ARPN Journal of Engineering and Applied Sciences

VARIATION OF VHF/UHF OF FORWARD SCATTERING RADAR DUE TO SOLAR RADIATION

Afifah Taat[1,2], Nor Ayu Zakaria[2], Atiqah Abdul Rahman[2], Mohamad Huzaimy Jusoh[1,2] and Zairi Ismael Rizman[3]

[1]Applied Electromagnetic Research Group, Advanced Computing and Communication Communities of Research, Universiti Teknologi Mara, Shah Alam, Selangor, Malaysia

[2]Faculty of Electrical Engineering, Universiti Teknologi Mara, Shah Alam, Selangor, Malaysia

[3]Faculty of Electrical Engineering, Universiti Teknologi Mara, Dungun, Terengganu, Malaysia

E-Mail: huzaimy@salam.uitm.edu.my

ABSTRACT

The performance of radio detection and ranging also known as RADAR has been investigated from the other researcher due to space weather effects. This research study is to investigate the variation of VHF/UHF due to solar radiation to the effectiveness of Forward Scattering Radar (FSR) during quiet period. The measurements were taken in mix environment area with four different frequencies in VHF (64 MHz, 135 MHz, 173 MHz) and UHF (434 MHz). The Doppler's raw data of different frequencies for 2 days within 24hours is collected and plotted by FSR and MATLAB Software respectively. The clutter received is varied during day and night time. This research has calculated the average percentage APD% for four frequencies of VHF and UHF. The percentage analysis of day and night time shows obviously that the higher frequency is more sensitive to the reflection due to shorter wavelength. Besides, the amplitude of signal strength is higher during night time compared to day time. The result has concluded that the low frequency (64 MHz) is more robust to solar radiation due to long wavelength and lack of sensitivity for data transmission. This research as a preliminary for further investigation and research on the variation of radio propagation.

Keywords: VHF/UHF, solar radiation, forward scattering radar, average percentage, day and night time, quiet day.

INTRODUCTION

Solar activity is refer to conditions on the sun that can be influenced the performance of the ground based technology systems. In recent decades, it has indeed been shown that the total amount of sunlight received by the earth varies with 11-year cycle of solar activity. The amount of the sun`s ultraviolet and X-ray radiation, which is absorbed in terrestrial atmosphere varies by enormous factors of 100 or more over the activity cycle. The radiation of solar contributes to ionization of particles in the atmosphere by heat energy which affects the strength of the transmission radio waves. Solar radiation is radiant energy emitted by the sun that ranges from gamma rays to radio waves [1]. The role of the sun in our solar system is to provide the main energy input that yet effects the interplanetary perturbation and energetic particles fluxes. The radiated energy of Sun outward into the heliosphere that carried the energy by the electromagnetic waves over the frequency band, a stream of hot plasma (solar wind), the interplanetary magnetic field (IMF) and violent solar out breaks solar flares and Coronal Mass Ejection (CME) [2].

In this research study, the Forward Scattering Radar (FSR) is used to investigate the variation of amplitude signal strength data in four frequencies. The more robust frequency is identifying from the trend of Doppler signal graph during day and night time. The FSR has some of advantages such as lower maintenance costs and simple hardware, which is an enhanced radar cross section of the target due to environmental conditions compared to monostatic radar. FSR also has disadvantage including the absence of range operation and resolution within narrow angles in proportional to the transmitter and receiver baseline [3]. The high noise such as solar radiation contributing to the received signal may significantly affect the transmission signal. The data is collected at United Kingdom (UK) on September 2009 (in autumn season). The equipment setup is based on a set of radars on a ground surface with an expected distance of 100 m between nodes in mix environment. A target crossing the FSR baseline shadows the transmitted electromagnetic (EM) field and produces a variation in the received signal strength at different time. The Doppler signal of the target selected by the receiver and four different frequencies bands are used in VHF (64 MHz, 135 MHz, 173 MHz) and UHF (434 MHz). The MATLAB software is used to process and plotted the raw data from Doppler signal. The signal is varied following the time such as during day and night time due to the effect of solar radiation during quiet period. The objectives of this project are to investigate the variation of amplitude of signal strength data at four frequencies to see the trend of Doppler within 24hours, and to identify which frequency is more robust to the solar radiation from analyses the trend of received signal data.

