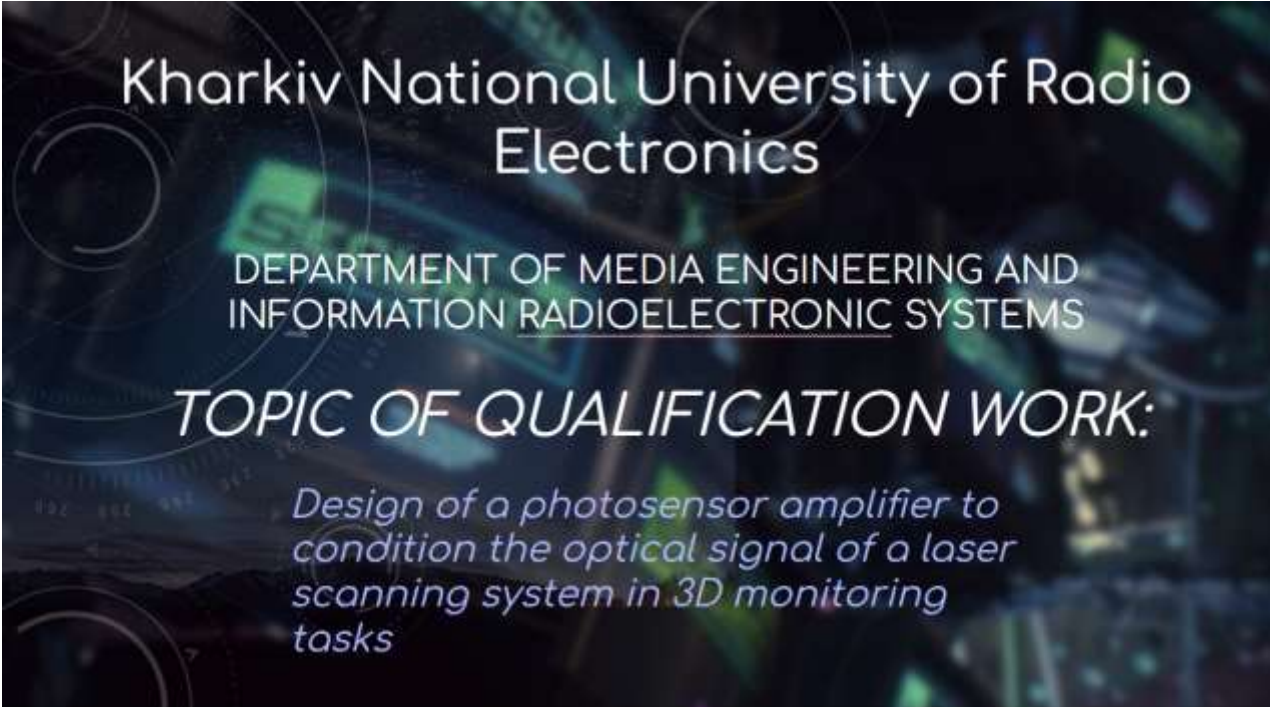


APPLICATIONS

APPLICATIONS A



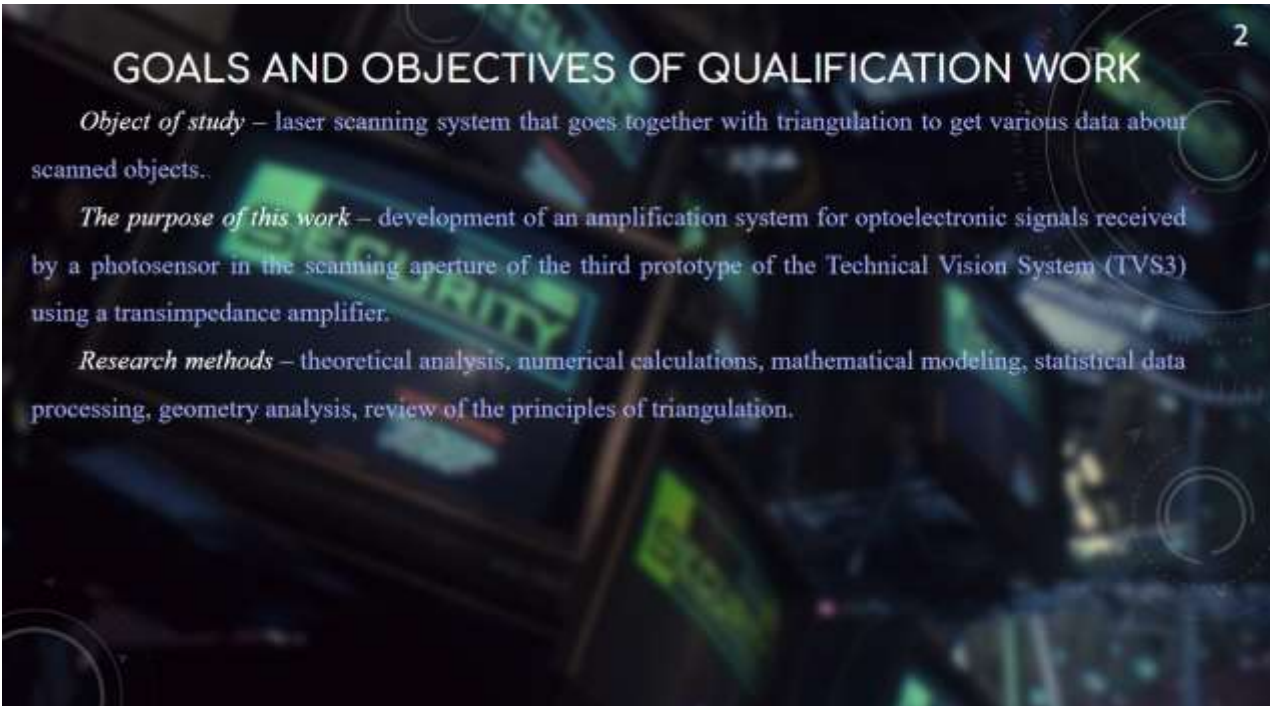
Kharkiv National University of Radio
Electronics

DEPARTMENT OF MEDIA ENGINEERING AND
INFORMATION RADIOELECTRONIC SYSTEMS

TOPIC OF QUALIFICATION WORK:

*Design of a photosensor amplifier to
condition the optical signal of a laser
scanning system in 3D monitoring
tasks*

Figure A.1 – Topic of qualification work



2

GOALS AND OBJECTIVES OF QUALIFICATION WORK

Object of study – laser scanning system that goes together with triangulation to get various data about scanned objects.

The purpose of this work – development of an amplification system for optoelectronic signals received by a photosensor in the scanning aperture of the third prototype of the Technical Vision System (TVS3) using a transimpedance amplifier.

