

DESIGN AND DEVELOPMENT OF AN IAGA
COMPLIANT MAGNETIC OBSERVATORY

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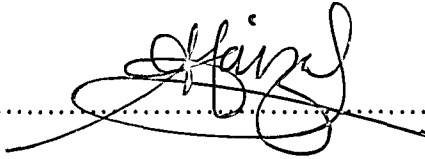
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OBSERVATORY

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ABSTRACT

The first attempt to construct a magnetic observatory station was initiated in 2002 at Kolej Universiti Teknologi Tun Hussein Onn, presently known as Universiti Tun Hussein Onn Malaysia (Lat. 1.51° N , Long. 103.55° E), as a scientific facility equipped to detect and record daily scientific phenomena of the earth's magnetic field variations. Preliminary activities such as magnetic surveys, construction of non-magnetic station and coding a new data logger software were carried out. The proton overhauser and fluxgate magnetometers were used to measure the daily magnetic field variations. Daily field variables of the horizontal (H), declination (D) and vertical (Z) components were recorded every second and the total intensity (F) component was observed every 5 seconds daily. One-minute digital gaussian filter was applied to the data to minimise the effect of aliasing to produce the values of dH , dD and dZ . Between the months of June to December 2005, three geomagnetic phenomena were observed namely the magnetic field variations, magnetic storms and pulsations. Daily average variations of the dH (-0.5039 nT) component shows that it is low at night and maximises around local noon. The average dZ (0.2817 nT) shows an opposite variation to the dH , minimising at local noon. This is due to the east-west ionospheric current enhancement by solar radiation which is a maximum at local noon. The average dD (0.3741 nT) follows a similar variation to dH . However, the dD does not always follow the trend, due to very strong north-south components of the equatorial electrojet (EEJ) current. The day-to-day variation of dD is influenced by the dawn to dusk effect and the EEJ current. Nine geomagnetic storms were detected during this period, with the most intense observed on 24 August 2005 with $Dst = -216$ and $Kp = 9-$. Eighty-five Pi 2 ($f = 2$ to 30 mHz) pulsations were also observed during magnetically quiet periods ($Kp \leq 2+$). The successful detection of these phenomena shows that quality magnetic data which comply with international measurement standards based on IAGA specifications can be observed.

ABSTRAK

Percubaan awal untuk membangunkan balai cerap magnet bumi telah di mulakan di Kolej Universiti Teknologi Tun Hussein Onn pada tahun 2002, yang kini dikenali dengan nama Universiti Tun Hussein Onn Malaysia (Lat. 1.51° N, Long. 103.55° E), sebagai sebuah pusat penyelidikan saintifik untuk mengesan dan mencatat perubahan harian magnet bumi. Kerja-kerja pembangunan merangkumi aktiviti tinjauan magnet, membina balai bebas magnet dan merekacipta perisian pengkalan data. Dua alat iaitu 'proton overhauser' dan 'fluxgate' digunakan di balai cerap untuk mengesan perubahan harian magnet bumi. Tiga komponen magnet bumi iaitu komponen mendatar (H), sudut pugak (D), menegak (Z) dikesan dan direkodkan setiap saat, manakala jumlah medan magnet F direkodkan setiap lima saat. Data-data dituras menggunakan penapis digital gaussian 1-minit untuk mengurangkan kesan pengalihan isyarat dan mengira nilai perubahan kecil komponen dH , dD dan dZ . Tiga fenomena magnet bumi yang dikesan di antara bulan Jun hingga Disember 2005 ialah, perubahan harian magnet bumi, ribut magnet dan getaran. Pemerhatian harian menunjukkan, komponen dH (-0.5039 nT) akan mencapai nilai maksima pada tengahari dan terendah pada tengah malam. Komponen dZ (0.2817 nT) pula, berubah berlawanan arah dengan komponen dH dan mencapai nilai minima di waktu tengahari. Perubahan ini di sebabkan oleh pertambahan nilai arus ionosferik timur-barat akibat dari sinaran matahari yang maksima. Bentuk perubahan nilai dD (0.3741 nT) pula hampir sama dengan perubahan dH , walau bagaimanapun kerap kali perubahan nilai dD dipengaruhi oleh arus komponen utara-selatan yang dihasilkan oleh fenomena arus elektrojet (EEJ). Perubahan harian nilai dD dipengaruhi oleh kitaran pagi dan petang, dan arus EEJ. Sembilan ribut geomagnet berlaku dalam tempoh pemantauan dan ribut terbesar terjadi pada 24 Ogos 2005 dengan nilai indeks $Dst = -216$ dan $Kp = 9-$. Dalam tempoh yang sama, lapan puluh lima fenomena getaran Pi 2 ($f = 2 - 30$ mHz) dikesan semasa magnet bumi dalam keadaan tenang ($Kp \leq 2+$). Kejayaan pengesanan fenomena-fenomena ini menunjukkan data magnet berkualiti yang menepati piawaian pengukuran antarabangsa berdasarkan spesifikasi IAGA boleh di cerap.

