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Investigation of radio astronomical windows between 1 MHz and 2060 MHz in Universiti Malaya, Malaysia

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ABSTRACT

An indoor and an outdoor radio frequency survey was conducted in Universiti Malaya, Malaysia, as a test site, for the purpose of developing radio astronomy research in Malaysia. This is the first radio astronomical survey of any such done in Malaysia. Observation and analysis were done in the radio frequency spectrum between 1 MHz and 2060 MHz. In this paper, the experimental setup and procedure of surveying are outlined and the measured data are interpreted. The eight radio astronomical windows were investigated from a 24 h observation, with the emphasis on two of the most important radio astronomical windows which are protected by the Malaysian Communications and Multimedia Commission (MCMC). Some intermittent observations were also done for referencing purposes. The radio frequency interferences (RFIs) are found to be relatively low. The overall relative Interference-to-Noise ratio (INR) at this test site ranges between 5.72% and 11.74%. The average strength of RFI in the eight focused radio astronomical windows at this site ranges between −100 dBm and −90 dBm (equivalently between 9.23×10^4 Jy and 93.29×10^4 Jy at resolution bandwidth of 125 kHz).

1. Introduction

Radio astronomy is an important subfield of astronomy that studies celestial objects in the radio frequency portion of the electromagnetic spectrum. Radio astronomy techniques are similar to optical techniques but radio telescopes have to be much larger in size due to the longer wavelengths being observed. The field originated from the discovery that most astronomical objects emit radiation in the radio wavelengths as well as in the optical wavelengths.

To start any radio astronomical observation, it is important to initially identify all the possible radio frequency interference (RFI) in the targeted observational windows. The sources of the RFIs are generally monitored by Malaysian Communications and Multimedia Commission (MCMC) while radio astronomical sources are listed by International Astronomical Union (IAU). We will carefully identify all RFIs in between the chosen RF window of 1 MHz and 2060 MHz. Within this range, there are eight radio astronomical windows. We measure the levels of RFIs within these windows and deduce whether there is any possible radio astronomical observation that can be done in any of the windows at the location chosen. An indoor survey is also done to identify indoor RFIs.

RFI is considered the disturbances that affect electrical circuits due to electromagnetic radiation emitted from an external source. The disturbance may interrupt, obstruct, or otherwise degrade or limit the effective performance of the circuit. The source may be any object, artificial or natural, that carries rapidly changing electrical currents, such as from some electrical circuits and also from the Sun. Because of these possibilities, and the need to observe 1420 MHz frequency, a set of radio frequency survey is conducted. Significant signals are discovered within the frequency range of 1 MHz–2060 MHz and we compare the signal that we have with the signal from the frequency plan obtained from the Malaysian Communications and Multimedia Commission (MCMC) (MCMC Manual of Spectrum Plan, 2006) to estimate the origin of the signals. In this paper, the methods and the results of RFI surveys are presented.

It should be worth noted again that the work done for this paper is aimed at investigating the eight windows in the MCMC frequency allocations allocated for radio astronomy. We do not aim to scrutinize the designated windows in the MCMC data as it is already been fixed by the law. We merely try to quantify the level of RFI in the allocated radio astronomical windows for the purpose of future radio astronomical observations in Universiti Malaya.

2. Materials and methods

The broad-spectrum outdoor surveys which cover from 1 MHz to 2060 MHz are performed just outside the block B building of the Physic Department of Universiti Malaya. The site is 10 km away from the city centre of Kuala Lumpur. Fig. 1 illustrates the local

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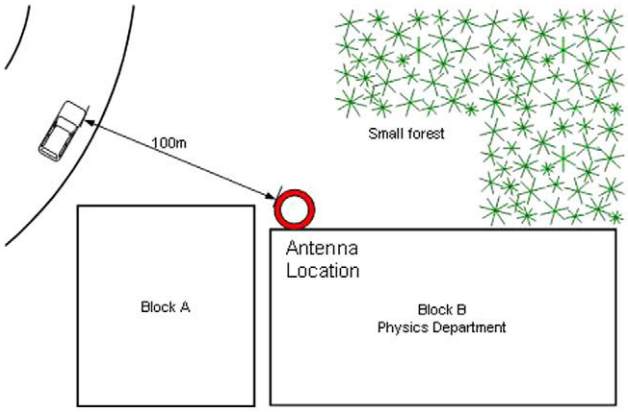

Fig. 1. Surroundings of the local observation site.

surroundings of the site. The receiver system includes a Radio Frequency Field Strength Analyser with an omni-directional antenna (see Fig. 2). The antenna is a detachable 9″ whip antenna which comes as a standard omni-directional antenna for the spectrum analyser. The equipment lists and characteristics of the spectrum analyser are summarized in Table 1. The RF Field Strength Analyzer shows the observed spectrum and there is also an option to listen to the audio signal. The characteristics of frequency responses are obtained from the analyzer. The data can be transferred to a computer for further analysis.