METHODOLOGY

Experimental site

The measurements were taken in mix environment area shown in Figure-1. An omnidirectional antenna is connected to the particular monitor to records VHF and UHF radio waves transmitted. Measurements of clutter were made at four different frequencies in the VHF (64 MHz, 135 MHz and 173 MHz) and UHF (434 MHz) bands with distance of 100m between nodes in mix

ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

environment area. The radar baseline was clear from vegetation, but it was surrounded by trees and brushes. The device is connected to a computer and the signal strength of all frequencies has been measured continuously for 2 days.

Figure-1. Measurement set-up.

The VHF and UHF radio waves include the clutter data were recorded on the personal computer using MATLAB software. The data were recorded to transfer analog data into digital values by the computer. The program measures the signal strength and record the data every 20 minutes for all four frequencies.

Data processing and analysis

The collected raw (Doppler) data is recorded every 20 minutes for 2 days and stored as amplitude of signal strength versus time frame in a bin formatted file. The data collected at four frequencies is totally 180 data. Before analyze the data, it is segmented into the day and its frequency for every 20 minutes. Then, convert the raw data which have target signal and clutter using MATLAB software, program a code to call required name file into graph to ease for the next process.

After segmenting the data, it needs to merge into a graph of one day (24hours). Later, the target signal in the data is removed to get clear clutter signal only. In data analysis process, the data is analyzed to investigate the trend of clutter during day until night and identify which frequency is more robust to the solar radiation from the variation of received signal strength. The data processing method is illustrated in Figure-2.

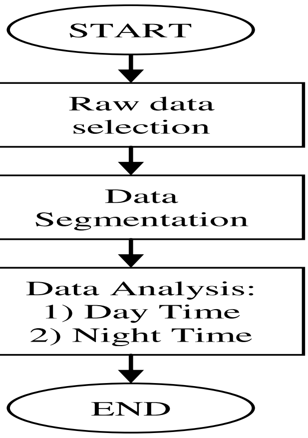


Figure-2. Data processing method.

Radar bands

Radar systems work in a wide of transmitted frequencies band. The higher the frequency of a radar system, the more it is affected by weather conditions such as rain or wind. Figure-3 shows the ranges of waves and frequency used by radar.

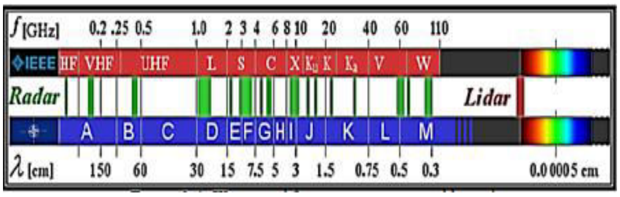


Figure-3. Waves and frequency ranges used by radar.

In this case, VHF (64 MHz, 135 MHz and 173 MHz) and UHF (434 MHz) bands is used. The propagation characteristics of A and B-Band (VHF-Radar) (30MHz-300MHz) are most suitable in terrestrial communication for short distance with a range normally farther than line-of-sight from the transmitter. It is also less affected by atmospheric noise and interference from electrical equipment. C- Band (UHF-Radar) (300 MHz-3 GHz) signal is used for target detection. Both VHF and UHF bands are used for intercommunication between nodes and target detection and target parameters estimation [4].