Research methods – theoretical analysis, numerical calculations, mathematical modeling, statistical data processing, geometry analysis, review of the principles of triangulation.

Figure A.2 – Goals and objectives of qualification work

ANALYSIS OF EXISTING DEVICES AND SCANNING SYSTEMS IN 3D MONITORING TASKS

In order to perform laser scanning of any kind we first need to understand how light works. We also analyzed some of the prior examples of the device we're working on. One of the main principles of laser scanning is photo conductivity. Photoconductivity is defined as the change in the electrical conductivity of a material due to the action of incident radiation. Below are some graphical examples explaining the concepts further.

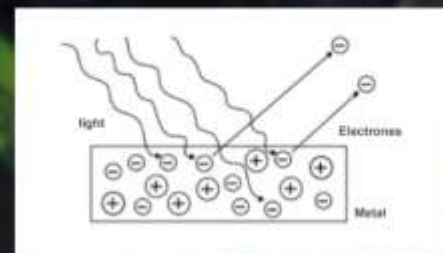
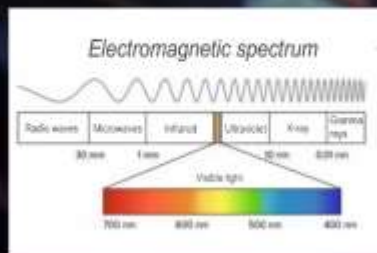


Figure A.3 – Analysis of existing devices and scanning systems in 3D monitoring tasks

How the signals are being received, filtered and converted.

