signal's maximum amplitude.

   C. To be able to deliver a high level of accuracy, guaranteeing that the tracked peak voltage is both within the desired range of values and satisfies the necessary requirements.

D. To be able to operate for long periods of time without depleting the power source thanks to its low power consumption, which qualifies it for low-power applications.

E. To be able to have low noise, making sure that it accurately represents the input signal's peak voltage without adding more noise or deformation.

A peak detector network's overall objectives include precisely measuring and holding the greatest or peak amplitude of an input signal while also ensuring quick response times, high accuracy, low noise levels, and low power consumption. These objectives are essential to the accomplishment of the peak detector network engineering project since they helped to make sure that the finished system will satisfy the requirements of the project parameters, be resource-efficient, be of high quality, and minimize risk.

Specifications

The peak detector network project developed by the team needed to be planned out to perfection, and the team was undoubtedly able to achieve this. Team E.E's (Electrical Engineers) project specifications are listed below.

I. Objectives

   A. Develop a peak detector network that detects peak signals within the appropriate parameters and standards.

   B. Perform successful prototyping of the peak detector network.

   C. Test the functionality, performance, and usability of the peak detector network and ensure it meets appropriate successful standards.

II. Constraints

   A. A 4 week time frame to deliver the project.

   B. A limited budget as well as number of resources.

III. Deadlines

   A. By April 27, 2023 the final project documentation must be delivered.

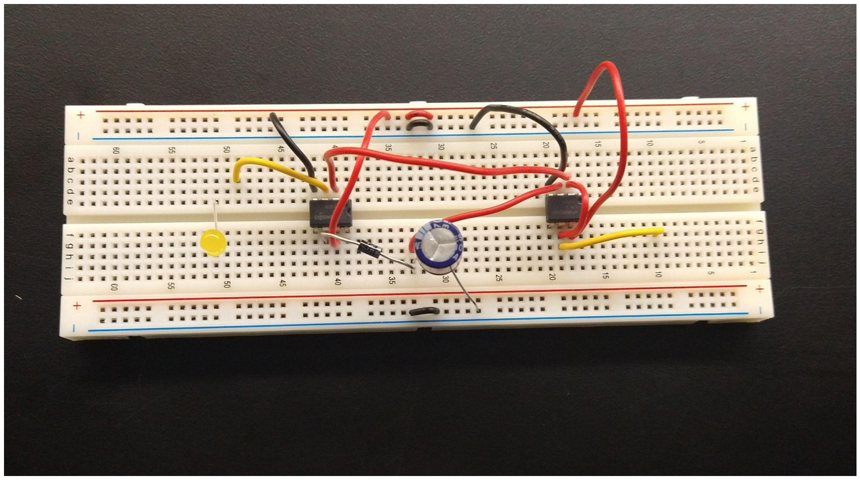
IV. Expectations

   A. To be able to specifically identify and determine the input signal's peak voltage, ensuring that it provides an accurate illustration of the signal's maximum amplitude.

   B. To be able to deliver data with a high degree of accuracy, ensuring that the peak voltage tracked is both within the desired range of values and meets the necessary standards.

Design Solutions and Evaluations

Design I.



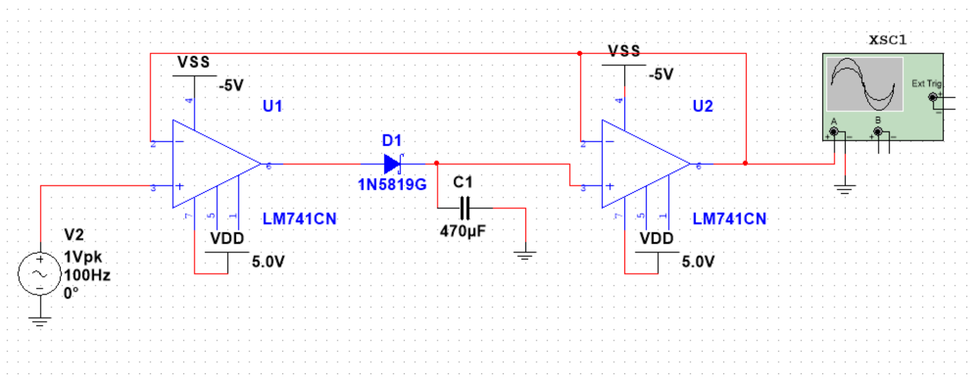
I. Attributes

A. For this peak detector network project, the physical prototype of design I. features a high input impedance to prevent loading the input signal and affecting its amplitude. The time constant of the circuit and the speed during which the capacitor charges and discharges depend on the capacitance value of the capacitor employed in the peak detection network of design I. The peak detector network's power consumption is sufficiently low to reduce the system's total power utilization. The peak detection network maintains performance across a wide range of operational temperatures considering its strong temperature stability. The design's dimensions and price meet the necessary requirements while being as small and inexpensive as possible.

