



UNIVERSITI PUTRA MALAYSIA

**DEVELOPMENT OF INTERNET-BASED INSTRUMENTATION
SYSTEM FOR THE STUDY OF SUPERCONDUCTING
MAGNETIC LEVITATION**

TEH JIA YEW

FSAS 2003 43

**DEVELOPMENT OF INTERNET-BASED INSTRUMENTATION SYSTEM
FOR THE STUDY OF SUPERCONDUCTING MAGNETIC LEVITATION**

**By
TEH JIA YEW**

**Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia,
in Fulfilment of the Requirements for the Degree of Master of Science**

August 2003



DEDICATION

The author wish to dedicate this thesis report to his parents,

especially his mother ,

Brother and Sister ,

And

His Fellow Course mates and

Friends

Who had been his source of flames of inspiration and perspiration .

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirement for the degree of Master of Science

**DEVELOPMENT OF INTERNET BASED INSTRUMENTATION
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August 2003

Chairman: Associate Professor Dr. Zainal Abidin bin Sulaiman

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Computers can be utilized to control instruments, machines, motors, devices etc. to automate tasks. Presently, an automation system had been constructed and successfully used to conduct the physics experiments to study the levitation force in the Bi-Sr-Ca-Cu-O (BSCCO) high T_c superconductor series. This research project aims to improve the automation system. Two major improvements were made; first, converting the existing automation system into a Web based automation system and replacing the DOS based QBasic program with Windows based user interface . The Web based automation system can be remotely controlled and monitored by users in remote locations by using only their web browsers; as if they (the users) are sitting right in front of the automation system! This is achieved by programming the server computer (which was interfaced to the automation system) to load Java Applets containing the user interface required to control the automation system, into the remote user's web browser The Web based automation system is also capable of remote data acquisition or DAQ, whereby experimental data can be remotely acquired by the user through File Transfer Protocol (FTP). Three major types of test essential for the study of superconducting levitation forces were also integrated into

the user interface. The tests are: detection of magnetic hysteresis, detection of stiffness loops for increasing distance and detection of magnetic stiffness for decreasing distance. Each test requires varying degrees of control over a stepper motor 's movement. The stepper motor is the key component of the automation system and is used to vary the distance between the magnetic materials in small, controlled, steps of 0.05 mm per movement. Both the user interface and the Web based features were developed using a graphical programming language called LabVIEW. The Web based automation system was used to conduct a series of experiments to study the levitation forces of Cadmium (Cd) doped Bi-Sr-Ca-Cu-O (BSCCO) high T_C superconductor series. Users are successful in logging into the automation system to control, monitor and acquire data remotely from the automation system in real time. The Web based automation system was successful in detecting magnetic hysteresis for all the superconductor samples measured. Further, magnetic stiffness loops were also detected over all samples. Analysis of the magnetic hysteresis and stiffness loops showed agreement with work done by Chang and Moon, two prominent researchers in the field of superconductor research.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi keperluan untuk ijazah Master Sains

**PEMBANGUNAN SISTEM INSTRUMENTASI BERLANDASKAN
INTERNET UNTUK MENGAJI DAYA APUNGAN MAGNET
SUPERKONDUKTOR**

Oleh

TEH JIA YEW

Ogos 2003

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Komputer boleh digunakan untuk mengawal instrumen, mesin, motor, alat-alat dan lain-lain untuk mengautomasikan tugas dan kerja. Pada masa ini, sebuah sistem automasi telahpun dibina dan telah pun berjaya digunakan untuk eksperimen kajian daya apungan di dalam siri sistem superkonduktor suhu tinggi T_c Bi-Sr-Ca-Cu-O (BSCCO). Objektif utama penyelidikan ini adalah untuk memperbaiki dan memajukan sistem automasi yang sedia ada. Kemajuan dilakukan di dalam dua aspek utama iaitu yang pertama, menjadikan sistem automasi yang sedia ada kepada sistem automasi berlandaskan jaringan Internet (iaitu berlandaskan Web) dan yang kedua, menukarkan perisian Qbasic berasaskan DOS kepada antaramuka berlandaskan Windows. Dengan keupayaan berlandaskan Web, sistem automatik dapat dikawal dan dimonitor oleh pengguna di suatu lokasi jauh melalui perisian halaman Web mereka seolah-olah pengguna tersebut sedang berada di hadapan sistem automasi tersebut. Sistem automatik berlandaskan Web ini juga berupaya mengumpulkan data eksperimen secara kawalan jauh, iaitu melalui Protokol Pemindahan Fail (FTP). Ini diperolehi dengan mengaturcarakan suatu komputer server (yang diantaramukakan kepada sistem automasi) untuk memuatkan Java Applet ke dalam Web browser