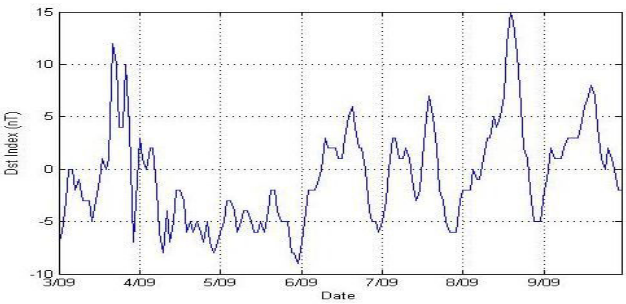
Quiet period

The observation and data of the space weather on 3rd September 2009 until 9thSeptember 2009 have been collected from ACE Real Time Data and World Data Centre (WDC) Kyoto. The raw data that considered in this study which are a) Dst index and b) Solar wind input energy and IMF Bz. Figure-4a) shows that the minimum Dst index is -9nT at 2400UT which is in range -30nT < Dst > 0 nT and clarified as quiet day. For Figure-4b), shows the graph of IMF Bz (blue) and SW input energy (green). It is shown the reconnection process is occurred between SW and earth during southward orientation [5]. The SW input energy high recorded at 1.55×10^{18} ergs on 4th September 2009 when the IMF Bz turned southward to

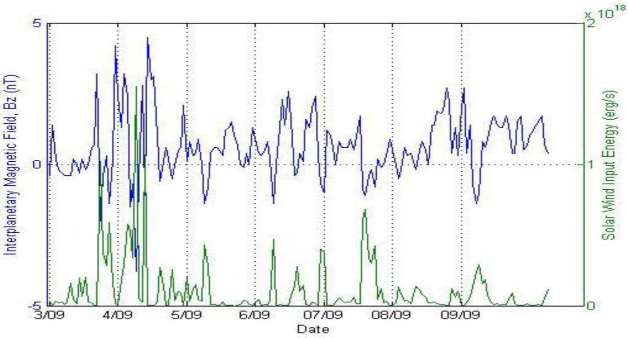
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

earth`s direction. Thus, it is considered as quiet period based on the SW parameters.



(a)



b)

Figure-4. Space weather parameters a) Dst index on 3rd Sept -9th Sept 2009 b) Solar wind input energy (green) and IMF Bz (blue).

Average percentage difference

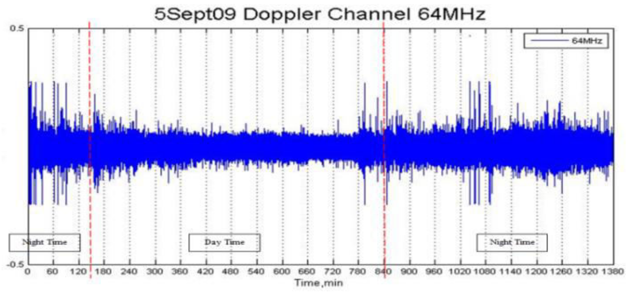
Average Percentage Difference, APD is a measure the difference between two values [6] which is in this case between average amplitude difference at night and the day as expressed in Equation. (1). Then, it divided by the averages of the two values. The percentage difference of signal strength for each frequency is calculated to compare the robustness of frequency. Lower APD of a frequency means that the frequency is less effected or more robust to the unwanted signal such as solar radiation.

$$APD(n-d) = \left|\frac{AADn - AADd}{(AADn + AADd)/2}\right| \times 100 \quad (1)$$

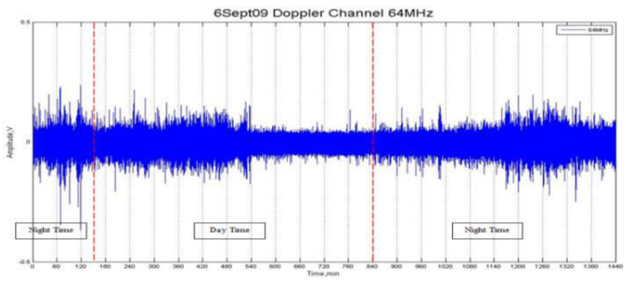
RESULTS AND ANALYSIS

In this section the variations at VHF and UHF frequency has been observed. The observation is done for 24hours for two days from 5th September 2009 to 6th September 2009. This finding of study is assist to understand the penetration of solar energy into the earth. At the Figure-5 until Figure-8, there are 8 graphs that where red line represent the borders between day and night time at Horton Grange in Birmingham. These analyses will help to make the comparison on frequency variations. The data recorded every 0.00083 minutes and the total for a day is 1440 minutes (24h). The data on Table-1, Table-2, Table-3 and Table-4 show the average of the amplitude (signal strength) difference for every hour during the day and night time.

