OBSERVATIONS OF MAGNETIC STORMS AT THE NEWLY DEVELOPED MAGNETIC OBSERVATORY IN MALAYSIA

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Abstract *The magnetic storm is a worldwide disturbance of the Earth's magnetic field when the plasma bursts emitted from solar flares cause the solar wind to behave erratically. When the plasma comes in contact with the geomagnetic field, it causes it to become ore compresses, and raises the field intensity on the surface of the Earth. This phenomenon was detected using a fluxgate magnetometer with 1 s sampling rate at a ground base newly developed magnetic observatory station (1° 51.3' N, 103° 5.1' E) in Parit Raja, Batu Pahat, Johor, Malaysia. One minute digital gaussian filter was applied to the data (**HDZ**) to reduce the effect of aliasing on the one minute data. This data was analyzed during the storm periods to investigate the characteristic of the local magnetic field components **dH**, **dD** and **dZ** during the events. The occurrence of the magnetic storm events are referred to the Dst index produced by the World Data Center.*

Nine magnetic storms were observed during seven month observations between June to December 2005 with Dst index range from -70 to -219. The most intense magnetic storm observed occurred on 24 August 2005 with Dst = -216 and Kp=9. During this storm, the sudden commencement (SC) in the form of sharp increase of the H-component occurred during the initial phase at 1500 LT. Then, the main phase occurred when the H-component decreases for a long period with the larger amplitude (~ 750 nT) than the initial phase at 2000 Local Time (LT). Finally the recovery phase lasted for 3 days after the storm until 26 August 2005. Calculation of the dynamic power spectrum and spectrogram were used to determine the peak power at the same frequencies between (18 to 22 mHz) and (40 to 50 mHz) and cross-power at the time range at 1200 to 2100 LT.

1.0 Introduction

Geomagnetic storm is the largest disturbances in the solar system. It is occurred when a plasma bursts known as a Coronal Mass Ejections (CMEs) emitted from solar flares cause the fairly constant solar wind to behave erratically towards the magnetosphere. When the CMEs comes in contact with the geomagnetic field, it causes it to become more compressed, and therefore raises the field intensity on the surface of the Earth. This occurrence is known as a magnetic storm [1, 2, 3]. One of the effects of a magnetic storm is an ionospheric storm [4, 5].

The coronal mass ejections are energetically the most important transient solar events. The CMEs are huge clouds bubbles of gas threaded with magnetic field lines that are ejected from the Sun. The frequency of CMEs occurs varies with the 11-years solar cycle [6]. The CMEs must be traveling faster than the surrounding solar wind, in order to trigger a magnetic storm. When these CMEs disturbances arrive at Earth, they do not always have the same effect. Only a prolonged southward component (*Bz*) of the Interplanetary Magnetic Field (IMF) is necessary to generate a magnetic storm [2, 3].

In principle manifestation of a magnetic storm is the increase of the ring current intensity, a circular current flowing around the Earth on the equatorial plane [2, 3]. The increase of this current produces a magnetic field disturbance which, at the equator, is opposite indirection to the Earth's dipole field. On the ground, a global decrease of the horizontal component (*H*-component) of the geomagnetic field is observed at the observatory stations. The signature of a geomagnetic storm is identified when a large decreases in the *H*-component below the normal variations measured by a magnetometer.

2.0 The characteristic of Geomagnetic Storm

The geomagnetic storms typically have three phases: initial, main and recovery phases [1] as shown in Figure 1. The initial phase is associated with a positive value of *Dst* (storm sudden commencement - SSC) due to the solar wind dynamic pressure enhancement acting on the magnetosphere. The main phase started when sudden and sharp jump in the Earth's magnetic field (*H*-component) occurring at the onset of the initial phase. The storm main phase is caused by an increase in energetic ions and electrons in the magnetosphere, where they become trapped on closed magnetic field lines and drift around the Earth, thus creating the ring current. The main phase was also found to be associated with sustained southward IMF. The recovery phase is associated with the loss of ring current particles from the magnetosphere caused by northward IMF. Charge exchange and Coulomb scattering have both been identified as major loss processes responsible for the decay of the ring current during the recovery phase of storms. The decay rate of the recovery phases it depends on the present of the ring current.