pengguna jarak jauh. Java Applet ini mengandungi antaramuka pengguna yang perlu untuk mengawal sistem automasi. Tiga jenis ujian yang penting di dalam kajian daya apungan superkonduktor juga digabungkan ke dalam system automatik ini iaitu : pengesanan histerisis, pengesanan gelung ketegangan di dalam peningkatan jarak dan pengesanan gelung ketegangan di dalam pengurangan jarak. Setiap ujian memerlukan pengawalan ke atas pergerakan motor langkah yang merupakan komponen utama sistem automatik ini. Motor langkah ini memvariasikan daya apungan superkonduktor melalui pergerakan sehalus 0.05 mm setiap *satu* pergerakan motor. Kedua-dua aspek antaramuka dan kawalan berlandaskan dibangunkan melalui penggunaan perisian LabVIEW. Ia adalah sejenis bahasa pengaturcaraan berlandaskan grafik. Sistem automatik yang telah dimajukan digunakan untuk menjalankan beberapa siri eksperimen bagi mengkaji daya apungan siri superkonduktor suhu tinggi Bi-Sr-Ca-Cu-O (BSCCO) yang telah didopkan dengan Cadmium (Cd). Para pengguna berjaya mengawal, memperhatikan dan mengumpul data secara jarak jauh di dalam masa sebenar. Sistem automatik berlandaskan Web ini berjaya mengesan histerisis di dalam semua sampel superkonduktor yang diuji. Tambahan lagi, gelung ketegangan juga dapat dikesan di dalam semua sampel yang diuji. Analisis kesan histerisis dan gelung ketegangan menunjukkan persetujuan dengan hasil ujikaji yang dilakukan oleh P.Z. Chang and F.C. Moon, iaitu dua orang penyelidik yang giat di dalam bidang penyelidikan superkonduktor.

ACKNOWLEDGEMENTS

Faithful thanks and appreciation are extended first to my supervisor, Associate Professor Dr. Zainal Abidin bin Sulaiman; co supervisors: Professor Dr. Abdul Halim bin Shaari, Dr. Ionel Valeriu Grozescu and Dr. Zaidan Abdul Wahab ; for their charismatic guidance, prevailing assistance in all aspects , priceless suggestions, comments and advice; from the beginning of this project till the curtains are drawn.

Thanks and appreciation is also extended to my fellow course mates in the Superconductor Laboratory for their invaluable and generous assistance . They are Dr. Imad, Dr. Lim Kean Pah, Abdullah, Kabashi, Mustafa, Ramadan, Mimi and Shamirwati.

I also would like to specifically thank Dr. Imad and Mr. Ali for supplying the superconductor samples to me for superconducting magnetic levitation studies.

Thanks and appreciation is also extended to Mr. Baharuddin, Mr. Zulambiar and Mr. Nordin of the Multimedia and Communications Laboratory, in the Department of Physics, for their generosity in assisting and permitting the author to use all facilities available in the Multimedia and Communications Laboratory.

Credit is also given to anyone who had either directly or indirectly contributed to the completion of this thesis and also this research project.

I certify that an Examination Committee met on 15th August 2003 to conduct the final examination of Teh Jia Yew on his Master of Science thesis entitled "Development of Internet-based Instrumentation System for the Study of Superconducting Magnetic Levitation" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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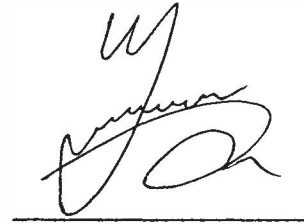
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I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.



