



بسم الله الرحمن الرحيم

oooooo

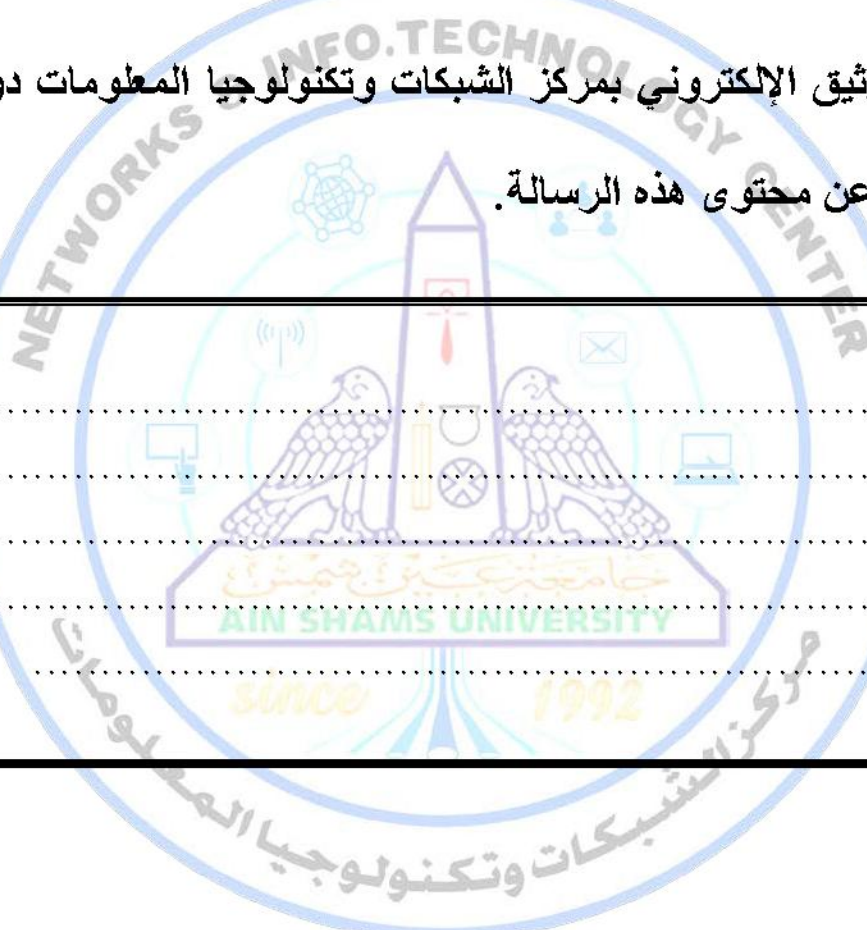
تم رفع هذه الرسالة بواسطة / حسام الدين محمد مغربي

بقسم التوثيق الإلكتروني بمركز الشبكات وتكنولوجيا المعلومات دون أدنى

مسئولية عن محتوى هذه الرسالة.

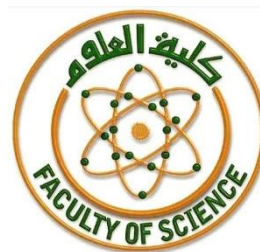
ملاحظات:

.....
.....
.....
.....
.....
.....
.....
.....





Physics Department



Establishing a Baseline for Calibration of Laser Distance Meters and Global Navigation Satellite System receivers

A Thesis Submitted for the degree of Master

in Science in Physics

By

Karim Mohamed Abdelfattah Mohamed

B. Sc. Al-azhar University (2013)

To

Department of Physics

Faculty of Science – Ain Shams University

Supervised by

Prof. Mohamed Medhat

Abdelrahman Hafez

Professor of Optics and Spectroscopy

Faculty of Science

Ain Shams University

Prof. Hatem Hussein Ibrahim

Professor of Laser

National Institute for Standards (NIS)

Prof. Osama Mohamed Elsayed Terra

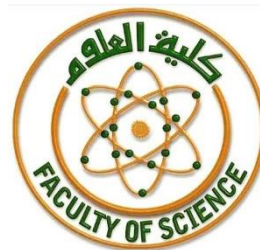
Professor of Laser

National Institute for Standards (NIS)

(2021)



Physics Department



M.Sc Degree Supervisor's Signatures

**Establishing a Baseline for Calibration of Laser
Distance Meters and Global Navigation Satellite
System receivers**

A Thesis Submitted for the degree of

Master in Science in Physics

By

Karim Mohamed Abdelfattah Mohamed

B. Sc. Al-azhar University (2013)

To

Department of Physics

Faculty of Science – Ain Shams University

Supervised by

Prof. Mohamed Medhat

Abdelrahman Hafez

Professor of Optics and Spectroscopy

Faculty of Science

Ain Shams University

Prof. Hatem Hussein Ibrahim

Professor of Laser

National Institute for Standards (NIS)

Prof. Osama Mohamed Elsayed Terra

Professor of Laser

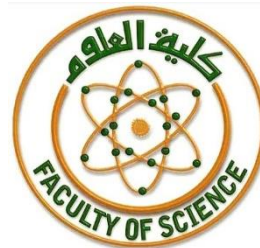
National Institute for Standards (NIS)

(2021)

Faculty of Science- University of Ain Shams- 11566 Abbassia-Cairo-Egypt



Physics Department



Validity of M.Sc of Science Thesis in Physics

Student Name: Karim Mohamed Abdelfattah Mohamed

Thesis Title: Establishing a Baseline for Calibration of Laser distance meters and global navigation satellite system receivers

