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Development of UKM-SID teaching module for space science education

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Abstract

This paper highlights the development of UKM-SID teaching module for solar flare detection utilizing VLF technique. This module consists of three segments namely, the antena development, preamplifier and data logger. It was introduced in selected high schools in Selangor, Malaysia, where students need to build the antenna, assemble the preamplifier and analyze the data. They were also required to keep a log book of their activities. With the aid of the teaching module, the students gained hands-on experience in carrying out a team project and indirectly enhance their knowledge in space science.

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Keywords: SID; VLF; solar flare; space science; teaching module.

1. Introduction

Space science program was conducted at the international level through the United Nations Office for Outer Space Affairs (UNOOSA) since 1970 and more actively expanded to developing countries through the

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declaration of Vienna "The Space Millennium: Space and Human Development" in 1999 [1]. In Malaysia, this awareness was realized with the establishment of the Planetarium Division, Department of the Prime Minister in 1989 and continues until the establishment of the National Space Agency in 2002. Space weather is an increasingly important research in space science in recent years in studying the effects of the sun in the environment of the earth, satellite, communication and others. Space science research has been conducted in the Faculty of Engineering, UKM since 1999 [2].

Through collaboration between the Institute of Space Science (ANGKASA) UKM with Stanford University, U.S. under the International Heliophysical Year (IHY), research in remote sensing using Very Low Frequency receiver (VLF) was initiated in 2009 at the university using Atmospheric Weather Electromagnetic System for Observation, Modelling and Education (AWESOME) monitor [3,4]. Following the success of the IHY program the International Space Weather Initiative (ISWI) was developed that focuses mainly on space weather. One of the objectives of ISWI is education and public outreach. Through this program and continuing collaboration with Stanford University, a low cost version of the AWESOME monitor designed for high school named Sudden Ionospheric Disturbance (SID), was obtained [5]. Based on this monitoring tool, the UKM-SID teaching module has been developed not only focus on the science of space weather but also provide a hands-on activities than can stimulate experiential learning.

This paper reports the development of UKM-SID teaching module to be used in high schools in Selangor, Malaysia. The purpose of this project is to provide exposure and early space weather education to high school students. This teaching module consists of both educational and research components used to detect the presence of solar flares which is one of the solar activities utilizing VLF signals reflected from the ionosphere.

2. Space Weather

Natural phenomena such as solar flares affect the space weather conditions that surround the Earth [1]. Disturbances to the space weather condition have been known to affect human activities on Earth such as disruption of electrical power grid system, navigation system and radio communication systems, as well as interfering with activities in space, such as satellite systems and other technological systems and endanger astronauts [6]. In order to overcome these problems, space weather research and education need to be intensified to ensure that space technology system well functioned. A remote sensing technique using very low signal frequency (VLF) in the range of 3-30 kHz has been widely used to study the disturbances in the D region of the ionosphere (40-90 km from ground level) [7]. This disturbance is referred as Sudden Ionospheric Disturbance (SID).

The occurrence of the solar flares that cause the disturbance can be detected by tracking the changes in VLF signal as it is reflected from the Earth's ionosphere [5]. The signal comes from transmitters that were set up by various nations to communicate with their submarines. Rapid ionization due to the effects of the Sun on Earth's ionosphere changes the signal strength of the VLF that can be detected by the SID monitor [8].

3. Development of UKM-SID module

Based on the support from Stanford University, we constructed our own SID system named UKM-SID teaching module. This teaching module consists of 3 main segments; VLF antenna development, preamplifier assembly and data logger. The antenna will receive VLF signals from various transmitters and this signal will be boosted by the preamplifier and stored in the data logger.

3.1. VLF antenna development

The first segment of the teaching module is the development of the VLF antenna. This antenna is used to pick up the VLF signals reflected from the ionosphere that are transmitted from all over the world. The antenna is a wire loop antenna that can be built in various shapes and sizes. The shape can be rectangular, square, circle,

hexagon and others. Larger antenna will have better signal reception. Figure 1 shows the antenna that has been built in UKM which is a rectangular loop antenna with 1 meter square in diameter and with 29 turns.