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LIST OF SYMBOLS AND ABBREVIATIONS

LIST OF SYMBOLS

Symbol	Description	Unit
J_C	Critical Current	A
T_C	Critical Temperature	K
χ	Magnetic Susceptibility	-
R	Resistance	Ω
ρ	Resistivity	Ω^{-1}
B	Magnetic Induction	Henry or H
H	External magnetic field	Tesla T or Gauss G
M	Magnetization in a material	Tesla T
μ_0	Permeability of vacuum	-
z	Distance between permanent magnet and superconductor	mm
F	Magnetic Levitation Force	N or mN
κ	Magnetic Stiffness	Nm^{-1}
B_C	Thermodynamic Critical Field	Tesla T
S	Number of Steps per revolution	-
θ	Stepper Motor Drive Angle	degrees °
I_{RMC}	Rated Motor Current	mA
P_{Max}	Maximum Power Dissipated	W
I_{CP}	Current per phase	mA
KS/s	Kilo Samples per second	-
t_{stable}	Waiting time for levitation force stabilization.	minutes

x	Dopant composition for superconductors	mol
$F_{\text{highest-up}}$	Highest levitation force in the increasing distance z	mN

LIST OF ABBREVIATIONS

BSCCO	Bi-Sr-Ca-Cu-O Superconductor
DAQ	Data Acquisition System
DOS	Disk Operating System
FTP	File Transfer Protocol
IIS	Internet Information Services
PC	Personal Computer
LabVNC	Laboratory Virtual Network Control
NI	National Instruments Malaysia
NT	New Technology
QBasic	Quick Basic.
RS	RS Technologies Sdn.Bhd.
SQL	Structured Query Language
TCP/IP	Transmission Control Protocol/Internet Protocol
UPS	Uninterruptible Power Supply
YBCO	Y-Ba-Cu-O Superconductor

CHAPTER 1

INTRODUCTION

1.1 Research Project Background

Prior to the birth of computers, many tasks had to be undertaken manually. The arrival of computers from the year 1981 with the very first IBM PC revolutionized the method we employ to have tasks done; from manual to automated. A fine example of automated task can be seen through the utilization of computers to control instruments, machines, motors etc. and also acquire data automatically.

In the past, superconducting magnetic levitation measurements were performed manually, with user controlling the instrument for measuring magnetic levitations. In order to measure superconducting magnetic levitation, the distance z between a superconductor and magnet must be varied to see how levitation force F changes with z . However, manually controlled instrument system has some problems and limitations.

The major problem is that the variation of distance z between the superconductor and the magnet is inconsistent (i.e. z is not varied linearly). Another problem is that the data acquisition of Force F and z is done manually, which is very time consuming. Further, users can't see the relationship between F and z in the form of a graph as the experiment progresses. By using manual DAQ, the graph of F versus z can only be obtained after experiments had completed. The limitation with manual control is that the manual system can only be locally controlled.

As a solution to the problems above, a fully automated automation system was developed and successfully used to carry out superconducting magnetic levitation measurements. The variation of z is now consistent since a stepper motor is used to vary z . Furthermore the data acquisition (DAQ) process is also fully automated. DOS based QBasic programs controls the stepper motor and also performs automated data acquisition. (Tan,1999) (Wong,1999)

Though fully automated, there are some limitations. First, the DOS based programs were not user friendly. What users see when experiments are in progress is a black screen. Second, QBasic can't be used to create an attractive Windows based user interface. Finally, the system can only be locally controlled since QBasic does not support neither remote control nor networking.

To overcome the limitations above, there is another solution : to design a Windows based user interface and design remote control features for the DOS based system. Essentially, the solution is to design a Remote Controlled, Windows based instrumentation system.

1.2 General Objective

The general objective of this research project is to design Windows based user interface features and remote control features for an already fully automated automation or instrumentation system mentioned above. With remote control features, the experiments involved in the study of superconducting magnetic levitation forces can be conducted remotely.

Computer interfacing technique is used to perform the improvements mentioned above. This technique involves the use of both computer interfacing software (for both local and remote control of the hardware) and electronics hardware for z variation and DAQ..

Another objective of this research is to conduct superconducting magnetic levitation studies on BSCCO superconductor samples using the improved system. The samples are prepared using a new technique called the precipitation technique.

1.3 Overview of Research.

Therefore, the development of this system shall involve three aspects of design: hardware and mechanical design and also software design. The hardware design details the electronic design that builds up the system, including how the hardware is interfaced to the computer. The hardware design involves electronic components consisting of a multifunction digital output card and a series of electronic circuits for controlling the Internet based instrumentation system.

The mechanical design details the design of mechanical components or equipment for conducting superconducting magnetic levitation measurements.

The software design details the software essential for controlling the instrumentation system: i.e. both the Windows based user interface design and the remote internet based control features of the system.