Figure-5a) and Figure-5b) show the amplitude (signal strength) of 64 MHz for 2 days which are from 5 to 6 September 2009. Consistent trend of signal strength of 64 MHz were observed in the 2 days. There was an increase in the signal strength after sunset and it decrease before sunrise as seen in Figure-5a) and 5b). The received signal strength is between -0.25V and 0.25 V for the whole day (24 hours). We can see the trend of clutter, there is barely different during the day and night. The signal strengths of the frequency are low due to lack of sensitivity.



a)



b)

Figure-5. Signal strength of 64 MHz on a) 5th September 2009 and b) 5th September 2009.

Table-1. Average amplitude difference, AAD for 64MHz.

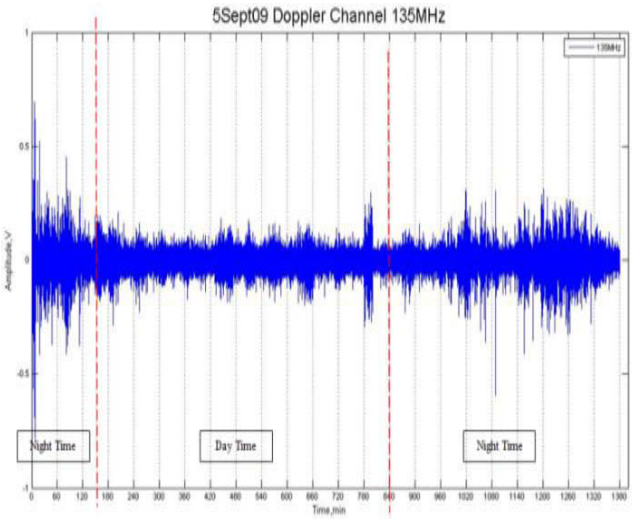
Time (LT)	Day	Time (LT)	Night
7:00	0.07843	19:00	0.1443
8:00	0.09766	20:00	0.1486
9:00	0.09659	21:00	0.1616
10:00	0.07584	22:00	0.1741
11:00	0.09155	23:00	0.1811
12:00	0.06622	00:00	0.1927
13:00	0.1103	1:00	0.2507
14:00	0.1505	2:00	0.2208
15:00	0.1524	3:00	0.1643
16:00	0.1332	4:00	0.1245
17:00	0.2344	5:00	0.1517
18:00	0.1283	6:00	0.1077

ARPN Journal of Engineering and Applied Sciences

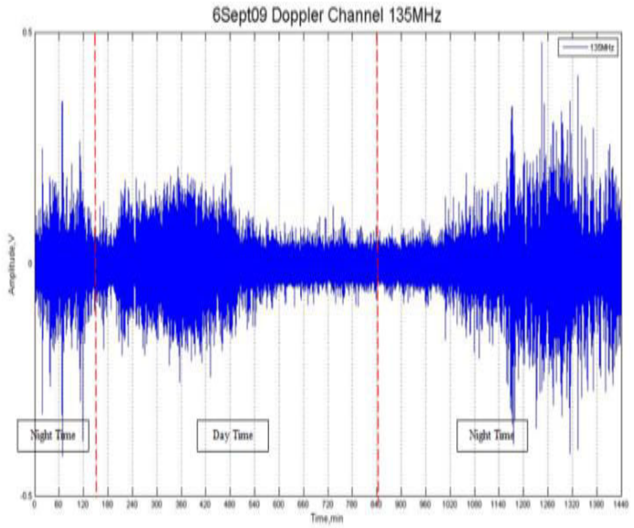
www.arpnjournals.com

AAD_d	**0.1179**	AAD_n	**0.1685**

From the graph shown in the Figure-6a) and Figure-6b), the signal strength of 135 MHz for 2 days is slightly increased during the night where the range of amplitude (signal strength) is between -0.35V and 0.35V. There was an increase in the signal strength from 7.00pm to 10.00pm. The trend of clutter is slightly different the signal strength during the day and night.



a)