II. Drawbacks

A. The capacitor's constant of time alongside the frequency of the source signal set an upper bound on design I's reaction time. The high-frequency signals can overlook peaks or not react soon enough due to long reaction times. The design's capacitor's sensitivity is temperature-dependent. This may have an impact on the peak detection's consistency and precision throughout an extensive spectrum of operational temperatures. Design I. may be vulnerable to noise, which might reduce peak detection performance and result in erroneous triggering. The component tolerances employed determine how accurate the peak detection network will be. Errors in the peak detection may be caused by variations in the component values.

Design II.



I. Attributes

A. The highest frequency of the signal being supplied that can be collected depends on the sampling ratio of the digital converter employed by design II. Peak detector signals at higher frequencies can be captured with a greater sampling rate. The amount of bits required for expressing the input signal depends on the design's resolution. The amplitude peak of the input signal may be captured more accurately with a greater resolution. When compared to analog circuits, the peak detector network can be more versatile and changeable thanks to digital signal processing methods. Due to the versatility of this design, many algorithms may be used for multiple purposes, and the peak detector can be quickly incorporated into an expanded digital signal processing system. In comparison to an analog circuit, a peak detector network constructed digitally can offer more accuracy, noise immunity, and adaptability.

II. Drawbacks

A. Without a doubt, design II. is susceptible to quantization error, which may reduce the precision of peak identification. The amount of quantization error is determined by the AD's resolution, which may be decreased by raising the degree of resolution. Due to the time needed to capture the signal, carry out the signal's digital analyzing, and output the result, design II has a processing delay. In situations where real-time peak identification is essential, this delay may be troublesome. In comparison to analog circuits, design II. required more complicated design and implementation. It requires familiarity with digital signal processing methods and can call for extra parts.

Final Design

The final design is illustrated below under *Figure 1.*

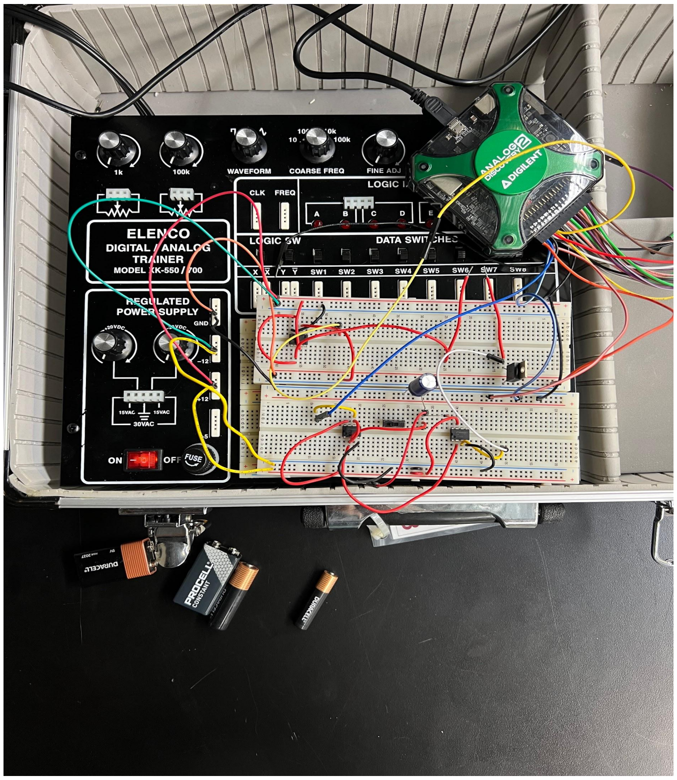


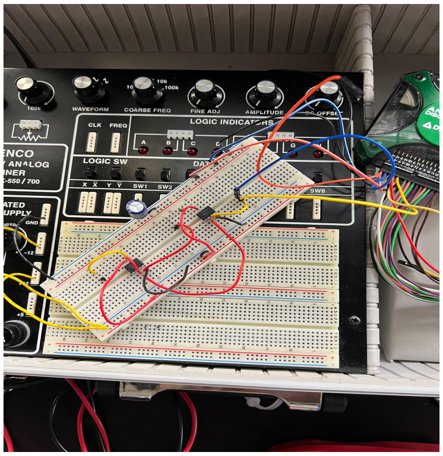
Figure 1. Final Design

This final design decision was made with the intention of operating within the input signal's frequency range. Throughout this design, the circuit structure and component selection will be based on the frequency spectrum of the signal range. The originating impedance of the input signal is matched to the input impedance of the peak detecting circuit throughout the whole design. By doing so, signal reflections are avoided and the peak detector circuit design receives the greatest amount of signal strength. The input signal level is able to be handled by the peak detecting circuit without distortion or saturation. The signal level will determine the components. The final design's component costs were reasonable as well as complied with the application's budgetary constraints. When choosing a peak detector network's final design, it was important to strike a balance between many aspects in order to get the optimum performance, precision, pace, and cost-effectiveness for the application at hand.

