



# Study the performance of silicon multiplier detector with Amplifier in Oscilloscope

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## Introduction

The Alpha experiment at CERN is one of the important and advanced laboratories There are some examples of activities that can take place in the Alpha experiment:

1. Research and Development: Research and development teams in the Alpha Laboratory can engage in theoretical investigations, circuit design, production and optimization of laboratory prototypes, evaluation of performance and testing of new circuits and equipment, and assessment and improvement of existing technologies in various fields.

2. Implementation and Testing: This includes implementing electronic circuits and devices, setting up and operating laboratory equipment, and conducting testing and measurement related to circuits and electronic systems.

3. Software Design and Development: If there are projects in the Alpha Laboratory related to software and device control, software design and development teams can work on developing and enhancing the required software.

4. Reporting and Documentation: Alpha Laboratory teams may regularly document their experiment results and research findings in reports and technical papers. Additionally, they may prepare and update technical documentation, user manuals, and guides.

Alpha is a unique experiment at CERN that can produce anti-hydrogen atoms, hold them in a specially designed magnetic trap, and then manipulate these anti-atoms slightly. Trapping atoms helps scientists study them using lasers or other radiation sources. Antiprotons or positrons are easy to move and trap because they are charged particles. But when the two are combined to make neutral hydrogen, they become much more difficult to trap, so the scientists designed a very special magnetic trap that relies on the fact that antihydrogen is marginally magnetic.

Antihydrogen is obtained from the plasma combination of about 90,000 antiprotons and positrons, as a result of which about 25,000 antihydrogen atoms are produced. If the antihydrogen atoms move slowly enough, they can be trapped. By shining a laser beam (with a very precise and controlled frequency)

on the trapped atoms, scientists can observe the interaction of this beam with the internal states of antihydrogen. In this experiment, 1S-2S transition was observed. The 2S state in atomic hydrogen has a long lifetime that results in a natural width in the spectral line, so it is very suitable for precise measurements.

## Motivation

The aim of this project is to investigate the performance of a silicon multiplayer detector integrated with Amplifier in Oscilloscope.

The study involves both experimental and theoretical approaches to comprehensively assess the functionality and effectiveness of the detector system. By conducting experimental measurements and simulations, we aim to gain a deeper understanding of the detector's response to different input signals, varying scintillation materials, and impedance configurations.

The experimental part of the project focuses on constructing a prototype detector system and conducting controlled experiments to evaluate its performance. With the help of an oscilloscope, signals such as frequency and waveform can be visually observed. These experimental results will serve as a basis for validating the theoretical models and optimizing the system's design parameters.

## Basic information

The LMH6629 amplifier is a wideband operational amplifier produced by Texas Instruments. This amplifier is suitable for applications that require high-frequency signal processing and precise performance. Some features of this amplifier include:

- Wide bandwidth: The LMH6629 is capable of processing high-frequency signals and supporting a wide bandwidth.
- Differential input and output: It have differential input and output, providing better performance against noise and electromagnetic interference.
- High operating voltage: This amplifier operates with high supply voltages 2.7 v up to 5.5 v.
- Gain control: The LMH 6629 (WSON- 8 package only) has user selectable internal compensation for minimum gains of 4 or 10 controlled by pulling the COPM pin low or high, thereby avoiding the need for external compensation capacitor required in competitive devices.

- Applications: The LMH6629 is used in applications such as laboratory equipment, sensors, wireless communications, and audio synthesis