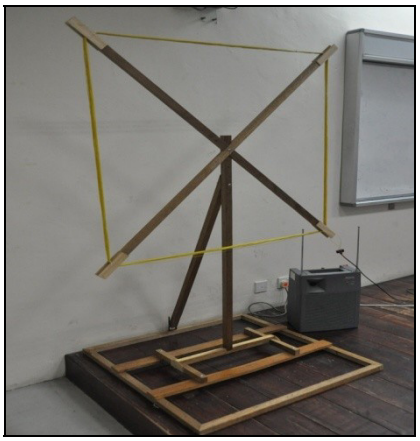

Fig. 1. UKM VLF antenna

3.2. Preamplifier assembly

The second segment is a preamplifier. The preamplifier is used to amplify the VLF signal as the signal received from the antenna is typically very low in amplitude (0.1mV). This will amplify the signal a thousand times so that it can be detected by the sound card in the data logger. The original preamplifier designed by Stanford University is in the form of double layer printed circuit board (PCB). This type of layout is not suitable for manual assembly, therefore we simplified the PCB to a single layer layout. Figure 2a shows the PCB layout while Figure 2b shows the PCB after being assembled with the components.

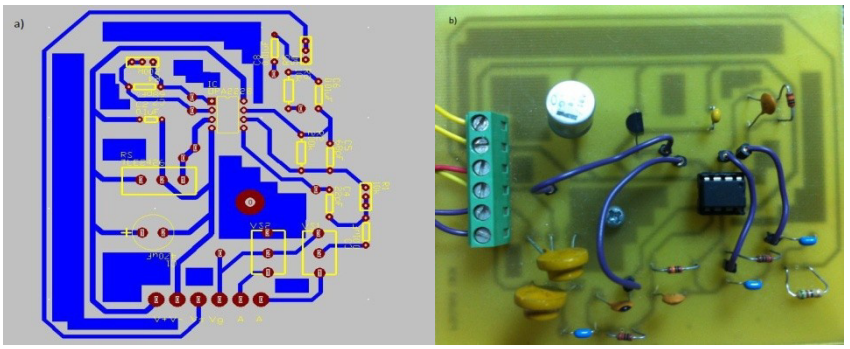

Fig. 2. PCB layout a) before assembly and b) after assembly with components

3.3 Data logger

The third segment is a data logger which consists of computer with sound card and configuration software. The sound card is recommended to be a High Definition audio card with a minimum sampling rate of 96 kHz. This sound card will convert the received analog VLF signal into digital signal. This signal will be processed by

the software and the output signal will be plotted. Figure 3 shows an example of the signal detected by the antenna and plotted by the software. The peak shown in Figure 3 indicates the detected VLF signal from the North West Cape (NWC) station located at Exmouth, Australia. The received signal in Figure 3 needs to be converted to local time (LT). The occurrence of solar flare can be seen from the existence of spikes in the converted signal as shown in Figure 4.

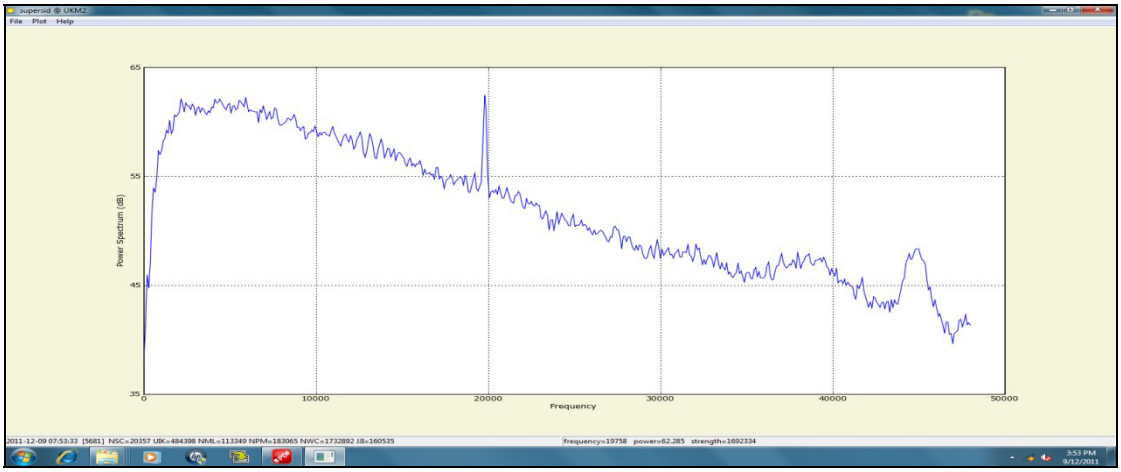

Fig.3. Receiving VLF signal from NWC station (freq: 19.8 KHz)