The team's justification for choosing a final peak detector network design based on characteristics and imperfections of earlier implemented designs is that it enables a more effective decision making process. The team was able to determine which aspects of the design worked effectively and those that did not by analyzing the advantages and disadvantages of earlier revisions. The group was successful in creating a new design that fixes the drawbacks of earlier designs while keeping their benefits, as shown in Figure 1. The most important qualities that a peak detector network should have were determined through the evaluation of earlier designs. Precision, and response time were some of these qualities. Analyzing the shortcomings of earlier designs made it easier to spot potential problems that might occur while developing a new design. The team was able to prevent these problems and guarantee that the new design is solid and trustworthy by being aware of these drawbacks. The group made sure the final design satisfied the needs of the intended application and corrected previous designs' flaws while preserving their advantages.

Testing

I. <u>Prototype Testing</u>

A. 

B. The prototype testing worked well and displayed the signal readings throughout all three peak levels. This test was deemed successful.

C. This prototype testing procedure provided some evident results and improvements that needed to be addressed throughout the testing process. The testing process and design could have been improved in several ways, but a few ways can be building a follow-up circuit to see if the Peak Detector works for actual circuits, switching several resistors and wires, and conducting testing with batteries which will be deemed successful if the internal resistance is low.

II. <u>Battery Testing</u>

A. 

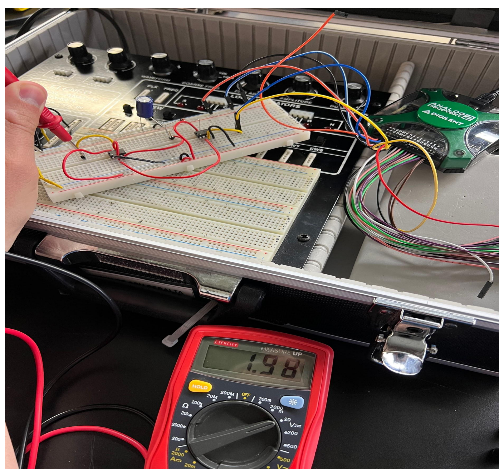

B. During the battery testing of the peak detector network, the peak detector circuit's functionality was evaluated. For battery-operated operations where the circuit must function dependably for a set amount of time, this kind of testing proved to be crucial. In order to make sure that the circuit performs consistently during the anticipated battery life and is appropriate for the intended usage, the peak detector network battery testing was a crucial stage in the process of finalizing and developing the device.

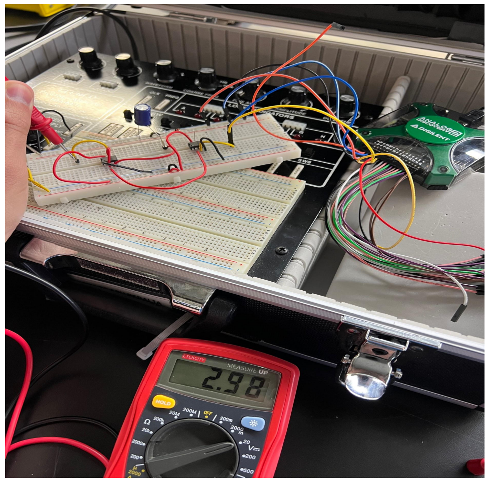
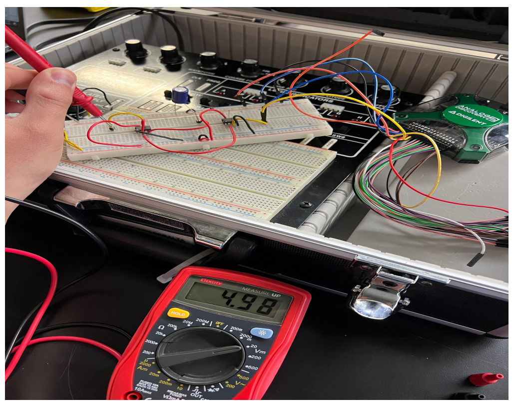
C.

	OLD AAA	NEW AAA	OLD AA	NEW AA	OLD 9V	NEW 9V
MEASURED VOLTAGE (V)	1.32	1.67	1.33	1.68	4.84	9.64
CALCULATED RESISTANCE (Ω)	14.19	12.03	13.98	12.8	34.48	10.2

III. <u>Input Testing</u>

A.