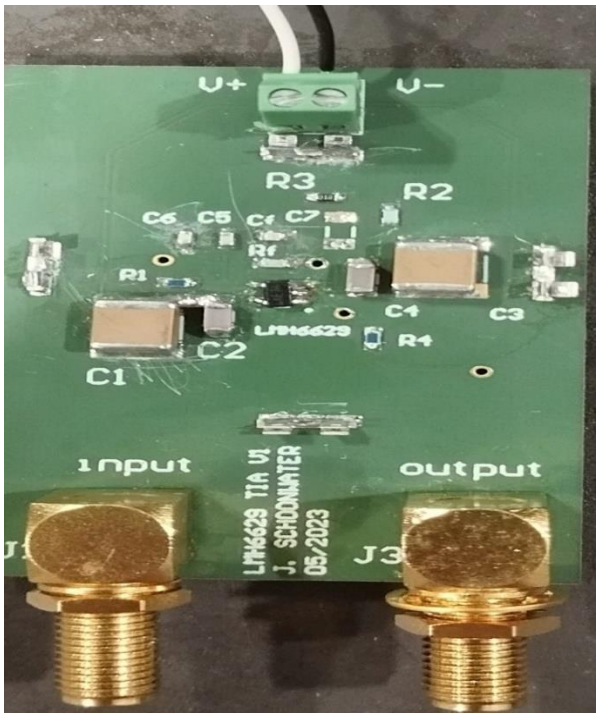



Figure 1: LMH6629 Amplifier

## Trans impedance Amplifier

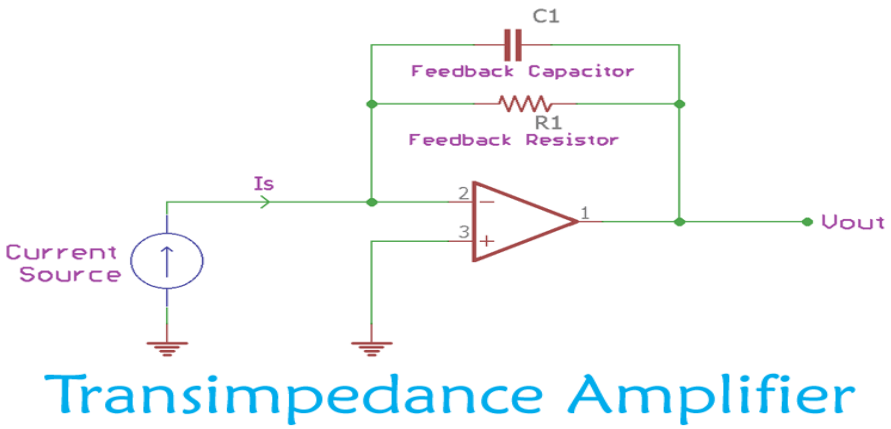



Figure 2: Transimpedance Amplifier

To explain in simple words a Transimpedance amplifier is a converter circuit which converts the input current to a proportional output voltage. As we know when current flows through a resistor it creates a voltage drop across the resistor which will be proportional to the value of current and the value resistor itself. Here, assuming the value of resistor to be ideally constant we can easily use Ohms Law to calculate the value of current based on the value of Voltage. This is the most basic Current to Voltage Converter, and since we have used a resistor (Passive element) to accomplish this it is called as a Passive Current to Voltage Converter.

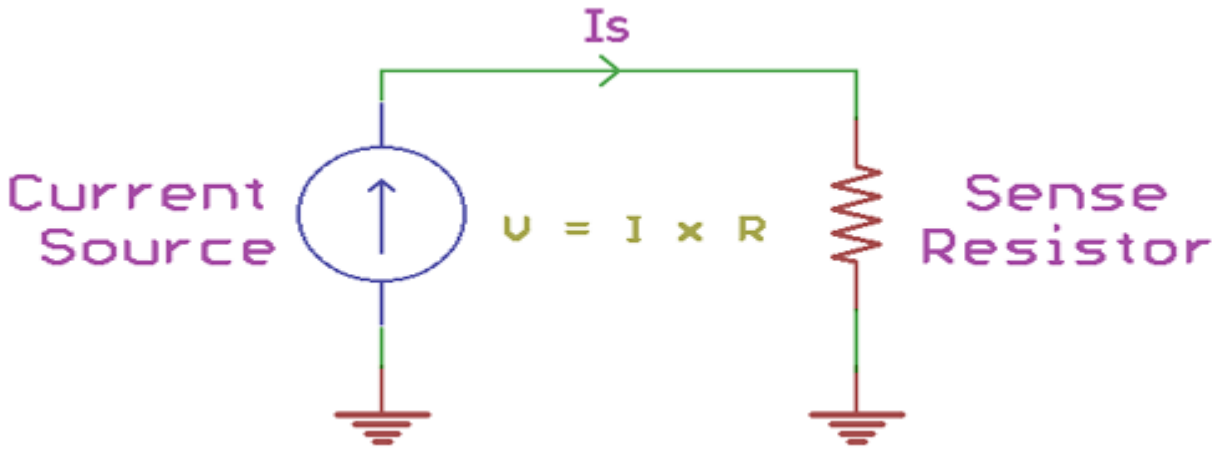
On the other hand, a Transimpedance amplifier is an active current to voltage converter since it uses an active component like Op-Amp to convert the input current to a proportional output voltage. It is also possible to build active I to V converters using other active components like BJTs, IGBTs, MOSFETs etc. The most commonly used Current to Voltage converter is the Transimpedance Amplifier (TIA), so in this article we will learn more about it and how to use it in your circuit designs.