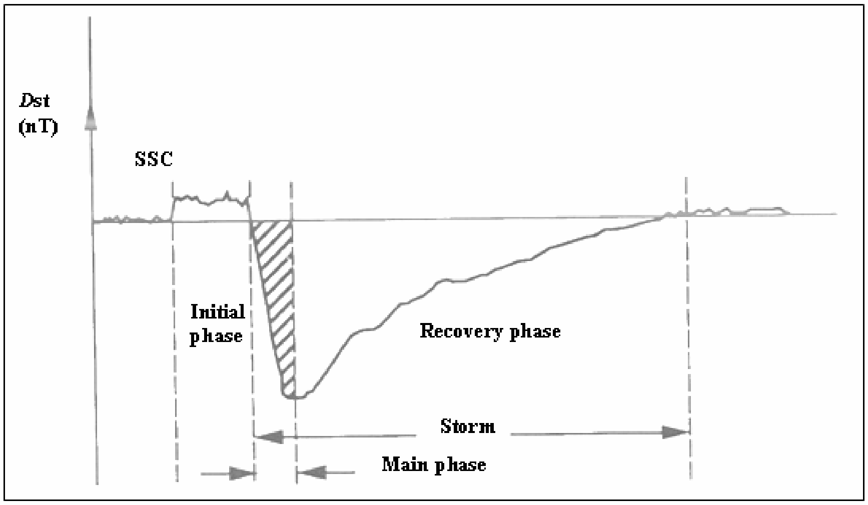

Figure 1: The three phases of a magnetic storm, adapted from Suess and Tsurutani (Ed.) (1998)

3.0 Geomagnetic Index

The geomagnetic indices describe the state of the magnetic field from their data recording [4, 7]. These indices have become useful tools for providing a global picture of geomagnetic disturbances levels. Two standards indices were used.

Dst index - The Dst index is an hourly index represent of the average *H*-components of low-latitude magnetic observatories. This index is derived from hourly scalings of low-latitude horizontal magnetic variation, which monitors worldwide magnetic storm levels. The *Dst* index values indicate the occurrence of a geomagnetic storm. A storm is defined to be intense if ($Dst < -100$ nT), major (-50 nT $> Dst > -100$nT) and minor (-20 nT $> Dst > -50$ nT) [2, 3]. This Dst index is published monthly, as hourly value by the World Data Center for Geomagnetism, Faculty of Science, Kyoto University, Japan.

Kp index – The *Kp* index is originates based on maximum fluctuations range of *H*-component field distributed 3 hours from 13 standards set of the observatories, which lie between 46 and 63 degrees North and South of the geomagnetic latitude stations. This index is considered to be a general picture of global magnetic disturbances level. In magnetic storm events, the *Kp* index is used to confirm the storm time and its magnitude. The *Kp* index is prepared by the University of Gottingen, Germany.

4.0 Data collection

The observation of geomagnetic storms were carried out on June to December 2005 at the newly developed magnetic observatory station at Parit Raja, Batu Pahat (1° 51.3' N, 103° 5.1' E) [8, 9]. A fluxgate magnetometer was used to measure the variations of magnetic components ***H***, ***D*** and ***Z*** with 1 second sampling rate. One minute gaussion filter was applied to the data to produce one-minute data of ***dH***, ***dD*** and ***dZ.***

5.0 Data analysis

Nine geomagnetic storms were detected during seven months observation (see Table 1). The storms were identified by two criteria's; (1). *Dst* index ≤ -50 nT, and (2). *Kp* index ≥ 5. The most intense geomagnetic storms was occurred on 24 August 2006 with *Dst* = -216 and *Kp* = 9. During this storm, the ***H*** component is varying approximately ~800 nT.

Table 1: Magnetic storms observed between June and December 2005

No.	Date Events	Time (LT)	Kp Index	Dst Index	Storm Class
1.	13 June 2005	0115 - 0600	7+	-106	Intense
2.	23 June 2005	1400 - 2100	7_0	-97	Major
3.	10 July 2005	1945 - 2215	6+	-94	Major
4.	12 July 2005	1815 - 2000	6+	-85	Major
5.	18 July 2005	1000 - 1700	5+	-76	Major
6.	24 August 2005	1700 - 1900	9−	-216	Intense
7.	31 August 2005	2000 - 0145	7_0	-131	Intense
8.	11 September 2005	1400 - 1815	8−	-147	Intense
9.	15 September 2005	1815 - 0015	7_0	-74	Major

During this event, the development of the main phase corresponded to the evening hours (local time), and it was followed by a fluctuating recovery phase. The storm's sudden commencement (SSC) in the form of a sharp increase of *Dst* at 1415 LT (Local Time) on 24 August 2005 is shown in Figure 2. The maximum value of the *Dst* variation amplitude equal to -216 nT was registered at 1900 LT.

The maximum values of the *Kp* index during this magnetic storm were 8-9. The beginning of the magnetic disturbance at 1700 LT is clearly manifested by the sharp jump of the ***H***-component of the magnetic field. After that, deep variations of the magnetic field were observed until 1200 LT on 25 August. Later, they changed to relatively smooth variations in the component until 2000 LT on 25 August and then again an increase of strong variations in the geomagnetic field occurred and continued until 25 August.