Testing #	Graphic	Measured Value
1		1.98

2		2.98
3		4.98

B. The peak detector circuit's performance was tested with various input signals as part of the peak detector network input testing. To make sure that the circuit can reliably detect the highest possible amount of the input signal under different circumstances, this kind of testing was crucial. During the latter phases of the design process, it's crucial to test the peak detector network input to make sure the circuit can reliably identify the input signal's highest value under various situations and is appropriate for the intended application.

Project Evaluation

Overall, the peak detector network is considered a success as it can do the following: evaluate the internal resistance of a battery and be able to show data of peak detection through the analog discovery board. At the beginning, there was difficulty with getting the product to work as there were several obstacles that prevented the group from getting data. These range from wires needed to be in different locations and having to go through several batteries to find a few that have low enough voltage that we can get data from. Additionally, receiving data was one of the few challenges the group faced as the analog discovery board was finicky on where the group needed to put the probes on the circuit board. Despite that, the group was successful in getting the data that is required to prove that the peak detector network was working.

Due to particular requirements of the developed project, there were numerous justifications for design changes made to a peak detector network within certain constraints. It took a great deal of research and experimentation over the course of the project to justify the design changes from the original design. One of the biggest modifications from the original design the group did was creating a second circuit board as a follow up to actually make sure the peak detector was working. When the follow-up circuit board was created, the group included a switch on that as well as a way for the capacitor to recharge so that the network can reset for new data. The peak detection network's output was changed and buffered in order to operate certain requirements. In conclusion, a peak detector network's design alterations are often justified by the requirement to increase accuracy, reaction time, and other components.

Summary, Conclusions, & Discussion

Electrical engineering has many real-world applications that make the world a better place. By creating a peak detector network, Team E.E. (Electrical Engineers) were able to put the practice of electrical engineering to use. Measurement equipment, primarily in amplitude modified wave telecommunications, uses peak detector networks. Equipment for measuring sound frequently employs peak detector networks. The peak level of an input signal is determined using a peak detector. The development of a peak detector network by the team contributed to a better understanding of the peak detector network's practical uses. Team E.E (Electrical Engineers) used a variety of steps from the engineering methodological process to build the peak detector network successfully throughout the project. To address the current situation, the team identified a problem and created a problem statement. In order to identify and evaluate various signal properties over a specific time period, the team developed a peak detector network with success.

The creation of this peak detector network facilitated the handling of practical signal processing applications. The peak detector network's ability to track specific signals within set parameters and deadlines led to the project's success. In order to ensure that the finished system will meet the project parameters, be resource-efficient, be of high quality, and minimize risk, the team developed objectives that were crucial to the success of the peak detector network engineering project. After creating two prototypes, the team decided on one to use as its final design. After that, the team conducted testing then later on evaluated the project. The project was undoubtedly successful. The importance of this project was that it enabled us to handle practical signal processing applications, as well as identify various signal properties throughout a given period of time.

The purpose of this project was to be able to record the extreme point of a voltage signal at its input, as well as the positive and negative points of the signal. This final design project's goal is to create a working peak detector network through prototyping and choosing an ideal design. The main design points for the peak detector network are shown below:

I. Main Design Points

There are plenty of real world applications for the developed peak detector network. There is a much bigger picture to the development of this network. A peak detector network's job in audio applications is to gauge a signal's peak level in order to avoid distortion. This can guarantee that the audio signal is being received at the proper volume for the intended use. A peak detector network's objective in instrumentation and measurement-related fields is to accurately determine a signal's peak amplitude. A peak detector network in data collecting systems aims to record and retain a signal's highest value for later analysis. Numerous applications, such monitoring environmental data or examining biological signals in medical research, can benefit from this. A peak detector network is used in control systems to identify the peak of a control signal and initiate a reaction, such as powering on an electric motor or opening a valve. Numerous applications, including robotics, process management, and automation, can benefit from this. There are numerous recommendations for the improvement of the peak detector network developed by the team. These recommendations for future work and potential considerations that should be considered are shown below:

I. Increasing Accuracy

A. This will enhance the peak detector network by increasing accuracy. This can be accomplished by utilizing high-quality parts, lowering incoming signal noise, or enhancing circuit construction.

II. Adjusting Time Constant

A. How fast the peak detection network reacts to modifications in the incoming signal depends on its time constant. The peak detection's precision can be increased by modifying the time constant.

III. Higher Sample Rate

A. The precision and conciseness of peak detection can be enhanced by increasing the peak detector network's sample rate. Using a quicker ADC or raising the circuit's frequency of operation will accomplish this.

IV. Adding Hysteresis

A. A method for avoiding inaccurate peak detection network activation is hysteresis. Hysteresis can be added to a circuit to lower noise and increase dependability.

These recommendations are listed because they can potentially modify the peak detector network to the next level. This will completely optimize the peak detector network and take it to a premium standard of performance as well as signal detecting reliability.

References

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