Degree: Master in Science in Physics

Supervisory Authority:

1- Prof. Mohamed Medhat Abdelrahman Hafez

Physics Department - Faculty of Science, Ain Shams University

2- Prof. Hatem Hussein Ibrahim

National Institute for Standards (NIS)

3- Prof. Osama Mohamed Elsayed Terra

National Institute for Standards (NIS)

Members of the Judging Committee:

1- Prof. Mohamed Medhat Abdelrahman Hafez

Physics Department - Faculty of Science, Ain Shams University

2- Prof. Osama Mohamed Elsayed Terra

National Institute for Standards (NIS)

3- Prof. Suzan Mohamed Sallahaldeen Fouad

Physics Department - Faculty of Education, Ain Shams University

4- Prof. Taha Zaky Nabawy Soker

Physics Department - Faculty of Science, Almansora University

Data for the administration of postgraduate studies

Date of discussion of the thesis: / /20

Department Council approval date: / /20

Date of approval of the Faculty Board: / /20

Date of approval of the University Council: / /20

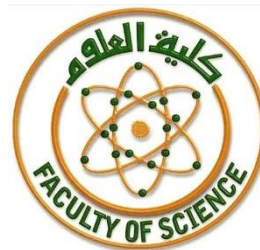
Employee Signature

Director of Studies Department Signature

Faculty Secretary



Physics Department



Researcher data

Name: Karim Mohamed Abdelfattah Mohamed

Date of birth: 31th October 1991

Place of birth: Egypt

Academic degree: Master degree in Science

Field of specialization: Physics

University issued degree: Ain Shams University

Date of issued degree: 2021

Current job: research Assistant - National Institute of Standards

Dedicated to

My beloved parents and beautiful sister

Without their love and support, I would not be where I am today.

Thank you for believing in me...

Acknowledgement

Praise be to Allah, the Lord of the Worlds

I would like to express my sincere thanks to **Prof. Dr. Mohamed Medhat Abd El-Rahman**, professor of Optics, faculty of science, Ain-Shams University, for his guidance, continuous support of my M. Sc. study and effort in developing the content and format of the thesis.

I am very grateful to **Prof. Dr. Hatem Hussein Ibrahim**, professor of laser and optics, National Institute for Standards, for his help and advice throughout the research.

I would like to express my sincere gratitude to my advisor **Prof. Dr. Osama Terra**, National Institute for Standards, for his patience, motivation, and immense knowledge. His guidance helped me in all the time of research, experimental work, and writing of this thesis.

Abstract

Nowadays, precise distance measurement plays an important role in surveying, construction and advanced engineering such as aircraft assembly, space missions, and geodetic applications.

Laser-based Electronic Distance Meters (EDMs) and distance meters that are based on Global navigation satellite systems (GNSS) receivers have become the major technologies utilized in most surveying and construction applications with millimeter-scale accuracies.

EDMs are the ideal choice to accurately measure the distance to an object while avoiding any contact measurement such as those conducted by bulky reel-in tapes or walking wheels. Additionally, EDMs can be used to measure large surfaces and volumes.

On the other hand, distance meter that are based on GNSS technologies are the primary tool not only for precision surveying but also for geodesy, geophysics, and many other industrial applications worldwide.

Rapid developments in these fields bring more and more requirements in their accuracy assessment. Since, the only way to assure the accuracy of these instruments' measurements is by calibration. In order to calibrate an instrument, a method with a superior accuracy is required. Since the accuracy of the GNSS distance meters is in the centimeter range, they can be calibrated using a calibrated EDM with accuracy in the millimeter range. For the calibration of EDMs, a method with a sub-millimeter accuracy is required. In addition, the calibration must be traceable to the SI unit of length, i.e., the meter. In order to facilitate such calibration chain, it is performed through a baseline, in such a way that, the distances between the bases of the baseline are accurately measured using the reference technique;

then the calibrated distances of the baseline are used for calibration of the device under-calibration.

In this thesis, a baseline is constructed at NIS campus over 300 m to be used as a transfer standard for the calibration of GNSS-based distance meters. The inter-pillar distances of this baseline is measured using a calibrated EDM. For the calibration of this EDM, an optical method with accuracy in the sub-millimeter range is required. An investigation is performed over several optical methods to find the suitable method that offers the submillimeter precision. The optical techniques considered in this thesis are: the time-of-flight (TOF), Phase-Shift of Amplitude Modulated signal (PS-AM), Frequency Modulation of Continuous Wave (FMCW), and Opto-Electronic Oscillator (OEO). These techniques were discussed and experimentally demonstrated throughout the thesis in order to establish a reference absolute distance measuring system for EDMs calibration. In the thesis we succeeded to establish a 1550 nm reference optical system based on off-the-shelf components using the optoelectronic oscillator (OEO) with a submillimeter accuracy, which is used for calibration of an indoor baseline and consequently the calibration of an EDM.

In addition, determination of the absolute position on earth using GNSS technologies plays a vital role in navigation in land, sea or in the air. Moreover, it is used for mapping the location of power plants or the location of the offshore gas and oil platforms. It can be also used for the guidance of the unmanned systems that are used in military applications. Calibration of GNSS-based position determination receivers is vital for their accurate operation. Therefore, another baseline is constructed in NIS campus for the calibration of the GNSS-based location receivers.