I dedicated this thesis to all my parents, my family and my friend.

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TABLE OF CONTENTS

CHAPTER	TITLE	PAGES
	ABSTRACT	ii
	ABSTRAK	iii
	ACKNOWLEDGEMENT	iv
	LIST OF TABLES	ix
	LIST OF FIGURES	x
	LIST OF SYMBOLS	xv
	LIST OF ABBREVIATIONS	xvii
	LIST OF GLOSSARYS	xx
	LIST OF APPENDICES	xxvi
I	INTRODUCTION	1
	1.1 The Importance of the Earth's Magnetic Field	1
	1.2 Overview of Magnetic Observatories	3
	1.3 International Association of Geomagnetism and Aeronomy (IAGA)	4
	1.4 Problem Statements	5
	1.5 Research Scope and Objectives	13
	1.6 Thesis Outline	14
II	THEORETICAL BACKGROUND	16
	2.1 The Earth's Magnetic Field	16
	2.1.1 Coordinate Systems	16

2.1.2	The Earth's Geomagnetic Field	18
2.1.3	Origin of the Geomagnetic Field	22
2.2	Variation of the Earth's Magnetic Field	23
2.2.1	Temporal Variations	23
2.2.2	Secular Variations	30
2.3	Summary	31
III	MAGNETIC OBSERVATORY STATION	33
3.1	Geomagnetic Observatories	33
3.1.1	History and Evolution	34
3.1.2	Classification of Observatories	35
3.1.3	Measurement Categories in the Observatories	36
3.1.4	Absolute Magnetic Measurement	37
3.1.5	Observatory Station	38
3.1.6	Standardisation and calibration	39
3.1.7	An Automatic Magnetic Observatory	40
3.1.8	Geomagnetic Indices	41
3.1.9	Observatories Data	44
3.2	Measuring Earth's Magnetic Field	45
3.2.1	Magnetic Measurement	45
3.2.2	Scalar Magnetometers	46
3.2.3	Vector Magnetometer	47
3.2.4	The Fluxgate Theodolite	49
3.3	Instrumentations at Variometer House	50
3.3.1	Proton Overhauser Magnetometer	50
3.3.2	Triaxial Fluxgate Magnetometer	52
3.3.3	Theodolite Declinometer/Inclinometer	54
3.4	Summary	56

IV	DEVELOPMENT OF MAGNETIC HOUSE	58
4.1	Magnetic Survey	58
4.1.2	Survey Area	59
4.1.3	Survey Instrument	60
4.1.4	Types of Surveys	63
4.1.5	Data Processing	69
4.1.6	Data Interpretation	70
4.1.7	Summary	72
4.2	Design and Construction of the Magnetic House	74
4.2.1	Design Constraints	74
4.2.2	Design Strategy	76
4.2.3	Construction of the Station	77
4.2.4	The Observatory Station	77
4.2.5	Materials	80
4.2.6	Pillars	81
4.2.7	Temperature	82
4.2.8	Power Supply	83
4.2.9	Summary	83
V	GEOMAGNETIC DATA ACQUISITION SYSTEM (GeoDAS)	84
5.1	Introduction	84
5.2	Design Goals	85
5.3	Data Acquisition System	86
5.3.1	Hardware Modules	88
5.3.2	Software Architecture	89
5.3.3	Data Logging Software	91
5.4	Laboratory and Field Evaluation	97
5.5	Summary	99

VI	RESULTS AND DISCUSSION	100
	6.1 The Data Recording and Processing	100
	6.2 Observation of Geomagnetic Phenomena	103
	6.3 Magnetic Variations	104
	6.3.1 Daily Variations	104
	6.3.2 Monthly Variations	107
	6.3.3 Seasonal Variations	108
	6.3.4 Spectrogram Analysis	110
	6.3.5 Power Spectra Analysis	111
	6.4 The Magnetic Storms	116
	6.4.1 The Storm of 24 August 2005	117
	6.4.2 Spectrogram and Power Spectra Observations	119
	6.5 Magnetic Pulsations	122
	6.5.1 Pi 2 Pulsation	122
	6.5.2 Pi 2 Histogram Analysis	124
	6.6 The Mathematical Model	126
	6.7 Summary	132
VII	CONCLUSIONS AND RECOMMENDATIONS	133
	7.1 Summary	133
	7.2 Contributions to Geomagnetic Research	134
	7.3 Recommended Future Work	139
	REFERENCES	141
	PUBLISHED AND PRESENTED PAPERS	147

