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SPECTRUM MONITORING: RADIO FREQUENCY INTERFERENCES (RFI) PROFILE FOR HYDROXYL (OH) LINES WINDOW

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ABSTRACT

It was crucial to monitor the Radio Frequency Interference (RFI) in order to conduct the radio astronomical research with very minimum RFI. These RFI will be distorted the astronomical data. In this work, we have investigated the RFI strength (dBm) and presenting on how the nearby RFI affect to the OH lines window (1600 MHz-1800 MHz). Measurement of RFI spectrum was done in one minute interval in 24 hours observation at Kusza Observatory (KO) using spectrum analyzer. RFI analysis was done by identifying the RFI strength (dBm) in 3 separated OH lines window which is window A, window B and window C. Window C was found as the higher RFI strength compared other two window. Besides, interference peak (1575MHz) has found affected the OH lines window by spilling out until 90MHz to the left and 180MHz to the right.

Keywords: radio frequency interference; hydroxyl lines; RFI strength.

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1. INTRODUCTION

Electromagnetic waves from universe transmitted to ground through earth atmosphere. Radio (15MHz-30GHz) and visible light (360THz-830THz) region is highly conquer by the earth atmosphere. Both regions is known as the main region for ground astronomical observation. The spectrum of celestial radio waves can penetrate the earth atmosphere and cover the whole frequencies range [1-2]. They bring together the large number of spectral lines of atom, ions and molecule. In order to observe the radio astronomical lines in radio region, the specific technique is created for over three decades namely Very Long Baseline Interferometry (VLBI). VLBI is created by linking radio telescope together located many thousands of kilometers apart. To succeed the VLBI experiment, the telescope in different countries must observe together at same frequency band without interference [3]. Therefore, it is essential to studies of radio frequency interference (RFI) for radio astronomy observation. Generally, the interferences usually come from man-made interferences and also weather. Examples of man-made interferences include a communication system, radar, electronic equipment, AM/FM radio and service provider [4-6]. There were many of recent RFI studies have been done as referred to [7], study the method for measurement RFI for radio astronomy observation at selected sites, they found major RFI interfere radio astronomical lines below 1 GHz are electronic equipment system specifically radio navigation between 73.1 MHz and 75.2 MHz, radio broadcasting (151MHz, 151.8MHz and 152MHz), aeronautical navigation (245.5MHz, 248.7MHz and 249MHz and fixed mobile at 605MHz, 608.3MHz, 612.2MHz, 613.3MHz. In [8] also have done RFI profile survey at University Technology Mara (UTM) and they found RFI strength showed moderate even though the population density is very high.

At the same time, in [9] have done a survey of Hydrogen lines around 1300MHz-1500MHz and investigate the RFI in this band. They found frequency between 1380MHz-1400MHz is very important window for radio astronomy. In this research, our attention on investigation and the impact of RFI on OH lines window. We have investigated the RFI and their impact on OH lines window (1600MHz-1800MHz) and nearby OH lines window. Table 1 shows frequency allocation by Malaysian Communications and Multimedia Commissions (MCMC) and International Telecommunication Union (ITU) at range frequency of 1600MHz until 1800MHz and their radio designation.

Generally, various atom and molecule exits in clouds which in interstellar space and other galaxies. For instance, OH molecule has spectral lines with their own rest frequencies. There are 1612.231MHz, 1665.402MHz, 1667.539MHz and 1720.530MHz as listed by International Astronomical Union (IAU). The OH spectral lines been observed in emission and absorption in different region of galaxies [10]. The emission is so called OH mega maser. It been seen as ‘red shifted down in frequency due to Doppler Effect [11]. The issue when the RFI that occur interfered and reduced the signal of OH mega maser. This observation of OH mega maser is to provide the research of initial stage of star formation [12]. Therefore, it is crucial to investigate the RFI and their impact to the astronomical observation. Thus, manage the spectrum for radio astronomy service.

