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THE INFLUENCE OF SOLAR RADIATION ON RADIO SIGNAL AT UHF BAND

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ABSTRACT

One of the common threats to earth-space communication is the data loss, which is possibly caused by weather factors. In this paper, the effect of solar radiation on radio signal at ultra-high frequency (UHF) band is investigated. The average radio frequencies found at UHF band were 382.5 MHz, 945.0 MHz, 1800.0 MHz, 1867.5 MHz and 2137.5 MHz. The variation of all prominent peaks begins during sunrise and sunset, where all most of the prominent peaks show weak signal strength during the daytime compared during the night time. We can conclude that the radio signals were depending on the presence of solar radiation and the level of solar radiation measured during daytime and night time as solar radiation measured differently as 376.0246 W/m^2 and 428.9846 W/m^2 during 26th July and 27th July respectively.

Keywords: radio frequency interference; solar radiation; UHF band; correlation analysis; radio frequency attenuation.

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1. INTRODUCTION

1.1. Communication Loss in UHF Band

Ranging from 300 to 3000 MHz, UHF band was commonly used by telecommunication services. Different types of wave are used in these services, according to its purposes. Like GPS and shortwave broadcast services, space wave was used to transmit data from transmitter to the receiver. Common issues arise from transmitting space wave data are the data loss.

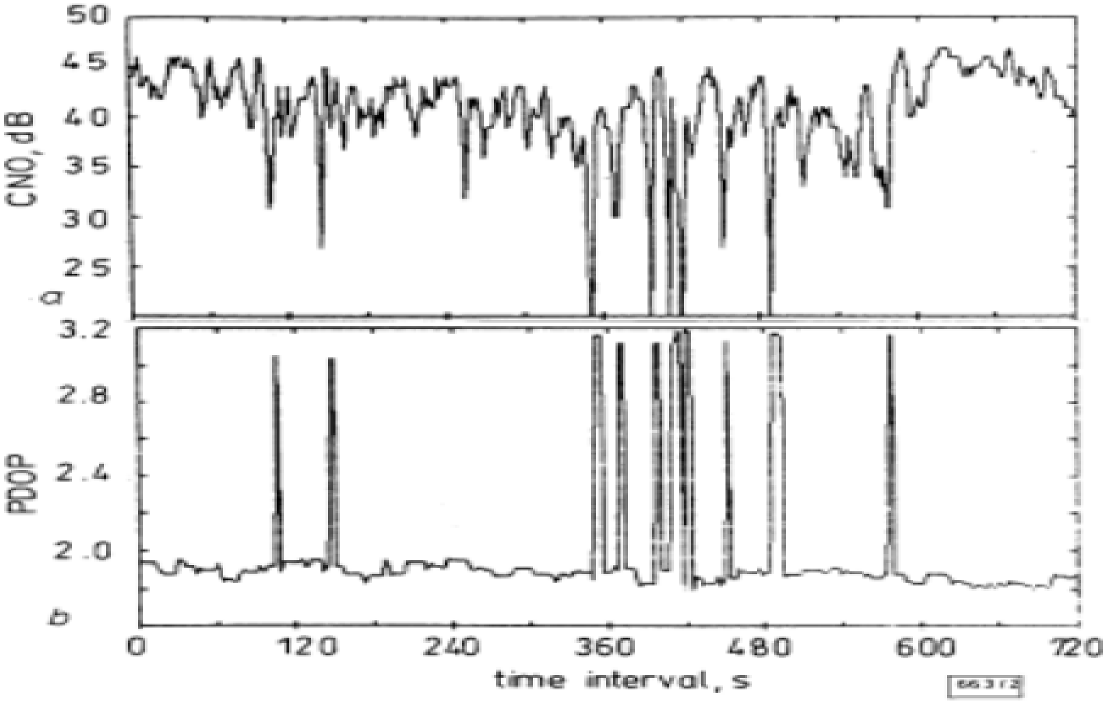

Fig.1. Variation of CNO of GPS corresponding to PDOP factor in Calcutta [1]