## Importance of Transimpedance Amplifier

Now that we know even a resistor can be used to convert current to voltage, why do we have to build an active current to voltage converters using Op-Amp? What advantage and importance does it have over Passive V to I converters?

To answer that lets assume a photosensitive diode (current source) is providing current across its terminal depending on the light falling on it and a simple low-value

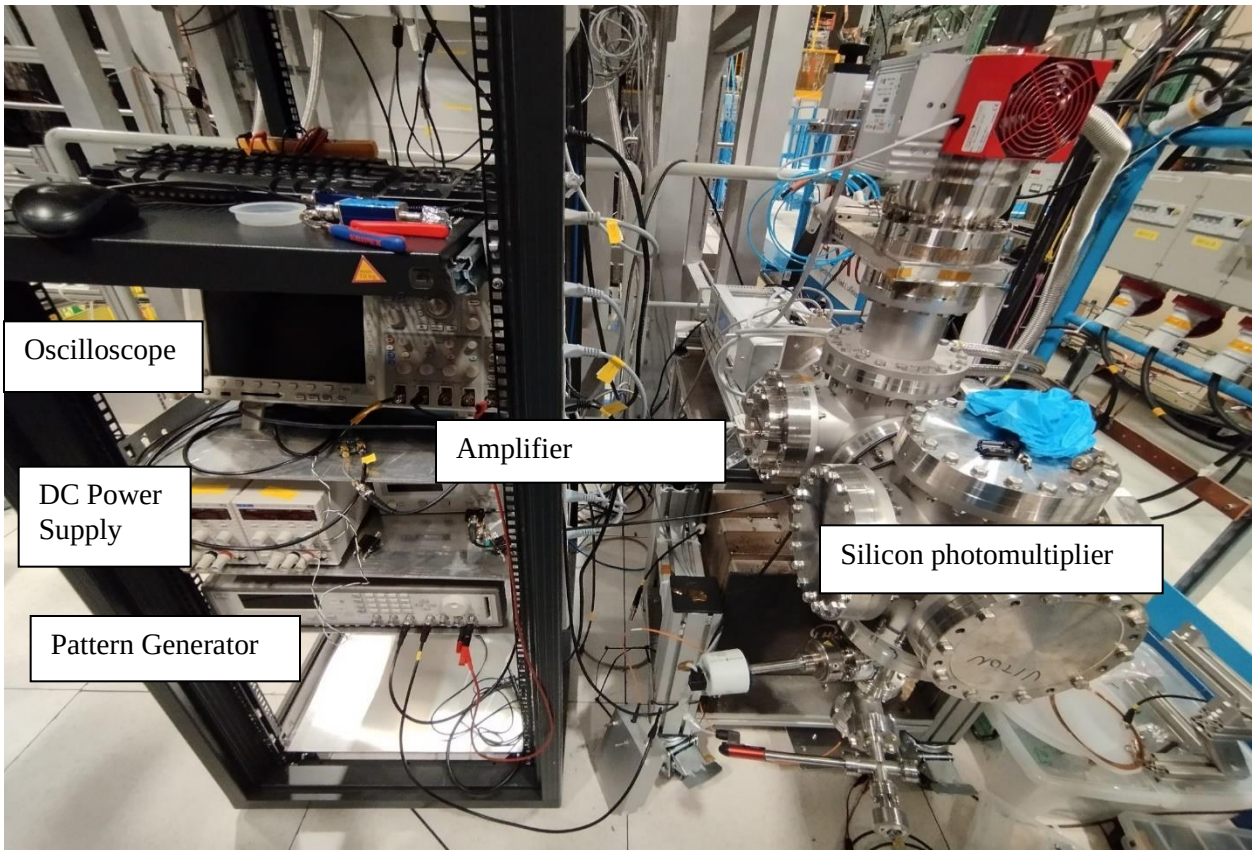
resistor is connected across the photodiode to convert the output current to a proportional voltage as shown in the image below.