In experimental section, we have described the instrument setup for RFI measurement and features of the observation site. Meanwhile, we do analysis of RFI and presented the waterfall analysis in order to determine the consistent of RFI in OH lines window for section of result and discussion.

Table 1. Several list of frequency allocation by MCMC and ITU and their radio designation [13]

Range of Frequency (MHz)	MCMC Allocation	ITU Allocation	Radio Designation by ITU
1610-1610.6	Mobile satellite (earth to space), aeronautical radio navigation, radio determination satellite	Mobile satellite (earth to space), aeronautical radio navigation, radio determination satellite)	-
1610.6-1613.8	Mobile satellite (earth to space), radio astronomy,	Mobile satellite (earth to space), radio astronomy,	Secondary

	aeronautical radio navigation, radio determination satellite	aeronautical radio navigation, radio determination satellite	
1613.8-1626.5	Mobile satellite (earth to space), aeronautical radio navigation	Mobile satellite (earth to space), aeronautical radio navigation, radio determination satellite	-
1626.5-1660	Mobile satellite	Mobile satellite	-
1660-1660.5	Mobile satellite, radio astronomy	Mobile satellite, radio astronomy	Shared
1660.5-1668.4	Radio astronomy, space research	Radio astronomy, space research	Primary
1668.4-1670	Meteorological aids, fixed mobile, satellite and radio astronomy	Meteorological aids, fixed mobile, satellite and radio astronomy	Shared
1710-1800	Fixed mobile	Fixed mobile	-

2. RESULTS AND DISCUSSION

RFI pattern at wide and OH lines window was shown as in Fig. 1 and 2. Based on the RFI graph, we have recognized the RFI sources and found the most RFI contributed from mobile phones and radio navigation satellite. Table 2 shows the list RFI sources for prominent peak in Fig. 1. For the analysis, we have provided the RFI strength (dBm) in each OH lines window in order to view the RFI profile in OH lines window. According to our result, window A has the lowest strength of RFI with average of -75.3357 dBm compare window B and C with average of -75.5250 dBm and -75.9109 dBm as stated in Table 3.

Clearly, window C shows the most polluted region compared to other windows and it may due to RFI comes from radio navigation satellite coupled with electronic equipment causes decreased the power spectra in window C and interfered that window. After observed the RFI, we have investigated how the impact of interference peak on OH lines window was also identified. Further analysis was done in order to present how the RFI gave the impact on the OH lines window.