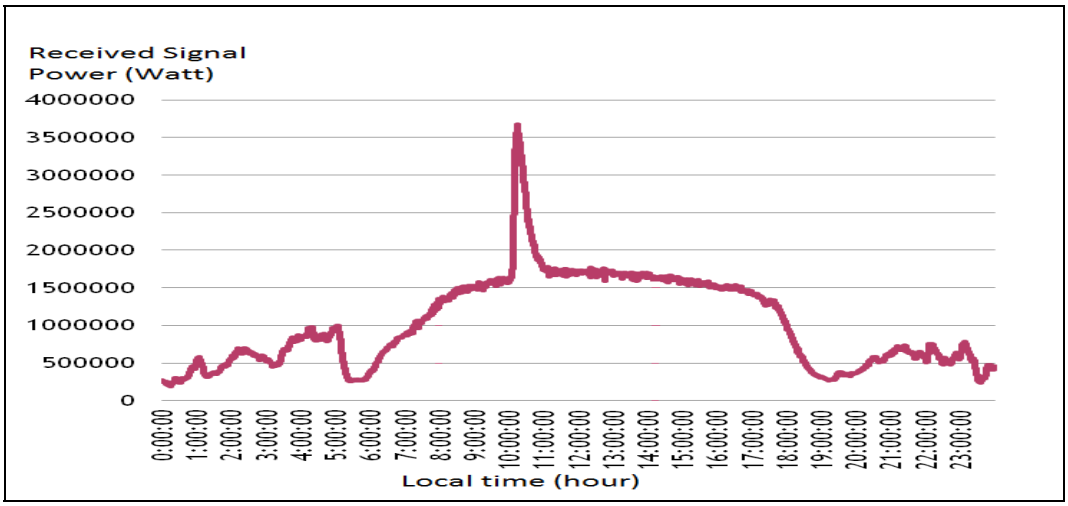

Fig. 4. The spike showing the detected solar flare

4. UKM-SID system

In order to develop the UKM-SID system, the 3 segments mentioned in section 3 need to be built and integrated. A teaching kit inclusive of software, electronic components, PCB, user manual, and related information will also provided. Figure 5 shows the steps in developing the UKM-SID system. First, the antenna should be designed and built according to the specification provided, then the electronics components should be

assembled on the PCB and soldered to build the preamplifier. Next, the antenna will be connected to the preamplifier which is then connected to the data logger. This is followed by the software installation and testing. Lastly data will be collected continuously to monitor the occurrence of the solar flare.

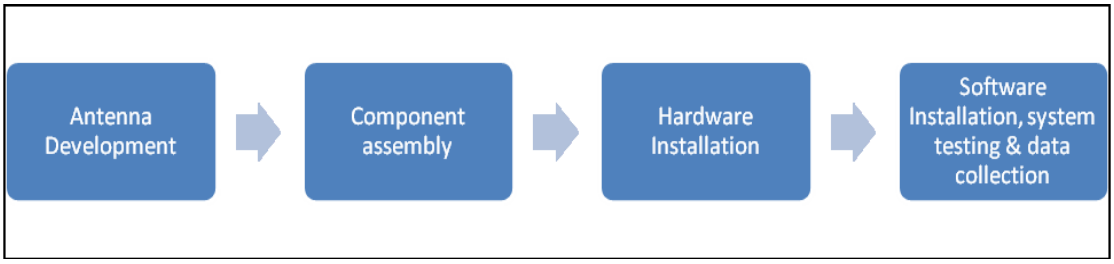

Fig. 5. UKM-SID system development

5. Way forward

The UKM-SID teaching kit has been introduced as a pilot project to Sekolah Menengah Agama Persekutuan, Kajang and Sekolah Seri Puteri, Cyberjaya. Several meetings and workshop have been conducted in order to brief the students and teachers about the UKM-SID system. Students are required to build the UKM-SID system according to the specified schedule. They will also facilitated by UKM post and undergraduate students who are actively involved in space science research.

Through the antenna development, preamplifier assembly and data processing, the student's technical skills, critical thinking and their ability to work in team will be enhanced. They are also required to record their activities in a log book, complete their assignments and present their work. These activities will strengthen their communication skills. As for data analysis, students utilize various software programs which will keep them abreast of the current development in information technology. In addition, the students are also required to do information searching in order to complete the task given. These activities will harness the students self-learning skills and enhance their knowledge in space science.

The hardware development will enable students to apply what they have learned in schools and stimulate their interest in space science. This also indirectly supports the government's intention to establish a Young Malaysian Aerospace Exploration Association (MyACE).

6. Conclusion

UKM-SID teaching module has been developed at UKM with the collaboration of Stanford University under the ISWI program. This module is capable in detecting solar flare using VLF technique. This module has been deployed to selected high schools in Selangor to expose and educate them on the space science. It is hoped that the skills and knowledge gained from the project will cultivate students' interest in space science.

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