The above circuit might work well by theory but in practice the performance will be decorticated because photo-diode will also consist of some unwanted capacitive properties. Due to this for a smaller value of sense resistor, the time constant (t) (t = sense resistance x Stray Capacitance) will be small and hence the gain will be low. The exact opposite will happen if the sense resistance is increased, the gain will be high and the time constant will also be higher than the small resistor value. This uneven gain will lead to an insufficient signal to noise ratio and the flexibility of the output voltage is limited. Therefore, to fix the poor gain and noise related issues, a Transimpedance amplifier is often preferred. Adding to this in a Transimpedance amplifier, the designer can also configure the bandwidth and the gain response of the circuit as per the design requirements.

## Method

To perform this test, we need the following devices, part of which can be seen in the figure.




## Result

1. we prepared the device as shown in the figure below and conducted tests in two stages for feedback capacitor of 1pf and 0.5 pf.
2. Coupling capacitors are essential components in amplifier circuits. They are used to prevent interference of a transistors bias voltages by AC signals. In most amplifier circuits, this is achieved by driving the signal to the base terminal of a transistor through a coupling capacitor.
3. A common op-amp circuit uses a feedback capacitor to limit the bandwidth, limiting op-amp bandwidth will reduce noise, so a feedback capacitor is a common way to reduce noise.
4. Larger value of capacitance provides better stabilization of the output voltage caused by the output load current transient.
5. In positive feedback, the feedback energy (voltage or currents), is in phase with the input signal and thus it. Positive feedback increases gain of the amplifier also increases distortion, noise and instability.