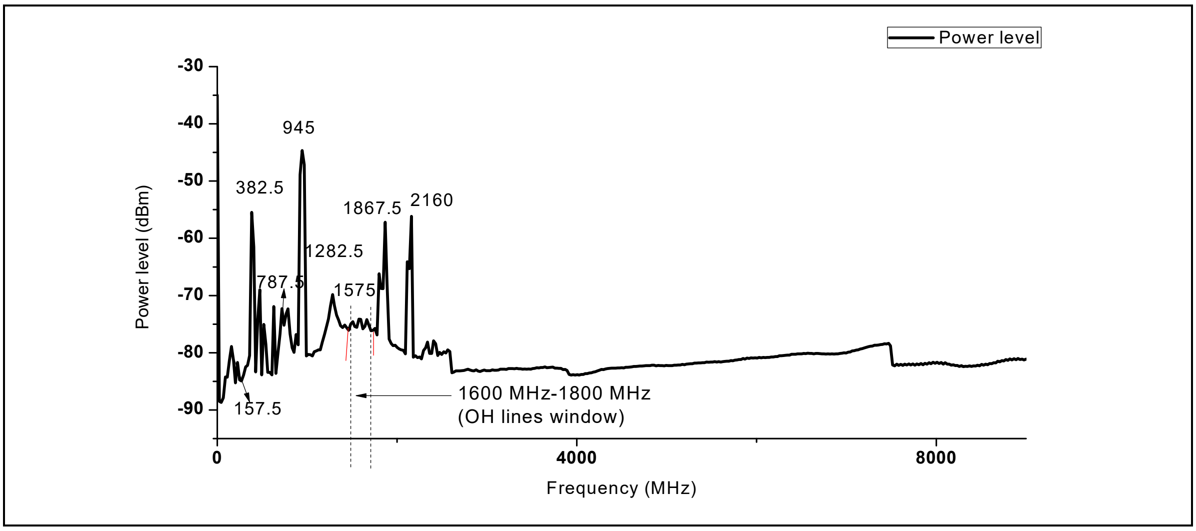

Fig.1. RFI spectrum in wide window (0-9000MHz)

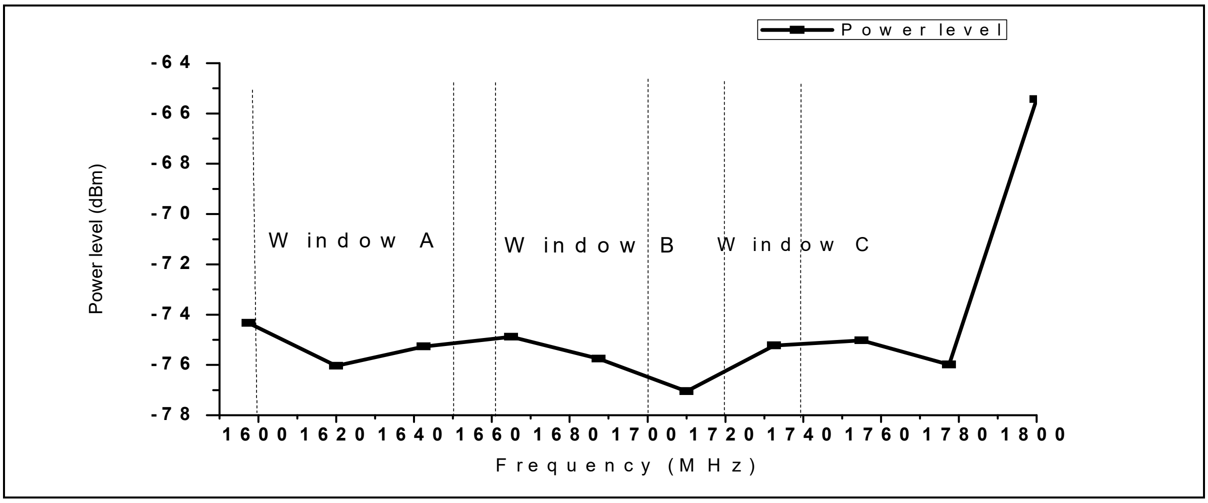

Fig.2. RFI spectrum in OH lines window (1600MHz-1800MHz)

As we can see on RFI graph in Fig. 1, there was found the interference peak nearby the OH lines window. This peak was from frequency of 1575MHz. The frequency was allocated as aeronautical radio navigation by MCMC and ITU. According to our analysis, we found that frequency of 1575MHz totally swapped the OH lines observation as the frequency spill out until 90MHz to the left and 180MHz to the right. The analysis was proved that the interference peak which is frequency of 1575MHz sideband out from their own frequency until took part in OH lines window. Therefore, causes the interferences to the observation of OH lines in OH windows. Fig. 3 illustrates frequency of 1575 MHz spill out from their nominal frequency.

Table 2. List of RFI sources

Frequency (MHz)	Sources
157.5	Fixed mobile
382.5	Digital trunked radio
787.5	Fixed mobile , broadcasting
945	Mobile phone (Celcom)
1282.5	Radio navigation satellite, space research
1575	Aeronautical radio navigation
1867.5	Mobile phone-Digi GSM 1800
2160	Mobile phone-Digi IMT 2000