A study conducted over the Brazilian territory shows that the variation of the Global Positioning System (GPS) was caused by magnetic activity in April 2000 and November 2003. The data collected differed from each other despite both periods were taken during active geomagnetic activity. During April 2000, geomagnetic index (Dst) measured -300 nT which considered as an intense geomagnetic storm and cause large variation to the data. Meanwhile, during November 2003, geomagnetic storm suppressed the GPS amplitude scintillations data. Similarly, in [2] found that during intense scintillation (post sunset hours, late evening hours and around midnight), the GPS accuracy of position fixing deteriorates. In the same vein, in [1] reported that both GPS links and geostationary satellite links suffered from signal fading which associated with the earth's ionosphere. The variations of carrier-to-noise ratio (CNO) of

GPS signal with the corresponding position dilution of precision for satellite Sv27 as shown in Fig. 1.

1.2. Effect of Solar Radiation

Solar radiation usually correlates with the numbers of free electron ionized in the ionospheric level. These free electrons have great influence on the radio wave especially one that passes through the ionosphere; sky wave and space [22-23] wave. A study by [3] examined the effect of tropical weather on radio signal which is solar radiation, wind speed, temperature, humidity and rain rate. In [3] identify solar radiation and humidity as the most parameters that have a significant effect on a radio signal. The study was statistically calculated to produce more reliable results. It was suggested that high solar radiation is related to the ionization in the ionospheric layer.

Solar radiation is the consequences from solar activity such as solar flare, sunspot number (SSN), solar burst and prominence. In an analysis of the effect of sunspot number on radio propagation, in [4] found that SSN has a large influence on high frequency (HF) systems during the daytime. The study was conducted from 2009 until 2011 during the early solar cycle 24 by comparing the data in morning, evening and night period. As more SSN producing more radiation from the sun during the daytime, ionized layer enables the penetration of HF transmission to propagate. In contrast, low frequency (LF) transmissions were absorbed by the ionosphere during the daytime.

In [5] discussed that the relation of propagation in UHF and L bands were closely related to the ionospheric condition. They suggested the effect of ionospheric on UHF propagation included Faraday rotation, time delay, refraction, change in direction of arrival, absorption in the auroral and polar cap, absorption at mid-latitude and dispersion. Communication engineer is suggested to be alert with these possible effects that will attenuate the propagation of radio wave, especially for GPS and satellite application that used UHF and L band as their propagation medium.

In this study, the effect of solar radiation on radio signal in UHF band was investigated for a month in July 2016. Further discussion was elaborated in section 2. The methodology used in this study was described in section 3 and the conclusion was drawn in section 4.