Figure 3 shows the characteristics of the magnetic field components ***dH***, ***dD*** and ***dZ*** observed during the storm. It is seen that the ***dD*** and ***dZ*** components variations exhibit a different pattern, where the ***dD*** has its minimum at 1930 LT, while the ***dZ*** has shown a variation opposite to that of the ***dH*** with maximum value at 1900 LT. The decrease of the ***dH*** and reversal of the ***dZ*** indicates that the belt of ring current flows in the reverse direction with respect to the normal West-East equatorial electroject flow [10].

Figure 4 displays the power level in ***H***-component has broad enhancement from 1000 LT to 2200 LT with frequencies lower than 250 mHz. When the analysis is restricted to a magnetic storm, the power peaks occur from 1500 to 2100 LT. As can be seen, the onset of the power intensification shifts at higher frequencies. The frequency of the power maxima increases from ~33 mHz at 1230 LT to ~50 mHz at 1600 LT. Power spectra density using FFT (Figure 5) of ***H***-component confirmed the power peaks occurred at frequencies ranging from ~7, ~20, ~35, ~50 and ~80 mHz.

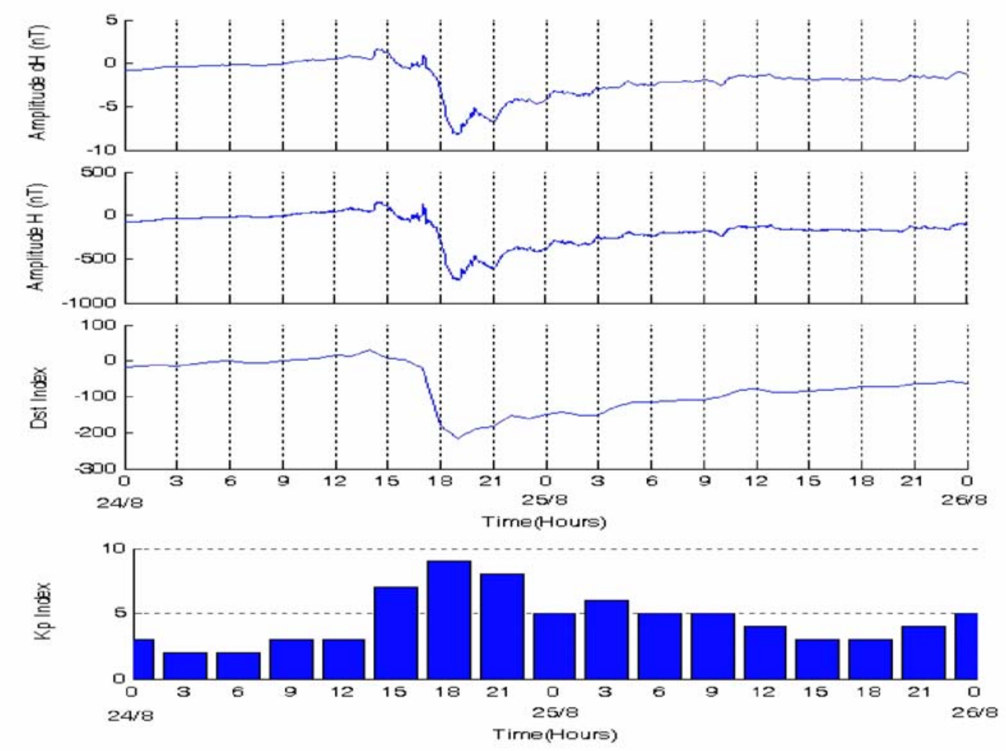

Figure 2: The variations of the ***H*** and ***dH*** components during the magnetic storm and its related indices (*Dst* and *Kp*), observed on 24 and 25 August 2005

