شبكة المعلومات الجامعية

بسم اللّه الرحمن الرحيم

شبكة المعلومات الجامعية

التوثيق الالكتروني والميكروفيلم

شبكة المعلومات الجامعية

جامعة عين شمس

التوثيق الإلكتروني والميكروفيلم

قسم

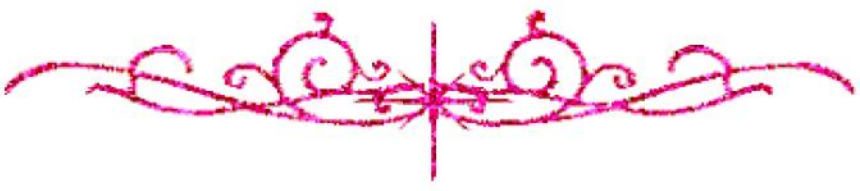
نقسم باللّه العظيم أن المادة التي تم توثيقها وتسجيلها علي هذه الأقراص المدمجة قد أعدت دون أية تغيرات

يجب أن

تحفظ هذه الأقراص المدمجة بعيدا عن الغبار

شبكة المعلومات الجامعية

بعض الوثائق الأصلية تالفة



بالرسالة صفحات
لم ترد بالأصل

AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING
Electronics and Communications Engineering Department

Enhancing the Performance of the Egyptian Time Scale (UTC(NIS))

A Thesis submitted in partial fulfillment of the requirements of the degree of Doctor of Philosophy in Electrical Engineering (Electronics and Communications Engineering)

Submitted by:

Aly Ibrahim Mostafa Mohamed
Master of Science in Electronic Engineering - Communication Engineering
Department of Electronics and Communication Engineering-
Faculty of Electronic Engineering - Minufiya University-2014

Supervised by

Prof. Dr. Abdelhalim Abdelnaby Zekry
Electronics and Communications Engineering Department,
Faculty of Engineering, Ain Shams University

Dr. Gihan Gomah Hamza
Time and Frequency Department,
Electrical Metrology Division, National Institute of Standards

Cairo-(2020)

STATEMENT

This dissertation is submitted to Ain Shams University in partial fulfillment for the degree of Doctor of Philosophy in Electrical Engineering (Electronics and Communications Engineering), 2020.

The work included in this dissertation was carried out by the author at the Electronics and Communications Engineering Department, Faculty of Engineering, Ain Shams University, Cairo, Egypt.

No part of this thesis was submitted for a degree or a qualification at any other university or institution.

Name: Aly Ibrahim Mostafa Mohamed

Signature:

Date:

Researcher Data

Name	: Aly Ibrahim Mostafa Mohamed
Date of birth	: November 11, 1985
Place of birth	: El- Menofia, Egypt
Academic Degree	: M.Sc. in Electrical Engineering
Field of specialization	: Electronics and Communications Engineering
University issued the degree	: Faculty of Electronic Engineering, Menofia University
Date of issued degree	: March, 2014
Current job	: Assistant Researcher at National Institute of Standards (NIS), Egypt

ACKNOWLEDGMENTS

First and foremost, I am thankful to ***God***, the most gracious most merciful for helping me finishing this work.

It is a pleasure to acknowledge my **supervisors** that have profoundly endued me with guidance and support.

I wish to express my sincere thanks to ***Prof. Dr. Abdelhalim Zekry*** and ***Assoc. Prof. Dr. Gihan Gomah Hamza***. I am deeply indebted to them for valuable supervision, continuous encouragement, useful suggestions, and active help during the course of this work.

I also extend my gratitude to ***Prof. Dr. Yuko Hanado from Japan and Dr. Calvin Lin from Taiwan*** for their valuable technical discussions during the course of this work.

I gratefully acknowledge the great effort exerted by ***the teamwork of the time department at the Bureau International des Poids et Measures (BIPM)*** in calculating and disseminating UTC and UTCr, the preservation of the results of the clock comparisons of the different labs from all over the world on the time server, and ensuring the availability of these data to the outside community is really a very appreciated job.

