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Investigation of Radio Frequency Interference (RFI) Profile and Determination of Potential Astronomical Radio Sources

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ABSTRACT

In this article, we have recognized a Radio Frequency Interference (RFI) sources that can potentially affect for radio astronomical observation. The main objective of this surveying is to test and qualify the potential of radio astronomical sources that can be observed in Malaysia generally. Analysis process focuses on the high sources that contribute the pollution and the significant region that can be considered for astronomical purpose beginning 1-2000 MHz. It was found that 13 individual sources contribute as a noise and mostly are telecommunication and radio navigation applications. We then compared of the RFI profiles based on three different periods in order to observe the variety of the signals. The main regions that still excellent to do an observation are: 13.36 -13.41 MHz (solar), (25.55-25.67) MHz (Jupiter) and (37.50-38.25) MHz (Continuum) respectively. This work is also an initiative of the International Space Weather Initiative (ISWI) project where Malaysia is one of the countries that involve in e-CALLISTO (Compound Astronomical Low Cost Low Frequency Transportable Observatory) network project. Some suggestions are recommended in order to improve the quality of the radio frequency profile.

***Keywords*:** Radio Frequency Interference (RFI); radio astronomy; RFI sources

1. INTRODUCTION

Determination of Radio Frequency Interference (RFI) is very important progress in order to discover the potential radio astronomical sources. This study is currently one of a main sub-research in radio astronomy in Malaysia [1]. Continuity RFI surveying has been conducted at several sites such as at the University of Malaya [2], Langkawi, National Space Centre Banting [3], and other relevant sites to choose the best candidate site for radio astronomical research. Previous study also focused on the effect of population density on the RFI profile [4]. The radio wavelength just not only covers a wide range with the longest wavelength compare other types of electromagnetic windows, but is also contain a very good

potential to determine a new celestial object in our Universe. However, the main challenges of the next generation radio telescope for astronomy are its capacity to cope with increasing polluted of RFI [5]. Due to the developments in electronics technology, the need for electromagnetic shielding has increased [2]. In recent years, due to the increasing conflict between scientific and commercial users of the radio spectrum Radio frequency Interference (RFI) is a serious problem for passive and active radio and microwave sensing of the Earth. As a result, it is very significant to verify the unwanted signals which are emitted due to the massive global increase. In order to determine a strategic site for radio astronomical research an effort has been made by penetrating a site that has very minimum radio frequency interference. An RFI is often localized in time and frequency, relative to the integration times and pre-detection bandwidths over which a space borne microwave radiometer acquires its samples of the brightness temperature. Based on this issue, we analyze the Radio frequency Interference (RFI) profile at three (3) different periods. This preliminary work also is a part of an initiative of the International Space Weather Initiative Program (ISWI) [6]. In this committee, we are hosting the e-CALLISTO (Compound Astronomical Low Cost Low Frequency Transportable Observatory) network [7]. In previous work, we have compared the RFI level at two (2) different sites [8]. Therefore, in this work, we need to identify all RFIs sources in the range of 1 MHz till 2000 MHz continuously. This study is to intend the best range of wavelength that possible for radio observation purpose.

2. MEASUREMENT SETUP AND OBSERVATIONS

We monitored an RFI profile at frequencies from 1-2000 MHz located at Faculty of Applied Sciences, Universiti Teknologi MARA (3°5′00″N 101°32′00″E / 3.0833333°N 101.5333333°E). A combination of detachable 9'' whip antenna with gain 30dB and 0.37 dB of NF connected with Radio Frequency Field Strength Analyzer Figure 1).