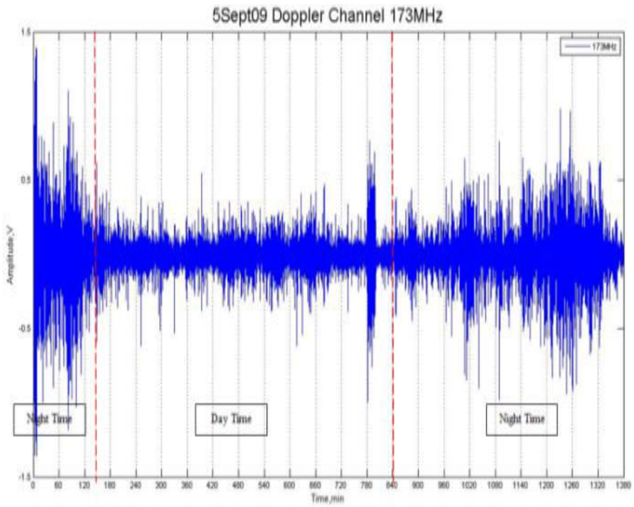
b)

Figure-6. Signal strength of 135 MHz on a) 5th September 2009 and b) 5th September 2009.

Table-2. Average amplitude difference, AAD for 135MHz.

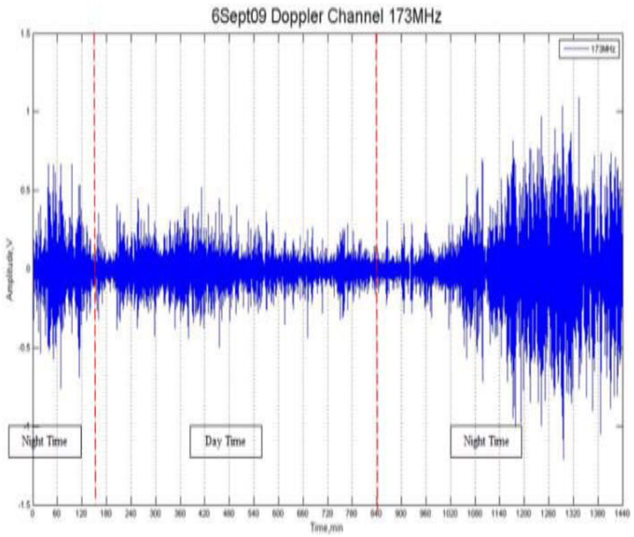
Time (LT)	**Day**	**Time** (LT)	**Night**
7:00	0.295	19:00	0.3397
8:00	0.2094	20:00	0.3448
9:00	0.1175	21:00	0.3278
10:00	0.08743	22:00	0.271
11:00	0.1013	23:00	0.2553
12:00	0.1231	00:00	0.2388
13:00	0.07996	1:00	0.265
14:00	0.08011	2:00	0.134
15:00	0.0946	3:00	0.1794
16:00	0.1434	4:00	0.1709
17:00	0.1942	5:00	0.2087
18:00	0.1587	6:00	0.1926
AAD_d	**0.1404**	AAD_n	**0.244**

The graph in Figure-7a) and Figure-7b) show that the amplitude was an increase in the signal strength after sunset. The received signal strength is in range between -1.0V and 1.0V for the whole day. While, low signal strengths is noticed through the day. The received signal strength is higher during the night compared to the day.



a)

ARPN Journal of Engineering and Applied Sciences



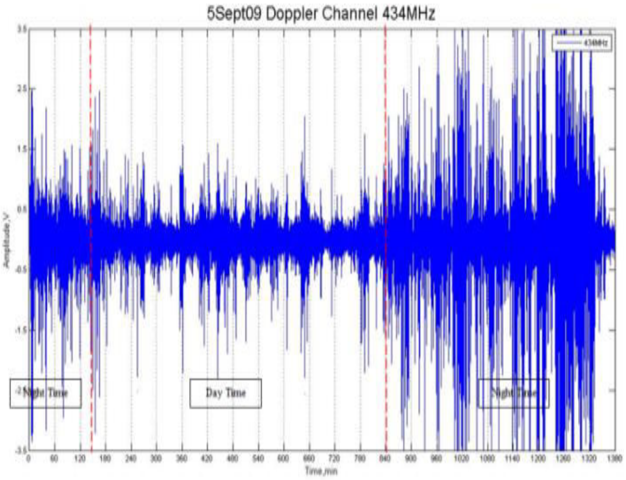
b)

Figure-7. Signal strength of 173 MHz on a) 5th September 2009 and b) 5th September 2009.