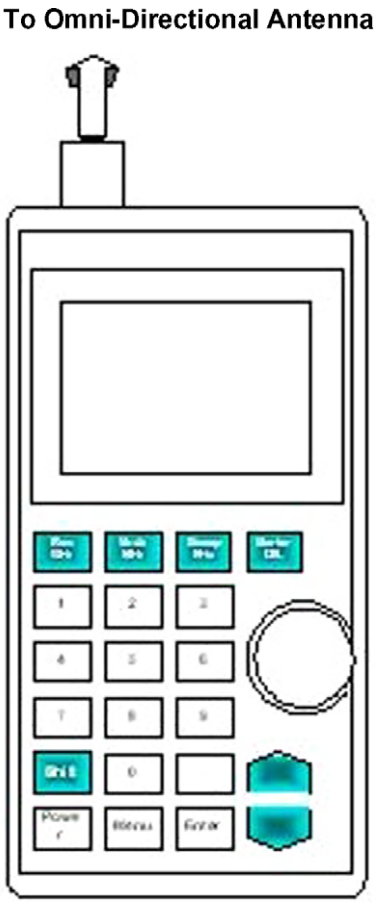

Fig. 2. Radio Frequency Strength Analyzer with omni-directional antenna for observation.

Table 1
Equipments' characteristics.

Equipments	Characteristics
Antenna	Detachable 9″ whip
RF Field Strength Analyzer 2.0 GHz (Protex 3200 Series)	Frequency range: 100 kHz–2060 MHz RBW: wide FM – approx. 180 MHz

Table 2
The five frequency windows of our RF survey.

	Frequency range (MHz)
A	1–400
B	400–800
C	800–1200
D	1200–1600
E	1600–2060

The spectrum analyzer is setup to observe five frequency spans of 400 MHz with a resolution bandwidth of 125 kHz. We label the five windows from A to E for convenience (see Table 2).

The indoor survey is performed inside the Physics Department building using the same receiver and method. Among the instruments we tested for RFI are desktop and laptop computers, television set and microwave oven and even automobile engines, where the survey is done just outside the laboratory.

3. Results and discussion

More than 45 individual RFI signals were found. Most of the signals are less then 15 dBm above the noise floor of the spectrum analyzer, with several notable exceptions.

At the band edge at 1400 MHz, two large signals at 1220 MHz and 1500 MHz were 15 dBm and 10 dBm above the noise floor. These two signals can be defined as RFI because they are significant enough near the important radio astronomical frequency of 1420 MHz. From the MCMC data, we recognize that these signals come from radio navigation and mobile satellites (MCMC Manual of Spectrum Plan, 2006).

To make sure that the internal RFI such as computer and engine did not disturb our observation, a survey is also done between the frequencies 1200 MHz and 1600 MHz in the laboratory with the computer switched on and off. From our observation the frequency computers do not interfere within the frequency range concerned. We also examine radio signals coming out from engines of motorcycles. The result is basically the same, so we conclude that the engine is not our concern as well.

A thorough outdoor survey is done within the spectrum from 1200 MHz to 1600 MHz. A flat noise floor punctuated by narrow band signals generally characterizes the spectrum.

By referring to the data from MCMC's frequency allocation table (MCMC Manual of Spectrum Plan, 2006), we investigate carefully the five windows as listed in Table 2.

Table 3
Radio sources in frequency window A.

No.	Sources	Frequency (MHz)
1	Radio wave	80.0–108.0
2	Aeronautical mobile	125.0–150.0
3	Broadcasting mobile (TV channel)	175.0–217.5
4	Deuterium (DP), fixed and mobile	327.5
5	Mobile satellite (intermittent)	150.0