2. RESULTS AND DISCUSSION

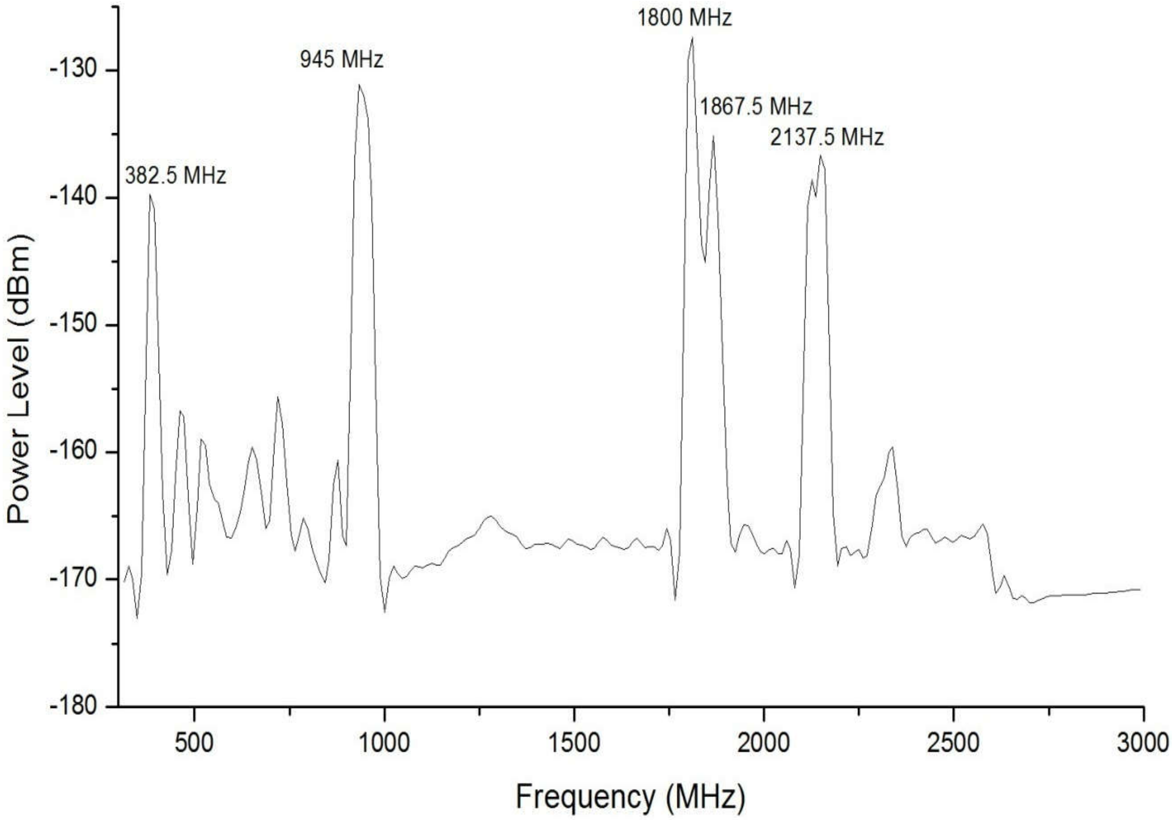

Fig.2. Average radio signal detected in July 2016

The average radio signal measured in BCK for 24 hours observation during July 2016 was shown in Fig. 2 with average power level of -164.2211 dBm (± 9.3237). Most of the prominent peaks were coming from telecommunication services as tabulated in Table 1 due to the users from nearby residential area and the Redang Jetty located 1.0 km away and 1.9 km away from BCK respectively. The frequency users increase as approach the residence area as according to [6-8], the RFI level increases with the population density and vice versa.

Table 1. Prominent peaks and its sources (MCMC) [9-10]

Peak (MHz)	Power Level (dBm)	Sources
382.5	-139.7360	Digital trunked radio system
945.0	-131.8785	Celcom FDD Downlink (EGSM/GSM)/(IMT)
1800.0	-129.2388	Broadband wireless access
1867.5	-135.0932	Cellular mobile services (EGSM/GSM) / (IMT)
2137.5	-139.9377	Maxis FDD Downlink

The relation between power level and solar radiation was given by the Fig. 3. Throughout the observation, there were some data losses due to instrument impairment during the night. The observation during the daytime and night time was compared in Table 2. The power level for most prominence peaks was seen higher during the night due to the absence of solar radiation compared during the day.

It is also seen that the radio signal was lower during the daytime in 27th July compared to 26th July. The ionosphere was ionized more during the high solar radiation day. This can be seen in solar radiation value where it achieved 376.0246 W/m^2 and 428.9846 W/m^2 during 26th July and 27th July respectively. The presence of solar played the most important role in producing solar radiation with some interfering from cloud covers that cause the difference in solar radiation during the day.

Table 2. Variation of prominent peaks during day and night

Frequency	**Average Power Level (dBm)**		
	Day 26th July 2016	**Night 26th July 2016**	**Day 27th July 2016**
382.5MHz	-140.3317	-139.5327	-139.7593
945 MHz	-132.1910	-131.3201	-132.3706
1800 MHz	-129.8887	-129.6284	-128.6151
1867.5 MHz	-134.0734	-134.0599	-136.500
2137.5 MHz	-140.4733	-138.7027	-141.0761

Closer inspection of Table 2 show all prominent peaks decrease in average power level as the sunrise. It is apparent from Fig. 3 that the variation of radio signal starts during sunset and sunrise. During these two occasions, free electron increased in the ionosphere and actively attenuate radio signal. These results seem to be consistent with other research which found that radio waves are influenced by free electrons during sunrise and sunset. This is because ionospheric condition becomes unstable during these two occasions as it is ionized and producing free electrons [11].