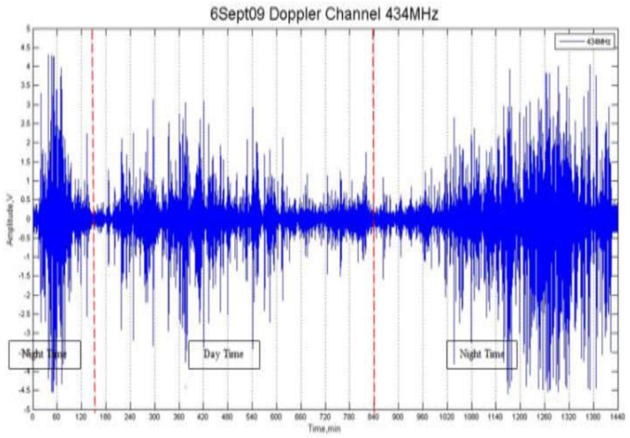
Table-3. Average amplitude difference, AAD for 173MHz.

Time (LT)	Day	Time (LT)	Night
7:00	0.4451	19:00	0.8051
8:00	0.4019	20:00	0.9695
9:00	0.3625	21:00	0.9886
10:00	0.2338	22:00	0.7214
11:00	0.2467	23:00	0.7364
12:00	0.2852	00:00	0.845
13:00	0.1842	1:00	0.5298
14:00	0.3038	2:00	0.3543
15:00	0.2838	3:00	0.4073
16:00	0.2803	4:00	0.4427
17:00	0.5971	5:00	0.3065
18:00	0.5145	6:00	0.5191
AAD_d	0.3449	AAD_n	0.6354

In Figure-8a) and Figure-8b), signal strength is obviously high which is between -5.0 and 5.0 from 3.00 pm until 11.00 pm. The signal strength is almost same as the day before from 5.00am until 8.00 am and 7.00 pm until 11.30 pm as shown in Figure-8a). The low signal strength is observed during the day from 10.30 am until 4.00 pm. The received signal strength is high during the night compared to the day. The signal strength of the frequency is higher than other three frequencies due to the higher sensitivity of the frequency.



a)



b)

Figure-8. Signal strength of 434 MHz on a) 5th September 2009 and b) 5th September 2009.

Table-4. Average amplitude difference, AAD for 434MHz.

Time (LT)	Day	Time (LT)	Night
7:00	2.285	19:00	2.939
8:00	2.077	20:00	3.154
9:00	1.977	21:00	4.938
10:00	1.013	22:00	3.552
11:00	1.16	23:00	3.935
12:00	1.001	00:00	0.7349
13:00	1.015	1:00	2.502
14:00	0.629	2:00	1.114
15:00	0.8472	3:00	2.083
16:00	1.123	4:00	2.346
17:00	1.376	5:00	2.166
18:00	1.911	6:00	3.06
AAD_d	1.3679	AAD_n	2.7103

VOL. 12, NO. 10, MAY 2017 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

DISCUSSIONS

Graph in Figure-5 until Figure-8 shown the Doppler signal before sunrise and after the sunset there was an increase in the signal strength at the location. The data in Table-1, Table-2, Table-3 and Table-4 are obviously shown that the average of the amplitude (AAD) signal strength is higher during the night compared to the day time. This is because the solar radiation contributes in heat energy creation that can degraded the transmitted signal during the day.

In this process, atmospheric particles are absorb sunlight and transferred it into heat energy. Some particles and gases in the atmosphere have the ability to absorb incoming insolation when intercepted occur. Absorption is a process in which a substance retains the solar radiation and converts it into heat energy. Heat energy creation also causes the substance to emit its own radiation. The absorption of solar radiation by substances in the atmosphere results in temperatures. The atmospheric scattering process causes sunlight rays to be redirected to a new direction after hitting a particle in the air. Small particles and gas molecules spread out part of the incoming solar radiation in random directions without any changes to the wavelength of the electromagnetic wave as a scattered process [7].