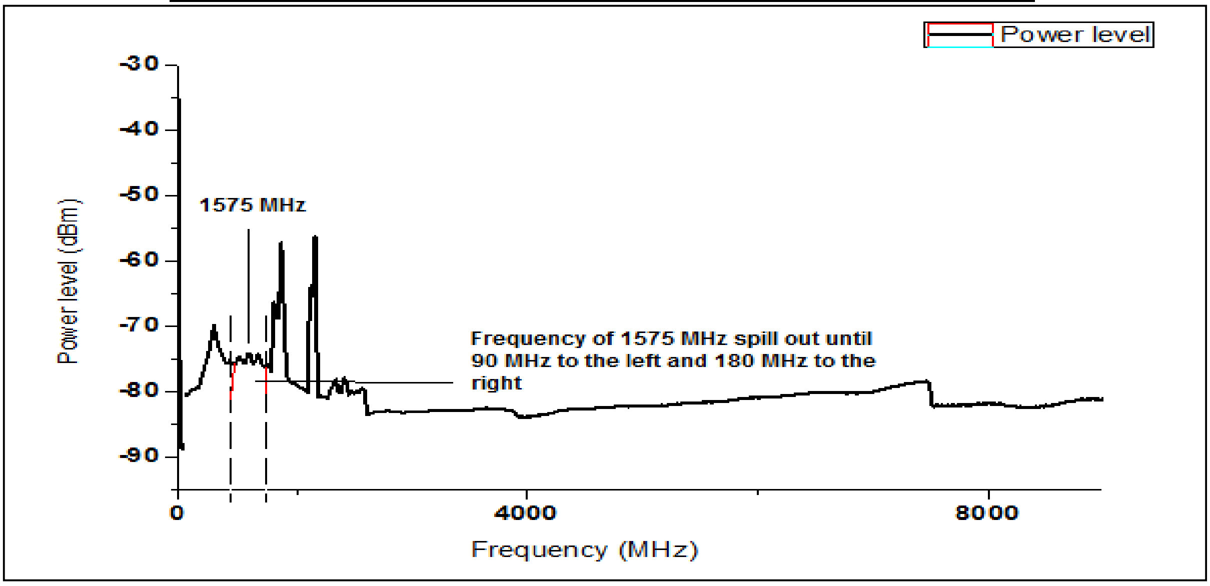

Fig.3. Frequency of 1575 MHz spill out from their frequency until take part in OH lines window

From that, the protection is needed in OH lines window in order to avoid the OH spectral lines observation from be interfered. The navigation are prompted to take the practicable step for keeping the radio astronomy window from interferences. In addition, they also need to follow the level of spectral density emission from space that has been set. As we refer to [14], GLONASS satellite system transmit a spectral power flux density exceed the harmful interference that was set by International Radio Consultative Committee (CCIR).

The spectral power causes spectrum power of the satellite sideband out until 80MHz from their nominal frequency. Since GLONASS satellite have shared band with radio astronomy service at frequency 1610.6MHz-1613.8MHz, thus it was absolutely causes interference to the radio astronomy observation.

Table 3. RFI strength and their standard deviation for each windows

Astronomical Lines	Rest of Frequency (MHz)	Window	Range of Frequency (MHz)	Standard Deviation	RFI Strength (dBm)
OH	1612.231	A	1600- 1650	0.3	-75.3357
OH	1665.402	B	1660-1700	0.5	-75.5250
OH	1667.359				
OH	1720.530	C	1720-1740	0.7	-75.9109

3. EXPERIMENTAL

RFI spectrum was measured by using 9000MHz spectrum analyzer (Keysight N9915A) 180kHz resolution of bandwidth and antenna connected with Low Noise Amplifier (LNA) using belden cable. Fig. 4 illustrates the instrument procedure for RFI observation. Measurement was focused on wide band (0-9000MHz) and OH lines window (1600MHz-1800MHz). In this paper, we have presented two analysis of RFI which are identifying and comparing the RFI strength (dBm) in OH lines window by separating into 3 window which are window A (1600MHz-1650MHz), window B (1660MHz-1700MHz) and window C (1720MHz-1740MHz). The RFI strength (dBm) calculated by averaging the power level at each window. Next, we was showed how the RFI gave an impact on OH lines window by calculating the RFI that spill out or sideband out from their own frequency.