Photo sensors

A photo sensor is an electronic component that detects the presence of visible light, infrared and/or ultraviolet light. Most photosensors consist of a semiconductor with photoconductive properties, in which the electrical conductivity varies depending on the intensity of the radiation reaching the material.



Figure A.4 – How signals are being received, filtered and converted

How the signals are being received, filtered and converted.

Signal filtering

Filtering consists of filtering the frequency spectrum of the signal, preserving only the useful frequencies, and separating the useful signal from the noise or blocking all the noise. Filters can consist of passive, active components or a digital algorithm. The passive filter uses only capacitors, resistors and inductors with the maximum gain, while, on the other hand, the active filter uses passive components in combination with active components such as operational amplifiers, resistors and transistors that use external power supplies and thus can amplify the input signal

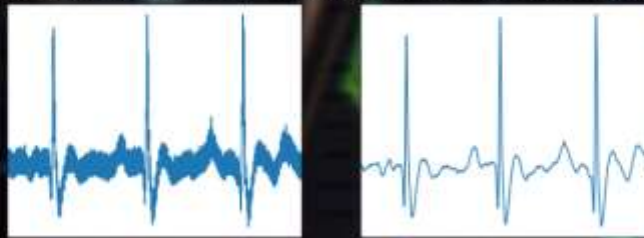


Figure A.5 - How signals are being received, filtered and converted

Use of laser scanning systems in the field of artificial vision

In the sphere of artificial vision, the systems of laser scanning are widely used in the works such as robotics, building, and geodesy. This kind of technology can be used for both manufacturing needs and scientific research. Both of the aforementioned require 3D coordinates of the surroundings they're working with.

That's where the triangulation comes in. Triangulation is a part of geodesy which is using mathematical methods for calculating different types of surfaces. The kind of triangulation we would need here is called dynamic triangulation which is basically two elements constantly moving and changing angles. The elements here are a laser pointer and a positioner which make an angle γ .

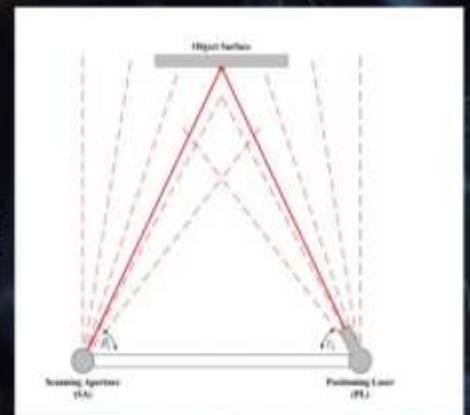


Figure A.6 – Use of laser scanning systems in the field of artificial vision

Use of laser scanning systems in the field of artificial vision

The positioning of the motors is done by the consecutive connection with the central microcontroller Arduino MEGA, which sends the instructions regarding the positioning in real time using the algorithm that allows to constantly control the location as well the speed of the motors. With closed control with rotary encoders and a precise LM629 controller, DC motors and servomechanisms are controlled by four-step adjustment of the step position, which allows precise control of the motor position.

This is all done with the help of a GUI which was programmed in LabView, where all the important information as well as the parameters of each and every controlled are being controlled.



Figure A.7 - Use of laser scanning systems in the field of artificial vision

Use of laser scanning systems in the field of artificial vision

How it operates

A triangle is used in many different working spheres, starting from navigation and ending with civil buildings because it presents us with very precise coordinates. Some examples include: positioning of a ship or a direction in which a tunnel or a road needs to be built. That being said, there are a lot of cases where the objects need to be scanned from a distance. This is all based on basic trigonometry, which uses at least one side and two available angles to calculate the remaining two sides and the remaining angle. In Figure 2.7 you can see how these angles are shown, followed by the equations that represent the equality of angles and the Law of sines

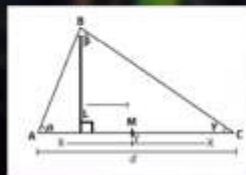


Figure A.8 – How it operates

Reason behind this research

Even though other TVS prototypes have previously proven to be quite successful there's a growing need in the range of scanning/calculation. Therefore the purpose of this research is to develop a transimpedance amplifier as well as a way to adapt it to TVS 3 in order to get readable data in the form of Gauss signal. After that we would need to compile this signal into in order to get a 3d info regarding the object being scanned. Other than that we will need to improve the range of our calculations and see how precise our prototype is using practical tests.