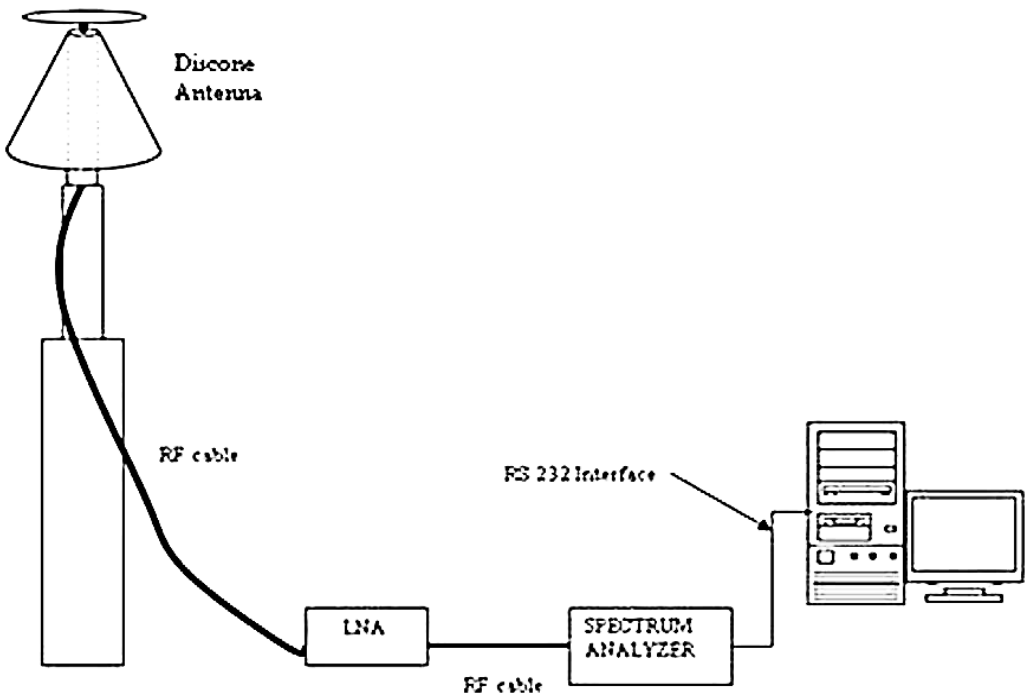

Figure 1. RFI system connection.

The measurement system is routinely gaining calibrated by using the low noise amplifier. This observation has been done from 9.00 am till 17:00 pm. In order to avoid the unnecessary noise due to weather condition, the strength of RFI were measured only when the atmosphere was optically clear so that the path of light through the Earth's atmosphere is completely stable. We also identified the peak signals of the frequency from the spectrum analyzer. Data acquisition hardware consists the strength of noise level in dB unit which will be transferred to a computer for further analysis. We can also predict the sources that caused the interference. The minimum RFI from the wavelength will give the best range for astronomical purpose while the maximum level of RFI, in contrast, is good to identify the elements that make it polluted. All digital electronics are located in a single screened enclosure to minimize self-generated RFI.

3. RESULTS AND ANALYSIS

It was found that 13 individual sources contribute as a noise and mostly are telecommunication and radio navigation applications. The RFI noise levels were initiated to be widespread in RFI at 800 MHz – 1200 MHz region comes from a mobile phone application (Maxis, Celcom and Digi) while moderate RFI at 1600 MHz – 2000 MHz due to earth exploration and radio navigation satellite.

Table 1. The five windows of RFI survey.

Frequency range (MHz)	Sources of RFI	Specific Frequency (MHz)
1-400	1. UFM-Radio 2. Hot FM Signal	93.6 97.6
400-800	1. Broadcasting	800-922.5
800-1200	1. Mobile (GSM) 2. DIGI 3. Celcom 4. Maxis	922.5-960 931-933 933-935 950-960
1200-1600	1. Earth exploration and radio navigation satellite 2. mobile satellite	1215-1222.5 1507.5-1525
1600-2000	1. Mobile (GSM) 2. DIGI 3. Celcom 4. Maxis	1800-1877.5 1800-1812.5 1825-1835 1852-1875

An analysis of RFI spectrum profiles of each time: (i) 9:00 am, (ii) 14:00 pm and (iii) 17:00 pm are presented in Figure 2, 3 and 4 respectively.

