

Chapter 3

Development of a Simple Home-Brew Radio Telescope

Kim Ho Yeap

 <https://orcid.org/0000-0001-7043-649X>

Universiti Tunku Abdul Rahman, Malaysia

Wei Gie Lim

Universiti Tunku Abdul Rahman, Malaysia

Tee Tang

Queensland University of Technology, Australia

Veerendra Dakulagi

 <https://orcid.org/0000-0003-1056-0004>

Lincoln University College, Malaysia

ABSTRACT

In this chapter, the design and construction of a simple home-brew radio telescope are illustrated. The radio telescope is built essentially from commercial off-the-shelf components. The main components include an offset prime-focus Ku-band reflector antenna, RF detector circuit, Arduino microcontroller, and a computer. To demonstrate the viability of the telescope, a drift-scan of the sun was performed. From the measurement, it is observed that the radiation signal from the sun has a peak power of -34.3 dBm, half power of -35.4 dBm, and a beamwidth of 3.13° . The impact of rain on the signal from the sky was also investigated. The result shows that there was a noticeable degradation of the power received. A significant amount of energy is absorbed by the dense water vapour in the atmosphere.

INTRODUCTION

When scientists discovered that additional information of the sky could be obtained by analysing the signal at different wavelengths other than that visible to the eyes (such as microwaves, radio waves, ultraviolet, infrared, x-rays, and gamma rays), they started to look for ways to view the sky. The full range

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of electromagnetic wave is called the electromagnetic spectrum. The invention of radio telescopes was one of the early successes in detecting signals which are not visible to human eyes (Wood, 2015). Radio telescopes create a picture of the sky, not in visible light, but in radio waves (Yeap et al., 2013; Yeap et al., 2016a; Yeap et al., 2016b). The invention of the radio telescope is very useful to mankind, because it is able to detect the invisible and hidden activities across the universe. By analysing the information obtained from the radio telescope, some of the greatest mysteries of the cosmos can therefore be unravelled. It is the advent of radio telescopes which has given birth to the field of radio astronomy in physics. To put it in simple terms, radio astronomy is nothing more than the study of cosmic sources which emit radio waves, such as stars, quasars, pulsars, planets, etc.

Constructing a radio telescope presents exceptional difficulties. This is mainly due to the specificity of this discipline and the limited availability of dedicated instrumentation. The main difficulty faced by amateur astronomers in building a radio telescope is the detection of the extremely weak signal radiated from cosmic sources – the magnitude of some of these signals may be comparable to that of thermal noise. Although the underlying operational concept of a radio telescope is pretty much similar to that of a typical commercial radio found in most households, the antenna of the radio telescope is significantly much larger in size. Since signals from the cosmic sources are usually extremely weak, the sensitivity and resolution of the radio telescope have to be high in order to detect these signals. As a result, the size of the parabolic dish antenna has to be sufficiently large, i.e. the diameter of a typical dish is usually larger than 10 m, and the electronics components have to sustain low loss and high signal-to-noise ratio – some of which may have to operate in cryogenic temperature so as to minimize thermal noise (Yeap & Tham, 2018). Hence, building a radio telescope is extremely costly. This is the main reason why courses related to radio astronomy are not commonly offered in secondary and, not to mention, tertiary education. To introduce radio astronomy as a common course, it may be necessary to simplify the process of building a radio telescope, so much so that, it can be easily built in schools and tertiary institutions.

The purpose of this chapter is therefore to introduce an effective approach to design and develop an affordable and relatively simple radio telescope. Since signals from the sun has the highest intensity and can easily be detected, it shall be used to demonstrate the operability of the telescope. At the end of this chapter, the readers should be able to learn how to:

1. Construct a radio telescope using off-the-shelf components.
2. Perform simple measurements using the telescope.
3. Interpret and analyze the obtained data.

A KU-BAND RADIO TELESCOPE

The Ku-band radio telescope can be separated into the outdoor and indoor units. The outdoor unit comprises mainly a parabolic reflector antenna and a low noise block (LNB). The reflector antenna focuses incoming electromagnetic waves towards the LNB. Satellite dishes which operate in the frequency range of 10.7 GHz to 12.75 GHz are often used as the reflector antenna for the detection of the signals in the Ku-band. The LNB consists of the mixer and amplifier units. It is used to down convert the frequencies of the signals from the Ku-band to an intermediate frequency and to amplify the magnitude of the signals (Furse & Bhatia, 2006). The indoor unit consists of a satellite receiver, rotator controller and computer

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