These RFI observation was done in one minute interval in 24 hour observation at KO. This chosen sites was selected due to area of low population density and possible low RFI. It was also suitable site for locating radio telescope to conduct radio astronomical observation. Table 4 indicates the description of KO.

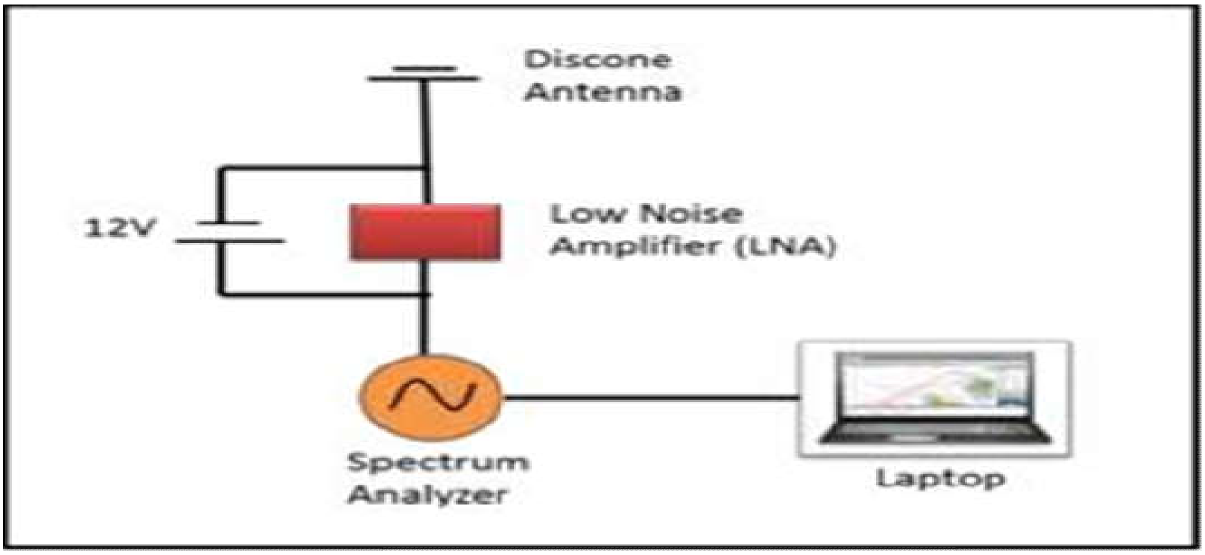

Fig.4. Instrument setup for RFI observation [15]

Table 4. Features of KO

Site	Longitude	Latitude	Characteristics
Kusza Observatory (KO)	5^{o} 32 10 N	102^{o} 56 55 E	Low population density, on top of hill surrounded by rain forest tropical, closed to the beach

Finally, the lowest RFI strength (dBm) OH lines window and how RFI sources effecting on OH lines window was determined.

4. CONCLUSION

From our RFI investigation at KO, there was found that window C (1720MHz-1740MHz) indicates the highest RFI strength (dBm) with -75.9109 dBm. It was computed by averaging the average of power level in each window. The highest of RFI at that window it may due to RFI come from radio navigation and mobile phone altogether with RFI from other factor such as electronic equipment that causes the interference by decreasing the power signal. At the same time, we also observed the interference peak nearby OH lines window and found 1575MHz gave an impact on the OH lines observation as the frequency spill out until 90MHz to the left and 180MHz to the right then take part in OH lines window. Thus, the interference in OH lines window was occurred. From this event, the administration should be concerned with the exposure limit of spectral power that has be assigned. By that, the radio astronomy observation be protected from worst interference. Meanwhile, the RFI monitoring also should be conducted continuously from time to time to detect the new RFI source and monitoring the RFI profile.

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