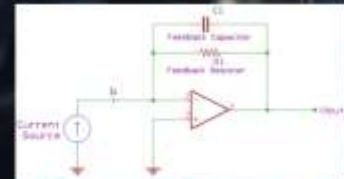


Figure A.9 – Reason behind this research

Transimpedance amplifier

Transimpedance Amplifiers - TIA, unlike non-inverting amplifiers, are devices that use a current signal and convert it into a voltage signal, supporting a certain signal amplification. This is extremely important for many applications of optics, because the means for detecting the light signal are photodetectors, because in general these photodetectors receive a signal of light intensity and generate a current signal that, when properly operated, is proportional to the specified intensity, depending on the use of photodetectors and their technical characteristics. The currents they produce can be significantly low (in the case of photodiodes used in this work, in the order of microamperes). That is why, in addition to converting the current signal into voltage, it must be amplified for the measuring devices.

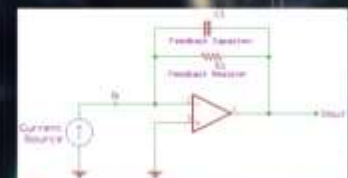


Figure A.10 – Transimpedance amplifier

Description of the experiments.

A later experiment was to collect data to verify the performance of a TVS3 scanning aperture equipped with a transimpedance amplifier in different gain configurations in accordance with the calculated distance that is supposed to be measured.

Measured effect	Way of measurement	Change Δ in factor
Light in laboratory	Turning the light off and on	
Voltage in photosensor	5V to 7V	1 V
Resistance for the amplifier	1 M Ohm to 1M Ohm	1 M Ohm
Opening speed scanning	300 rpm 6500 rpm	
Distance from scanned object	10 to 50 cm	5 cm

Figure A.11 – Description of the experiments

Laser scanning and data collection experiment

Scanning an object requires the combined use of two systems. The laser positioner DC motor control system and the z-axis positioner, to position the laser every number of degrees on the object relative to the TVS laser positioner and to maintain the stability of the z-axis angular position. These signals were captured by an Arduino Mega microcontroller, which is used to control a motor designed to scan aperture at a constant speed by receiving a command from a computer using each new pulse of a rotary encoder to store 200 units of data in an array in memory. Memory, which will later be sent to the computer system



Figure A.12 – Laser scanning and data collection experiment

Triangulation and mapping of objects

To triangulate and display objects, in particular, you need to use the data obtained in the filter, using points defined as signal peaks, to then obtain the scan aperture angle stored with scan information and the angle of the laser positioner, also stored with information to use triangulation equations and this allows us to find a point in 3D and the distance to the object that will be added to the memory record to build a 3d cloud of points

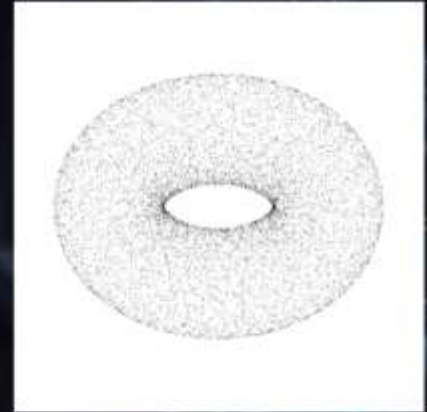


Figure A.13 – Triangulation and mapping of objects

Conclusions

In addition to the above, the use of a transimpedance amplifier had an effect on the sensitivity range of the system in the prototype, where it was used to significantly expand compared to previous prototypes. Using a low-level program can be recommended for subjects who need a quick scan of their faces, while a scan that lasts longer can be used in situations where an additional sensitivity range is important. A novelty used in this field with a transimpedance amplifier is the acquired ability to obtain information about the energy distribution of scanned objects, it is clear that the study of this new information can be branched into several studies. Possibilities for future work may include analyzing this energy distribution information, which can provide information such as the texture of the object, the material from which it is made, and the color of its surface, as well as advanced methods for detecting energy centers and signal peaks.

Figure A.14 - Conclusions