LIST OF TABLES

TABLE NO.	TITLE	PAGES
1.1	Impacts of Solar-Terrestrial Processes on Technologies, adapted from Lanzerotti [6]	12
2.1	Pulsation Classes	30
3.1	The standard scale of Kp indices	43
3.2	Field Strength Instrument Characteristics	46
4.1	The locations of magnetic surveys carried out from September to December 2003	64
6.1	The daily magnetic field variations data recorded	101
6.2	The quiet days of magnetic activity ($Kp \leq +2$)	103
6.3	Magnetic storms observed between June and December 2005	116
6.4	The result of comparing multiple polynomial curve fit cases using the basic fitting interface tools in Matlab™	128
6.5	The coefficients values for ninth-order polynomial equation	130

LIST OF FIGURES

FIGURE NO.	TITLE	PAGES
1.1	Illustration some of the effects of space weather on technical systems, adapted from Lanzerotti [6]	2
1.2	Locations of the geomagnetic observatories, adapted Macmillan and Quinn [13]	6
1.3	Number of observatories provided annual means - North (gray) and South (black) hemispheres, adapted Macmillan and Quinn [13]	8
1.4	Yearly sunspot numbers with indicate time of selected major impact of the solar-terrestrial environment, adapted from Lanzerotti [6]	11
2.1	Earth's magnetic components, adapted from INTERMAGNET [27]	17
2.2	The magnetic field and its geographical axis	19
2.3	Geomagnetic coordinates in the year 1995, adapted from Campbell [2]	20
2.4	The magnetosphere, adapted from NASA SP-8017 (Ed.) [29]	22
2.5	Amplitude of natural variations of the horizontal components H , adapted from Jankowaski and Sucksdoff [14]	24

2.6	Diurnal variation of the magnetic field at different latitudes on solar quiet days, adapted from Parkinson [26]	25
2.7	The three phases of a magnetic, adapted from Tsurutani and Gonzalez (Ed.) [34]	28
3.1	Layout of a classic magnetic observatory station, adapted from Jankowaski and Sucksdoff [14]	39
3.2	The proton overhauser magnetometer consists of a console and a sensor	51
3.3	The fluxgate magnetometer consists of a console and a sensor	53
3.4	A sensor of the fluxgate magnetometer model FGE	54
3.5	Absolute magnetometer	56
4.1	The map of areas surveyed covering part of the Peninsular Malaysia in 1956, adapted from Agocs [16]	61
4.2	The map of areas surveyed covering part of the main university's campus and the old airport strip.	62
4.3	The complete set of the instruments and tools used during the survey	62
4.4	Layout plan of the surveyed locations carried out at the main university's campus	65
4.5	The four locations surveyed at the old airport strip	66
4.6	The surveyed location carried out on private land (Kg. Parit Sumarto)	66
4.7	The photos taken during magnetic surveys at the university - (a). Location A; (b)., Location B; (c)., Location C; (d)., Location D; (e). Location E and (f). Location F	67
4.8	The photos taken during magnetic surveys at the airport strip and private land - (a). Location G; (b)., Location H; (c)., Location I; (d). Location J and (e) Location K	68

4.9	An example to determining the statistically averaged smooth value of a graph	69
4.10	The temporal variation shows that the variations in background magnetic field observed during while performing magnetic survey at location K are less than 10 nT	70
4.11	The lowest magnetic gradient profile is at Location K	71
4.12	The gradient field contour at Location K	72
4.13	Process of integrated design strategy	76
4.14	Photographs of the observatory station under construction	78
4.15	Photograph of the underground PVC pipe and cables	79
4.16	Photograph of the observatory building constructed using nonmagnetic materials	79
4.17	The layout of the observatory station	80
4.18	The roof's design enhances air ventilation and keeps the room's temperature stable	81
4.19	A pillar and its ground foundation	82
5.1	General system configuration of GeoDAS	87
5.2	Nested-ring structure of GeoDAS software architecture	90
5.3	The MagTerm screen capture with processed data	92
5.4	Process flow for a GPS receiver	93
5.5	Process flow for the proton magnetometer	94
5.6	Process flow for the fluxgate magnetometer	95
5.7	The process flow of changing parameters at the GeoDAS system	96
5.8	A newly developed software for data logger simulation test	98
6.1	Example of temperature variations at a fluxgate sensor during December 2005	102
6.2	Daily variations of dH dD and dZ components on 4 and 5 October 2005 during quiet magnetic activity ($Kp \leq 2+$)	105