Energy emitted from a source is referred as radiation such as heat or light from the sun. Ionizing radiation is a process to remove bound electrons from an atom orbit by radiation with enough energy during an interaction with an atom causing the atom to become charged or ionized. Lower frequency radio waves have less energy due to its longer wavelength compared to higher frequency waves with its shorter wavelength [8]. It is shown obviously the different variations between day and night time in Figure-9 and Figure-10. The variations of the signal are higher during night time compared to day time. During day time, ionizing radiation enters the atmosphere, it collides with oxygen molecules. The shortest energy waves from the sun are absorbed by the oxygen molecules, these waves that ionize the particles [9]. Therefore, the signal strength fluctuates because of the amount of absorption. The radiation of the Sun contributes to atmosphere ionization, which can change the strength of the transmitted radio waves [10].

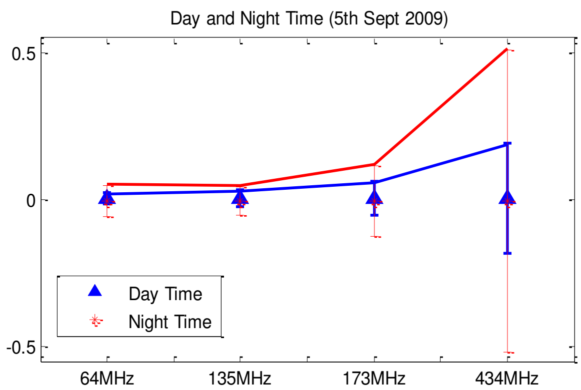


Figure-9. Variation different between day and night time on 5th Sept 2009.

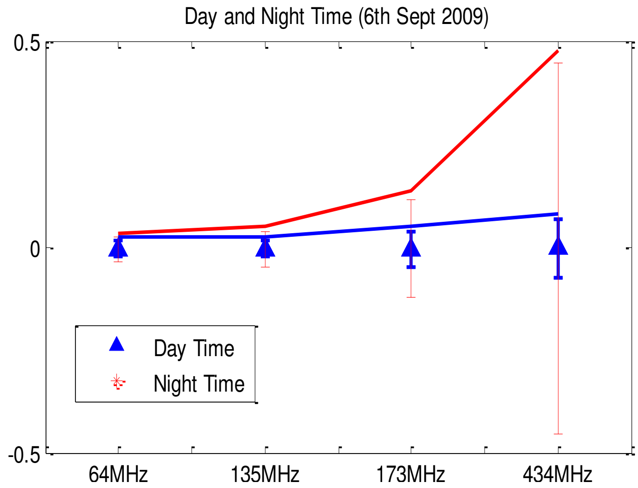


Figure-10. Variation different between day and night time on 6th Sept 2009.

In additional, Figure-11 and Table-5 show the lowest average percentage difference of signal strength during the day and night time is at the frequency of 64MHz which is 35.34%. The lower the average percentage difference of signal strength means that the frequency is more robust to the unwanted signal such as solar radiation. Based on the observation of the signal strength, we can conclude that frequency of 64 MHz is more robust to the solar radiation due to its lack of sensitivity. The lower frequency has longer wavelength. The absorption by the intervening particles on the transmitted energy is drastically reduced when using the longer wavelength. The lower frequency waves penetrate materials better because photons with lower frequencies not have enough energy and simply pass through without interacting with the matter. It is suitable for the transmission of radio waves in communication system.

Table-5. Average percentage difference, APD %.