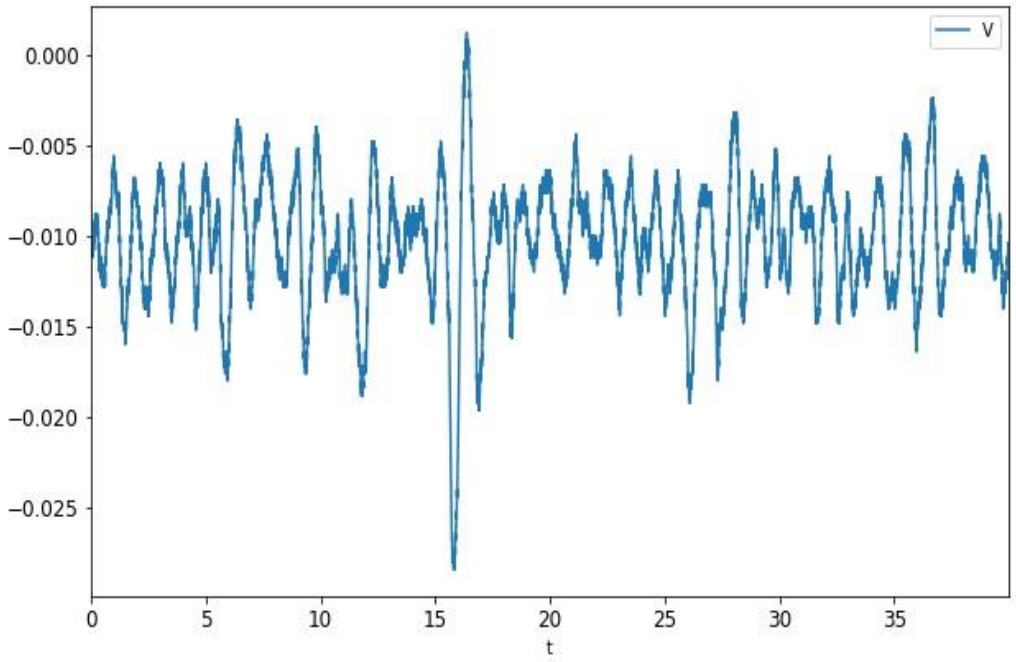



Figure 3: The resulting diagram with 3.9 voltage and 1 pf feedback capacitor

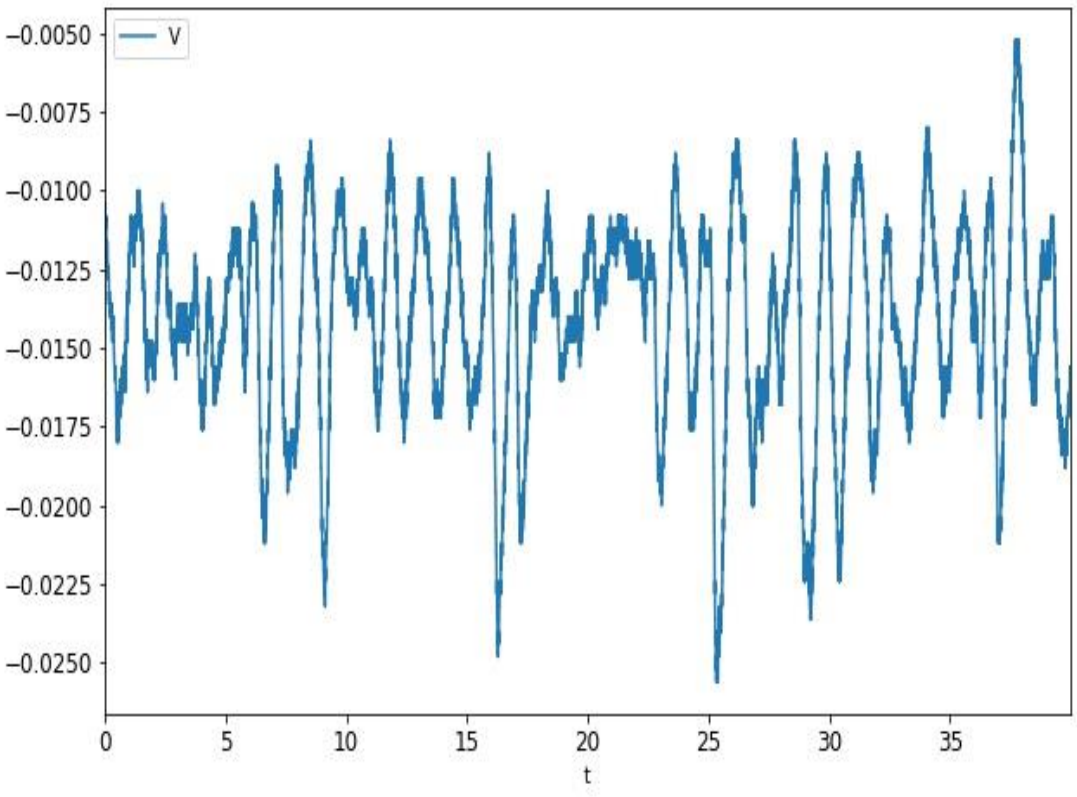


Figure 4: The resulting diagram with 3.1 voltage and 0.5 pf feedback capacitor

## Conclusion

- If this test is done for the second time, it will be recommending the amount of connecting line should be short in order to prevent noise and the amplifier parts should be installed more carefully.

## *Reference*


1. David E Johnson v. Jayakumar "Operational Amplifier Circuits Design and Application" January 1, 1982.
2. Texas Instruments, Op Amps and Comparators – Don't Confuse Them, SLOA067, Bruce Center, 09/06/2001