6.3	One-minute variation data of dF and dH observed on 7 July 2005, using (a). a proton magnetometer (b). a fluxgate magnetometer	107
6.4	The magnetic field components variations dH , dD and dZ were observed in August 2005 along with the associated indices Dst and Kp	109
6.5	The six-month seasonal variation of dH , dD and dZ components for the months of July to December 2005 based on quiet days for each month	110
6.6	Spectrogram of daily magnetic components variations dH , dD and dZ as observed on 4 and 5 October 2005 ($Kp \leq 2+$)	112
6.7	Spectrogram of monthly magnetic field components variations dH , dD and dZ as observed in August 2005	113
6.8	An average of the power spectra density of the magnetic field components observed during the quiet magnetic activity on 4 and 5 October 2005	114
6.9	An average power spectra density for all magnetic components for the month of August 2005	115
6.10	The variations of the H and dH components during the magnetic storm and its related indices (Dst and Kp), observed on 24 and 25 August 2005	118
6.11	The characteristics of the magnetic field components dH , dD and dZ observed during the magnetic storm from 24 to 25 August 2005	119
6.12	Spectrogram of H -component data for the magnetic storm event on 24 to 25 August 2005	120
6.13	Power spectra density of H -component identifying power peaks occurring at frequencies ranges ~ 7 , ~ 20 , ~ 35 , ~ 50 and ~ 80 mHz	121

6.14	The magnetograms of H -component observed during Pi 2 pulsation occurred (a). Unfiltered data (b). Filtered data	124
6.15	The spectrogram of the dH -component identified power peaks occurring at frequency ranges of ~ 8 to ~ 13 mHz	125
6.16	Power spectra density of the H -component confirm that the power peaks occurred at frequency ranges of ~ 8 to ~ 13 mHz	125
6.17	The histogram of Pi 2 pulsation occurrence during the seven months of observation	126
6.18	A scatter plot and its ninth-order polynomial regression line	129
6.19	The residual of the ninth-order polynomial equation	129
6.20	The 95 percent confidence interval of the prediction model	131

LIST OF SYMBOLS

Dst	Disturbance storm time index
E	East
elf	Extremely low frequency
f	Frequency
Hz	Hertz or cycle per second
kg	kilogram
Kp	Planetary three-hour-range index
L	Entropy rate or Reconstruction rate
m	Magnetic dipole axis
mA	mili Ampere
mdnt	Midnight
mrاد	miliradian
nT	nanoTesla
N	North
N	Number of coil turns
Pc	Pulsation continuous
Pi	Pulsation irregular
R_{\oplus}	Radius of the Earth
S	South

T	Time
V	Voltage
W	West
γ	Gamma
μ	Permeability of core material
μ_0	Permeability of free space

LIST OF ABBREVIATIONS

A/D	Analogue to Digital
AC	Alternating Current
AE	Auroral Electroject
ADC	Analogue-Digital Converter
ANSI	American National Standards Institute
USA	United State of America
AU	Astronomical Unit
BGS	British Geological Survey
CANMOS	Canadian Magnetic Observatory System
CME	Coronal Mass Ejections
DC	Direct Current
DGRF	Definitive Geomagnetic Reference Field
DMI	Danish Meteorolical Institute
EEJ	Equatorial Electroject
FE	Fluxgate Magnetometer
FFT	Fast Fourier Transform
G-DAS	British Geomagnetic Data Acquisition System
GeoDAS	Geomagnetic Data Acquisition System
GIC	Geomagnetically Induced Current

GPS	Global Positioning System
GSM	Group Special Mobile
GUI	Graphical User Interface
HF	High Frequency
IAGA	International Association of Geomagnetism and Aeronomy
ICSU	International Council of Scientific Unions
IGRF	International Geomagnetic Reference Field
IUGG	International Union of Geodesy and Geophysics
IMF	Interplanetary Magnetic Field
INTERMAGNET	International Real-time Magnetic Observatory Network
IQD	International Quiet Days
KUiTTHO	Kolej Universiti Teknologi Tun Hussein Onn
LAN	Local Area Network
LT	Local Time
MagTerm	Magnetic Observatory Terminal
NGDC	National Geomagnetic Data Center
NMEA	National Marine Electronics Association
NOAA	National Oceanic and Atmospheric Administration, United States of America
PC	Personal Computer
POM	Proton Overhauser Magnetometer
PPM	Proton Precession Magnetometer
PPS	Pulse Per Second

PSD	Power Spectrum Density
PVC	Polyvinyl Chloride
SQUID	Superconducting Quantum Interference Device
STFT	Short Time Fourier Transform
SCW	Substorm Current Wedge
SSC	Storm Sudden Commencements
ULF	Ultra Low Frequency
UPS	Uninterrupted Power Supply
USB	Universal Serial Bus
UT	Universal Time
UTC	Coordinated Universal Time
UTHM	Universiti Tun Hussein Onn Malaysia
WARAS	Wireless and Radio Science Center
WDC	World Data Center
WMM	World Magnetic Model
TNB	Tenaga National Berhad
TFT	Thin-Film Transistor
VGA	Video Graphics Array
VAC	Voltage Alternating Current