Frequency (MHz)	**Average percentage difference, APD** (%)
64	35.34
135	53.90
173	59.27
434	65.83

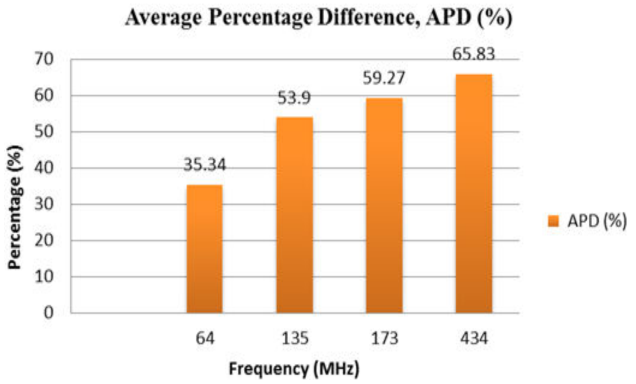


Figure-11. Graph of average percentage difference for four frequencies.

CONCLUSIONS

Radio waves propagation is affected by the ionization particles in the atmosphere, due to heat energy produced by the Sun. The signal strength of four frequencies using FSR is lower during the day compared to the night due to the disturbance in transmitted signal by heat energy. Besides that, there also a few other factors that affect the signal strength (clutter) which are surrounding strong wind, rainfalls and other atmospheric reflection. The higher frequency, it is more sensitive due to the smaller wavelength. We can conclude that frequency of 64 MHz is more robust to the solar radiation due to the long wavelength and its lack of sensitivity. It is suitable for the transmission of radio waves in communication system. This topic has the potential to further study in analysis of factors that affect the signal strength of radio waves during the day and night.

ACKNOWLEDGEMENT

We acknowledge ACE Real Time Data and World Data Centre (WDC), Kyoto for providing the data of Dst Index Solar wind input energy and IMF. This work is financially supported by Sultan Mizan Antarctic Research Foundation, YPASM (Code No.YPASM/RGrant/12-2014/JLD. 1(23)), Fundamental Research Grant Projects, FRGS (Code No.600-RMI/FRGS 5/3(140/2014)) and Research Acculturation Grant Scheme, RAGS (600- RMI/RAGS 5/3(155/2014)). We also would like to thank Universiti Teknologi MARA for the management support and consideration throughout the project.

REFERENCES

[1] B. A. Ezekoye and R. M. Obodo. 2007. The effects of solar radiations on telecommunications. Pacific Journal of Science and Technology. 8(1): 109-117.

[2] R. K. Mishra and P. C. Pandey. 2015. The effect of solar radiation on telecommunications. International Journal of Engineering Science Invention Research and Development. 2(6): 324-335.

[3] D. Contreira, F. S Rodrigues, K. Makita and C. G. Brum. 2004. An experiment to study solar flare effects on radio-communication signals. Advances in Space Research. 36(12): 2455-2459.

[4] Cherniakov M., Chapurskiy V. V., Abdullah R. R., Jancovic P. and Salous M. 2004. Short-range forward scattering radar. In: International Radar Conference. pp. 322-328.

[5] Kasran F. A. M., Jusoh M. H., Ahmad S. N. A. and Ibrahim S. N. 2015. Geomagnetic disturbance during quiet period at low latitude station. In: IEEE International Conference on Space Science and Communication. pp. 273-276.

[6] D. A.Gilbert, N. Lehman, S. J. Brien and R. K. Wayne. 1990. Genetic fingerprinting reflects population differentiation in the California Channel Island fox. Nature. 344(6268): 764-767.

[7] Pidwirny M. 2006. Atmospheric effects on incoming solar radiation: Fundamentals of physical geography. 2nd Ed.http://www.physicalgeography.net/fundamentals/7f.html.

[8] G. H. Millman. 1958. Atmospheric effects on VHF and UHF propagation. Proceedings of the IRE. 46(8): 1492-501.

[9] Khanal S. 2004. The effect of solar flares on the VLF radio waves transmitted in the ionosphere.http://solar-center.stanford.edu/SID/docs/effect-of-flares.ppt.

[10] Sankaran S. and Ehsani R. 2014. Introduction to the electromagnetic spectrum. In: Imaging with Electromagnetic Spectrum. A. Manickavasagan and H. Jayasuriya (Eds.). Springer-Verlag Berlin, Germany. pp. 1-15.

[11] Burrows R. and Attwood S. S. 1949. Radio wave propagation. Academic Press Inc. Publishers, New York, USA.