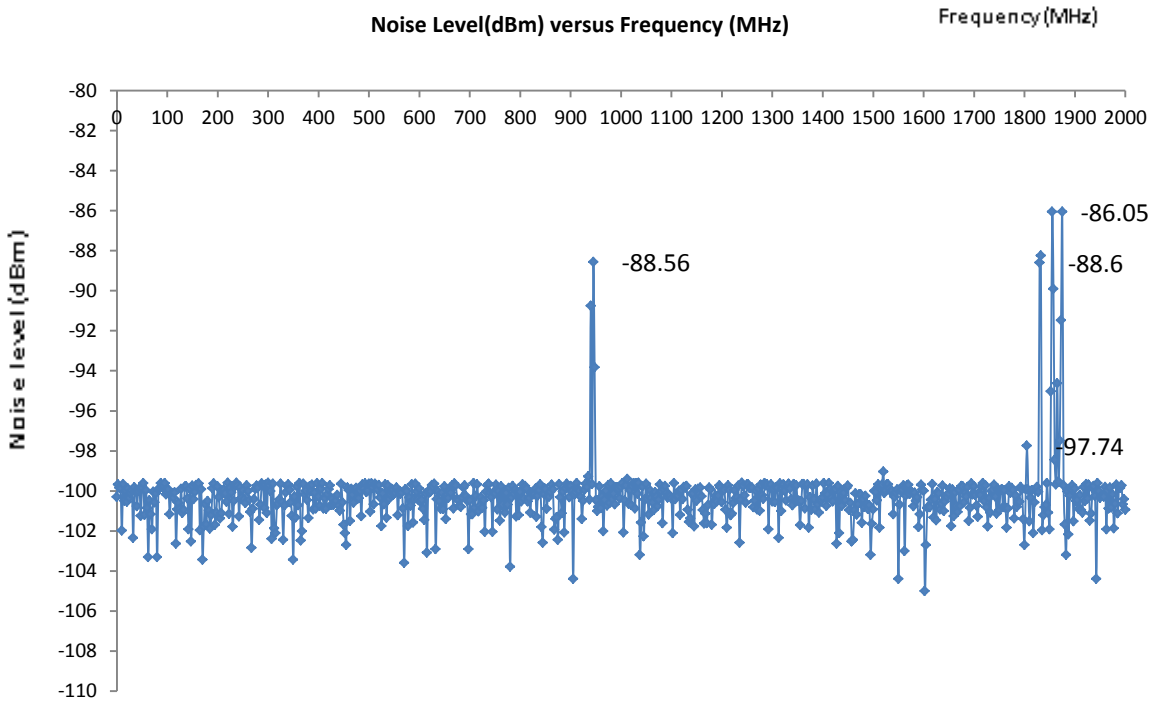

Figure 2. RFI spectrum profile at Faculty of Applied Sciences at 9:00a.m.