Finally, I am indebted to ***my father***, ***my mother***, ***my brother, my sisters, my wife*** and ***my daughters*** that are usually beside me in all happy as well as hard times.

ABSTRACT

Enhancing the Performance of the Egyptian Time Scale (UTC(NIS))

Improving the frequency stability of the Atomic Time Scale (TA(K)), and hence that of the national time scale (UTC(K)), is a main target for all timekeepers. Coordinated Universal Time (UTC) is the international reference time, and K is the abbreviation given by the Bureau International des Poids et Measures (BIPM) to the timekeeping laboratory. TA(NIS) is the atomic Time Scale (TS) of the National Institute of Standards (NIS), and UTC(NIS) is the national TS of Egypt. The stability of TA(K) can be improved by either increasing the number of atomic clocks in the ensemble or by adding clocks of higher stability. In both cases, a large financial budget is needed which may be unaffordable by some developing economics.

In this thesis, **firstly** we propose a new method for improving the stability of atomic TS by a factor approaching 50 % with zero expenses by replacing the real clocks in the ensemble by Virtual Clocks (VCs). The VCs are obtained by Downscaling (DS) the frequency offset of the real clocks. The DS process improves the frequency stability of the clocks and hence that of the resultant average TS. Since the down-scaled clocks are correlated to the original ones, then they replace the real clocks and not added to the ensemble. The performance of the proposed method is verified by applying it on the daily clocks comparison data of the Observatory of Paris (OP) published on the time department server of the BIPM. The performance of the proposed method is compared with that of the Kalman filter (KF) noise reduction method presented in the literature. It is found that the proposed method is simpler and acting as a wider bandwidth de-noising filter than the KF noise reduction method for achieving the same performance.

Almost all the timekeeping laboratories maintain the 5071A Cesium (Cs) frequency standard for generating their national time scales. The frequency stability of this standard is limited by different

types of noise; especially the White Frequency Modulation (WFM) noise which is the dominant noise source. These noise types affect the stability of the resultant average TS (TA(K)). The KF is still applied till now within the TS algorithm for de-noising and prediction for improving the resultant TS frequency stability. But, this method is very complicated and is based on difficult estimation techniques. In 2013, the Empirical Mode Decomposition (EMD) technique was applied for the first time on Cs atomic clock signal de-noising and frequency prediction.

Secondly, the EMD technique was embedded in the TS generation algorithm for studying its effect on the stability of the resultant TS. Results show that the frequency stability of the resultant TS is improved for averaging times up to nearly 40 days due to EMD. These results are verified by comparing the effect of the EMD to that of the KF on the resultant TS frequency stability. Results show that the frequency stability of the resultant average TS is improved due to using EMD or KF for Cs clock signal-de-noising for averaging times up to nearly 40 days. But, EMD is found to be more effective and simpler than the complicated KF.

Thirdly, a new more effective use of EMD in the TS algorithm for enhancing the frequency stability of national TS was introduced. The EMD was used directly for smoothing atomic clocks errors used in the TS ensemble algorithm without detrending. Then, the smoothed clocks errors were used for building an average TS to improve its resultant frequency stability and hence that of national TS. The use of EMD for smoothing atomic clock error was compared to that of the KF as a famous signal processing technique for the same purpose. Obtained results show that the simple EMD achieves an average TS frequency stability improvement factor of 44% as compared to 41% of the complicated KF. Also, this new proposed use of EMD saves the processing effort and time required for clock detrending step before denoising.

Finally, TA(NIS) was built using two Cs atomic clocks of NIS with the master clock. Obtained results from this simulation were introduced and showed that the frequency stability of TA(NIS) is better than that of the bad stability clock and is very close to that of the other high stability clock. Also, the DS, EMD denoising methods proposed in this thesis for enhancing the frequency stability of TA(K) are applied to TA(NIS). Obtained results show that DS, EMD, and