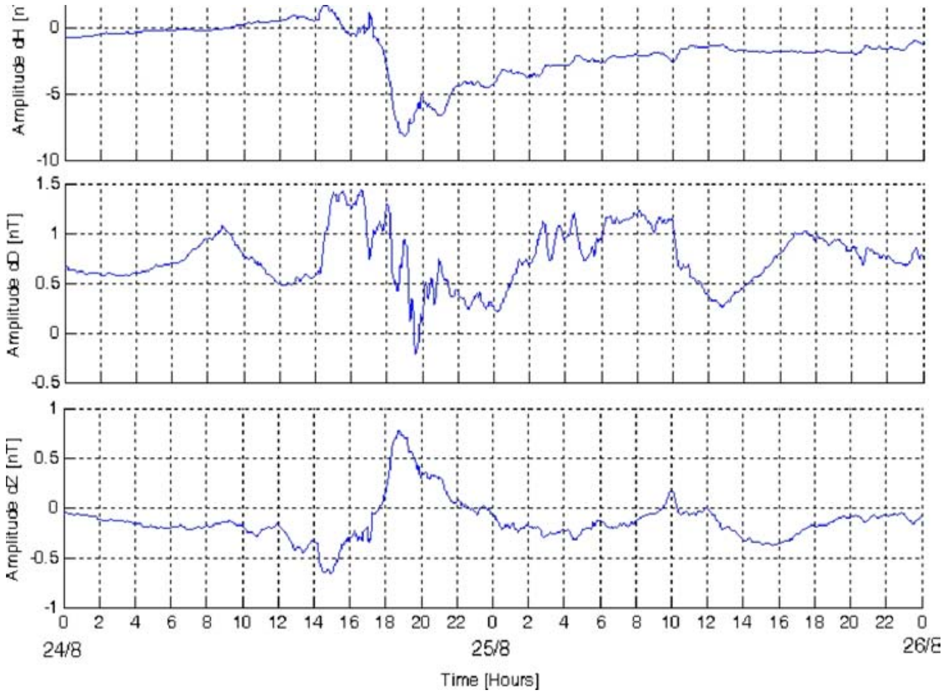

Figure 3: The characteristics of the magnetic field components ***dH***, ***dD*** and ***dZ*** observed during the magnetic storm from 24 to 25 August 2005

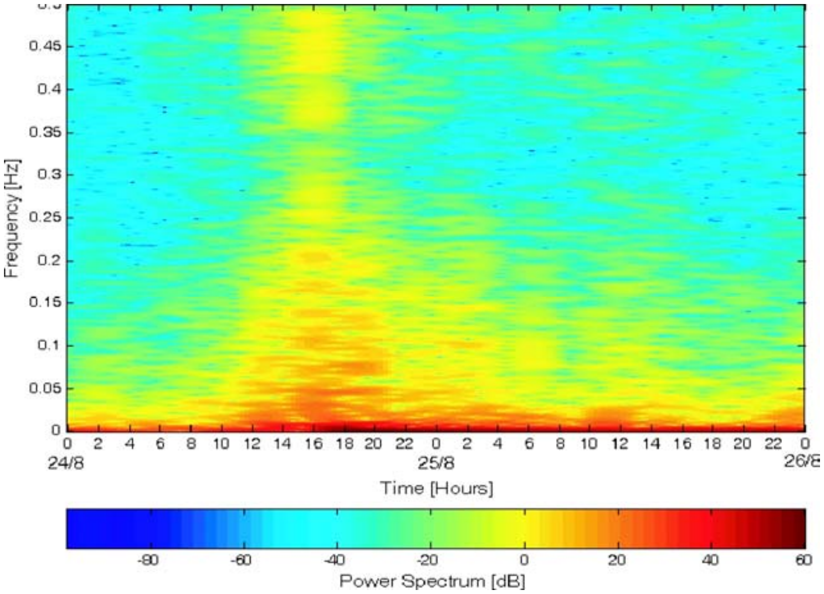

Figure 4: Spectrogram of ***H***-component data for the magnetic storm event on 24 to 25 August 2005

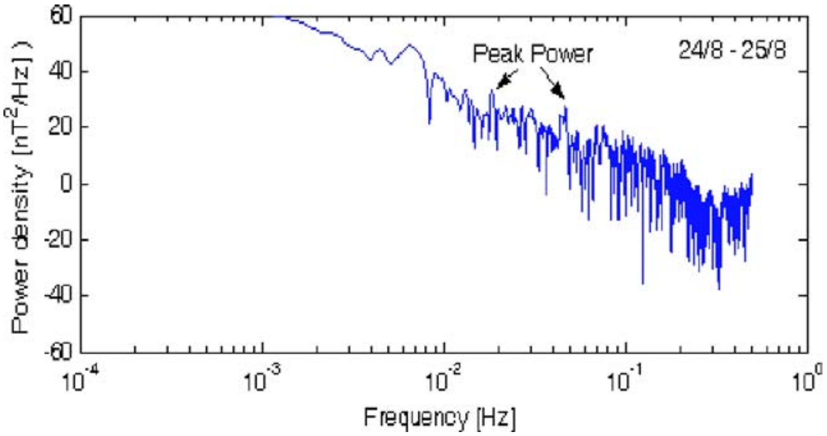

Figure 5: Power spectra density of ***H***-component identified power peaks occurred at frequencies ranges ~7, ~20, ~35, ~50 and ~80 mHz

6.0 Discussions

Nine geomagnetic storms were detected during seven months observation. The storms were observed only on months of June to September. Six storms were observed during daytime and three during nighttime. The magnetic storms were frequently observed around local noon (1400 - 2000 LT). The ratio of the number of magnetic storms occurring on the dayside to the night side was about 66%. This study also provided the opportunity to validate a global *Kp* and *Dst* indices in Malaysia environment. A comparison of the *H*-component variations obtained from the newly developed observatory and the global *Kp* and *Dst* indices shows a reasonable agreement during the storm periods.

7.0 References

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