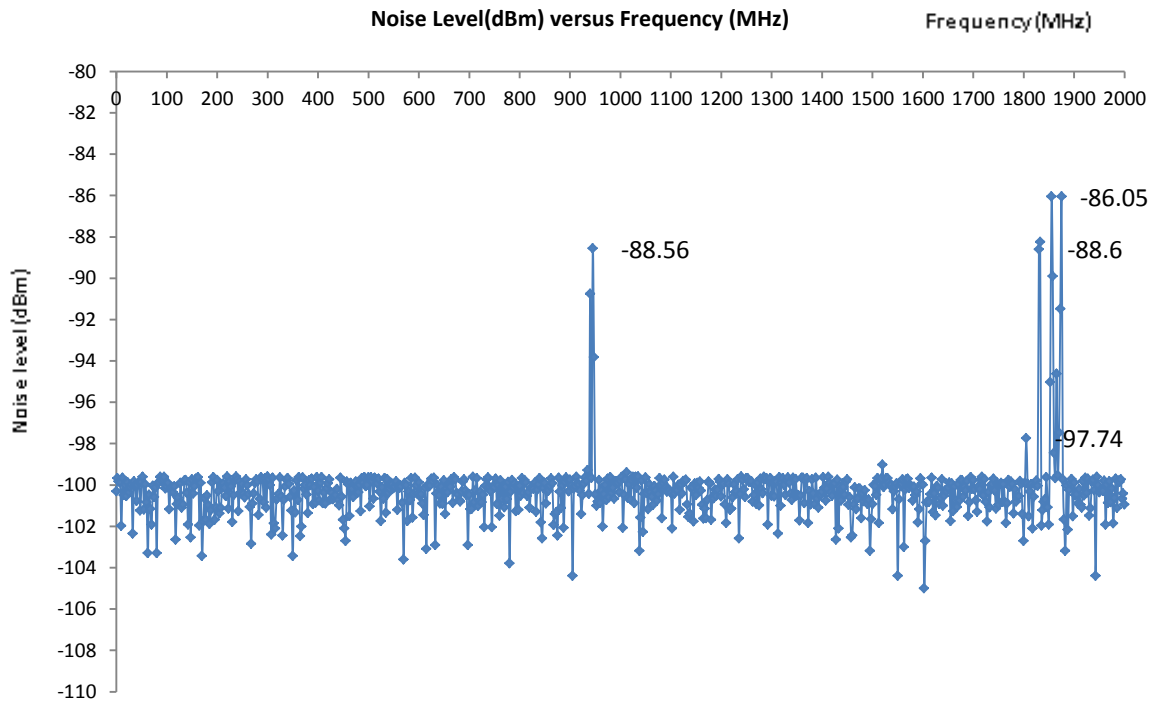

Figure 3. RFI spectrum profile at Faculty of Applied Sciences at 14:00 p.m.