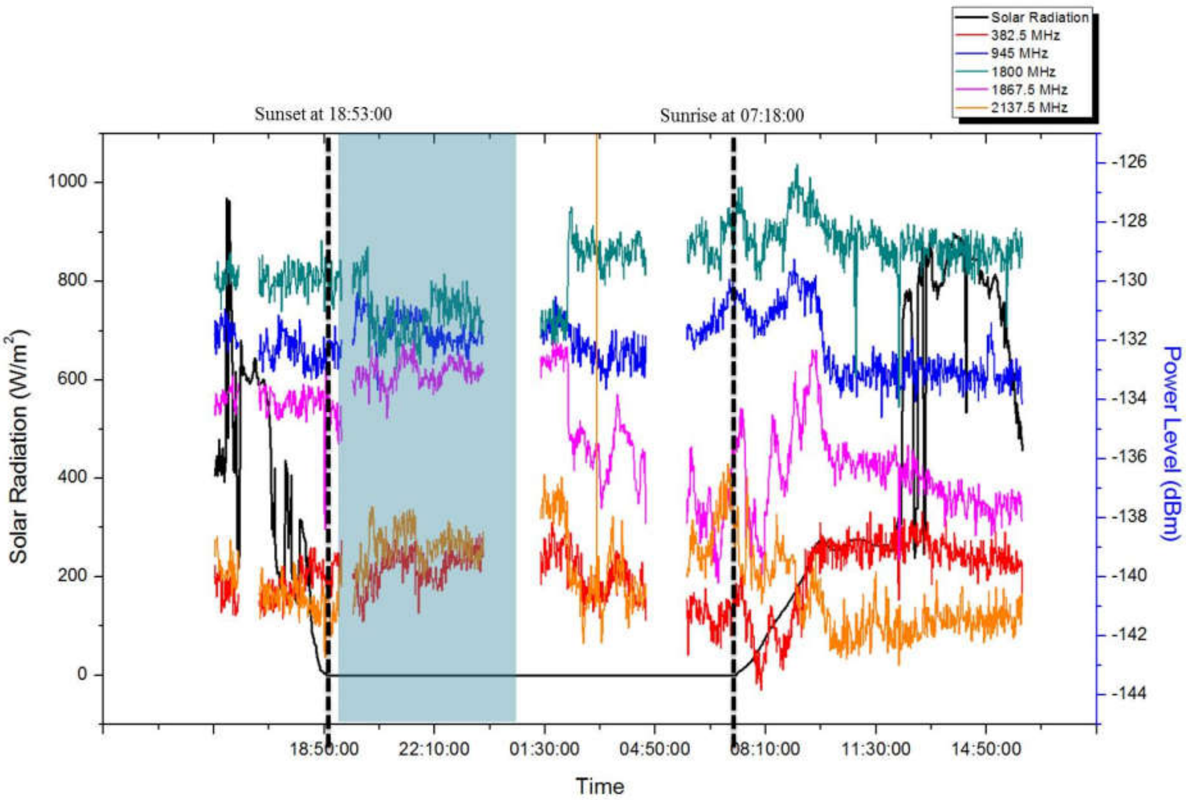

Fig.3. Relationship between solar radiation and prominent peaks detected on July 2016

Some prominent peaks are seen to be varied during the night because of the external factor from the rain. Presence of rain may have also contributed to the increase of power level during the night of 26th July 2016 for most peaks. Rain started from 19:20:00 until 19:51:00 and 20:15:00 until 00:20:00 with rain rate of 22.5313 mm/hour and 12.6703 mm/hour respectively. It has been suggested that the rain rate are one of the external factors that could attenuate radio signal. In their comprehensive study of the rain effect on a radio signal, in [12] showed that frequency of 100 MHz, 200 MHz, 300 MHz and 500 MHz are affected by rain rate. It is also supported by [13] where radio propagation was affected by rain as it passes through rain medium causing the some of the energy to be absorbed and scattered away.