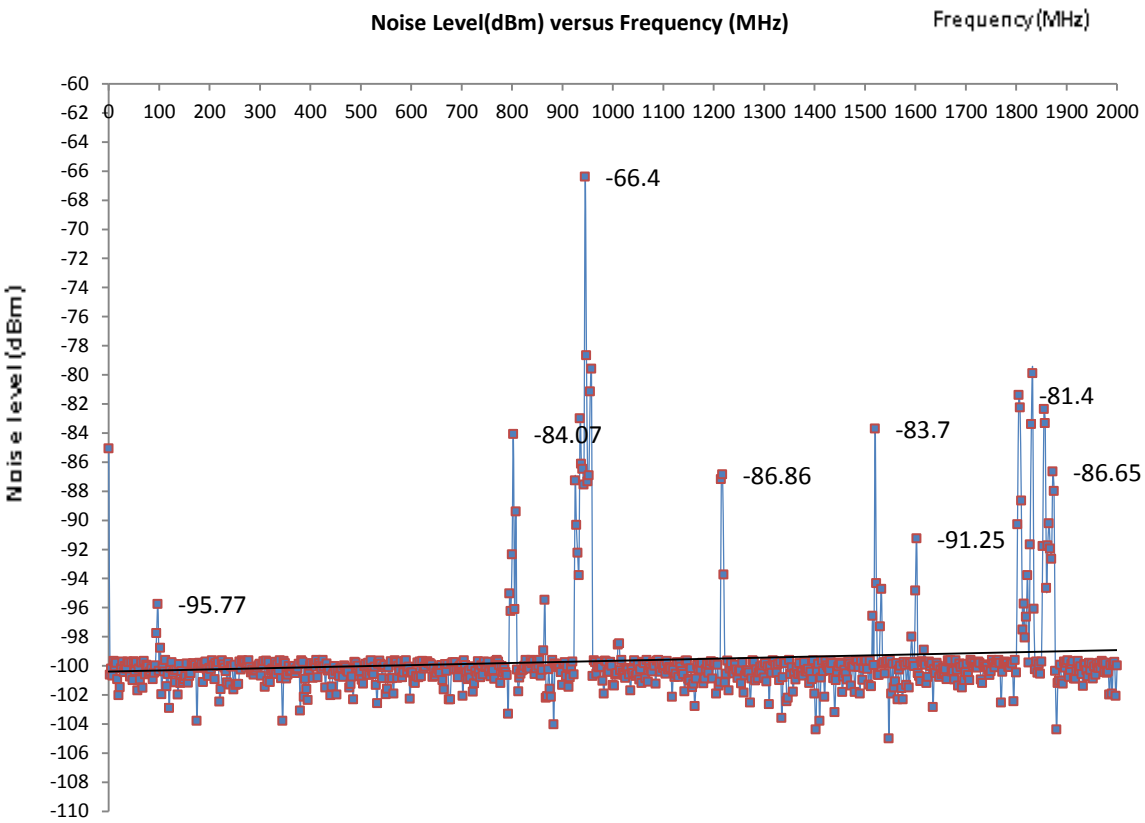

Figure 4. RFI spectrum profile at Faculty of Applied Sciences at 17:00 p.m.

According to the results, Faculty of Applied Sciences has the value of noise level with an average of -100.007 dBm. It means that this site is a moderated site for radio observations. It was found that there is no difference of RFI profile at 9:00 am and 14:00 pm. We can say that the signal of the sources remains consistent within 5 hours. However, during 17:00 pm, the profile changed obviously. There are a few signals that can be found in the range of 1100 MHz-1600 MHz. The peak of signals is also becoming increasing up to -66.4 dBm.

It should be noted that The Malaysian Communication Multimedia Commission had protected the eight (8) exclusive frequency bands for radio astronomical observations. Based on our analysis, there are three main regions are still at a very minimum of RFI level which are: 13.36-13.41 MHz (solar), (25.55-25.67) MHz (Jupiter) and (37.50-38.25) MHz (Continuum) observations respectively. There are also a signal from other services, as well as from our own poorly-engineered equipment, sometimes contaminate our bands. Therefore, a continuous observation of RFI is important.

Unfortunately, in the band 800-1200 MHz and 1600-2000 MHz, there are more than 4 individual sources of RFI with a signal of more than ~90 dBm. This range can be considered as the most polluted range compares the others. Therefore, every practicable effort should be made to avoid the assignment of frequencies to stations in the fixed and mobile services that could interfere with radio astronomy. A quantity of mitigation can be achieved by frequent data dumps and the excision of RFI, or by real-time detection and blanking of the receiver, or by more sophisticated algorithms.

Table 2. Potential astronomical sources at Faculty of Applied Sciences.

Specific Frequency range (MHz)	Average strength (dBm)	RFI level	Suitable observation
13.36-13.41	-103	Very low	Solar
25.55-25.67	-101	Very low	Jupiter
37.50-38.25	-102.5	Very low	Continuum observation
73.00-74.60	-95	low	Pulsar
322.00-328.65	-91	medium	Deutrium observation
406.00-410.00	-96	low	Pulsar
1400.00-1427.00	-103	Very low	Hydrogen-line

It could not be denied that the radio spectrum is a finite resource, on which humanity makes many demands. Hence, we need a regulatory protection at the highest level, strong local protection, and self-protection through interference mitigation techniques. Continuances surveying should be done from time to time in order to detect new sources of interference and monitoring the level of RFI. Thus, RFI detection and mitigation strategies are needed to ensure a radiometer will not be damaged by extreme RFI (survivability). The International Telecommunication Union provides regulatory protection from licensed radio transmitters, through the allocation of passive frequency bands, through limits to unwanted emissions.

4. CONCLUSION

Overall, the RFI strengths of the Faculty of Applied Sciences, MARA University of Technology, Shah Alam showed the moderate rate although the population density in Shah Alam is very high. We can conclude that this area is the intermediate site for developing the radio astronomy research. We should highlight the importance of protecting the radio window for astronomy purpose through the campaign and the media so that they will alert and realize the consequences if no action are taken.

Acknowledgement

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Biography

Zety Sharizat Hamidi is currently a PhD candidate and study in Solar Astrophysics specifically in radio astrophysics at the University of Malaya. Involve a project under the International Space Weather Initiative (ISWI) and also a lecturer in School of Physics and Material Science, at MARA University of Technology, Shah Alam Selangor.

N.N.M..Shariff Her current research is communicating sustainability. She is looking forward for cross-field research i.e. solar astrophysics, light pollution measurement (mapping) and application of technology on sustainability.

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