3. METHODOLOGY

The experimental setup for the observation was illustrated in Fig. 4. The observation was done at BCK (5^o 32' 10" N, 102^o 56' 55" E), which located on top of Merang hill and near the coastal area of South China Sea. The instrument setup was adapted from similar studies that have been done by [14-16] to study the effect of tropical weather on radio signal.

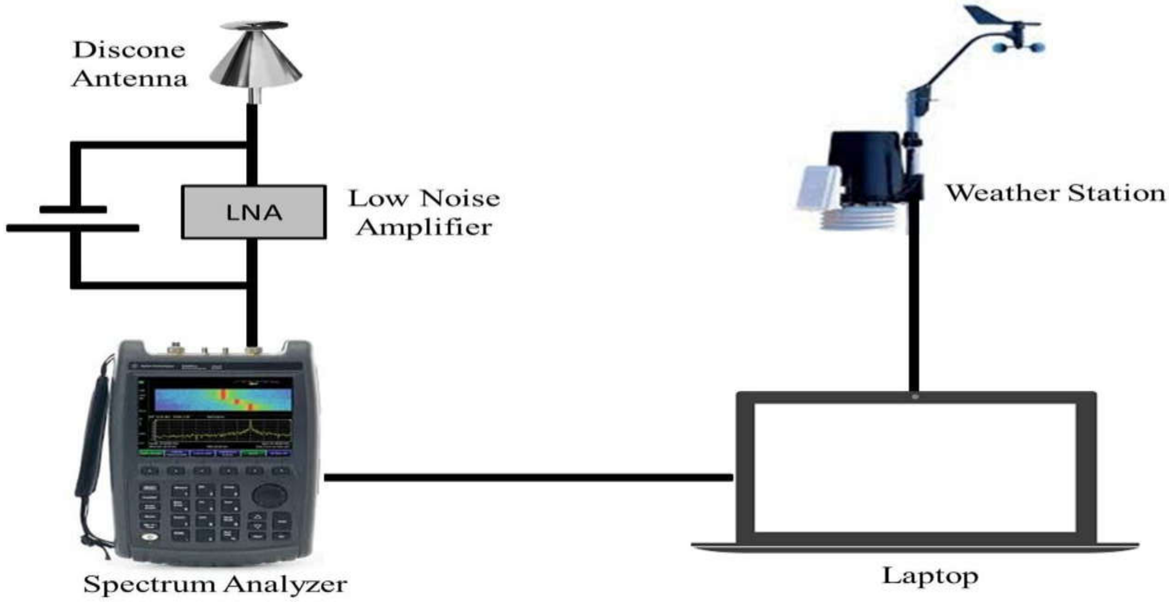

Fig.4. Instrument setup used in this study [17]

Discone antenna optimized at UHF band was used in this study because of its omnidirectional pattern. The antenna was connected to the low noise amplifier (LNA) and spectrum analyzer. Weather station Vantage Pro 2 was used simultaneously to measure solar radiation. The data was collected for 24 hours period in one-minute interval similar to study conducted by [18]. This study focuses only in 300-3000 MHz which is UHF band since this band is concentrated with telecommunication systems. The data were then plotted against the weather to determine the relationship.

4. CONCLUSION

In this study, we have presented average radio signal detected on July 2016 where frequency detected were 382.5 MHz, 945.0 MHz, 1800.0 MHz, 1867.5 MHz and 2137.5 MHz. Most of the detected peaks were coming from communication systems. We also have presented the effect of solar radiation on radio signal in UHF band for a month period of observation. We can conclude that the radio signals were depending on the presence of solar radiation and the level of solar radiation measured during daytime and night time as solar radiation [24] measured differently as 376.0246 W/m^2 and 428.9846 W/m^2 during 26th July and 27th July respectively. The variation of radio signal measured start during the sunrise and sunset as ionospheric become unstable. This research will benefit communication engineers to build telecommunication base station by considering the effect of weather on radio propagation [19-21].

5. ACKNOWLEDGEMENTS

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