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Signal Detection Performed by Log Periodic Dipole Antenna (LPDA) in Solar Monitoring

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ABSTRACT

This article describes signal detection by Log-Periodic Dipole-Antenna (LPDA) which designed for solar monitoring with very high-performance in 45 MHz till 870 MHz. The LPDA, consisting of 19-elements, achieves a gain higher than 10 dBi with low noise amplifier. It has successfully setup at National Space Centre, Banting on 15th February 2012. Our objective in this work is to detect any signal at National Space Centre, Sg. Lang, Selangor which connected with CALLISTO spectrometer. Detailed analysis also revealed the interference sources that caused interruption of solar signal. Specific range of frequency that considered a minimum Radio Frequency Interference (RFI) also has been done. We found that high level interference is received from FM-band (80 MHz – 108 MHz), from VHF-band and from UHF-band. In the UHF-band, we could recognize (beside a lot of analog-TV) two (2) DVB-T channels between 650 MHz and 700 MHz. The 'comb' of signals proves that the whole system is working correctly with good sensitivity. This feature can be used to check the system as part of periodic maintenance. Beside the established detection techniques, some improvization of LPDA is also highlighted. The noise floor at all frequencies below 3 dB is in fact not noise, but represents standing waves due to the fact that the LPD antenna is not matched to the 50Ω coaxial cable due to the small size of boom's diameter. Total sensitivity can be improved by impedance matching of antenna and coaxial cable.

Key words: Log Periodic Dipole Antenna (LPDA), signal detection, CALLISTO
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INTRODUCTION

The Log Periodic Dipole Antenna (LPDA) is a coplanar linear array of unequal and unequally spaced parallel linear dipoles fed by a twisted balanced transmission line that suit as described by Isabell in 1960 for wide band applications. It play an important role in the modern communication and radar system (Zhai, Hong, Wu, & Kuai, 2010). This straightforward design inspired by Carrel normally capable of operating over a frequency range of about 2:1 (Carrel, 1961). Generally, a basic concept is based on gradually expanding periodic structure array radiates most effectively when the array elements (dipoles) are resonance so that it will change in frequency the active (radiating) region moves along the array. Several studies have been documented on the design and characteristics of LPDA antenna in a free space environment since 1960s (Carr, 1961; Constanttine, 2005; Mittra., 1964).In addition, measurements of this type of antenna will give strong evidence that the amplitude of the emitted radio pulse depends on the geomagnetic field. In our work, we constructed Log Periodic Dipole Antenna is that fulfil the criteria to maximize the range of frequency from 45 MHz till 870 MHz to monitor solar activities. They consist of two (2) crossed logarithmic periodic dipole antennas, one aligned in north-south direction while the second in east-west direction. This project is under (ISWI) International Space Weather Initiative (ISWI) to monitor 24h/7d coverage of solar observations in state of support develops countries participate internationally with latest technologies of instrument.

Radio emission of flares at wavelengths from millimetre to decimetre waves includes a large variety of emission processes (A.O. Benz, 2002).

However, radio detection of cosmic rays is currently technical challenge for radio astronomer. It can be denied that the increasing of human made signal will polluted the radio astronomy sources signal. However, it still can be eliminate by calibration techniques and subtraction method. In order to evaluate the performance of LPDA it is important to detect any signal from the site where LPDA is been installed. Our LPD antenna has successfully setup at National Space Centre, Banting on 15th February 2012. This paper applies the signal that potentially harm to solar monitoring.

SYSTEM CONFIGURATION AND OBSERVATIONS

Generally, signal from the antenna is directed to the (Compound Astronomical Low-cost Low-frequency Instrument for Spectroscopy in Transportable Observatory) CALLISTO spectrometer, which is housed in a steel case, via a low loss coaxial cable, LMR-240. The cable is 5.5m long so that the cable attenuation at 50, 450 and 900 MHz is 0.7, 2.1 and 3.0 dB respectively. We used a low noise preamplifier and CALLISTO spectrometer to amplify the gain and as a detector that has a sensitivity of 25 mV/dB supplied by ETH Zurich. The frequency range from 45 MHz to 870MHz divided in three (3) sub bands. The channel resolution is 62.5 kHz, while the radiometric bandwidth is about 300 KHz. The sampling time is exactly 1.25 ms per frequency-pixel while integration time is about 1ms. The front end antenna system has to be broad band within 45 to 870 MHz range. It can be of either E or H polarization; both polarizations can be catered for by a parallel back end. In our case, we have decided to use E plane polarized antenna which responds in the 45 to 870 MHz bandwidth.

Our main observations system consists of log periodic dipole antenna (LPDA), CALLISTO spectrometer and Windows computer connected to the internet. Meanwhile, CALLISTO is a frequency-agile spectrometer that is easily transportable and can be used in many observatories (Arnold O. Benz, Monstein, & Meyer, 2004). For standardized the time, GPS clock is using to control the sampling time of the spectrometer and a tracking controller controls the antenna direction. The daily observations will start from 7.00 am till 7.00 pm. We used a log periodic dipole antenna directly control via low loss coaxial cable to the CALLISTO spectrometer. The antenna has a boom length 5.45 meter and covers the range from 45MHz till 870MHz with gain 7dBi. Low Noise Preamplifier is connected to maximize the gain more than 10 dB. So far, wide-band frequency techniques have focused on optimizing the accuracy and dynamic range achievable in the continuum burst by divided it into 15 minutes for each image to gain high resolution of frequency. Each spectrum data file and the tracking log file stored by CALLISTO software and tracking software are transferred to the data acquisition server to process and display data and the current tracking status in the Space Weather Monitoring Laboratory (SWML) in real time.

PRELIMINARY RESULTS AND DISCUSSION

Survey has been done in day starting from 9.00am till 17.00pm on 21st of February 2012. Measurement of the quiet sun is called ON-source while the measurement away from the sun is called OFF-source. We then identify the continuity signal of frequency responses from the spectrum analyzer. Data will be transferred to computer for further analysis. Objectively, this measurement involve technical basis to decide how to continue concerning spectroscopic measurements below 870 MHz. Occasionally, the Sun was very quiet a few days after installation and configuration. Detailed analysis also revealed the interference sources that caused interruption of solar signal. To achieve a good signal of Sun, it is necessary to recognize the range of minimum interference. In order to identify the signal sources, we then compared with the reference of frequency allocation of International Telecommunication (ITU) and Malaysian Communication and Multimedia Commission (MCMC) as well.

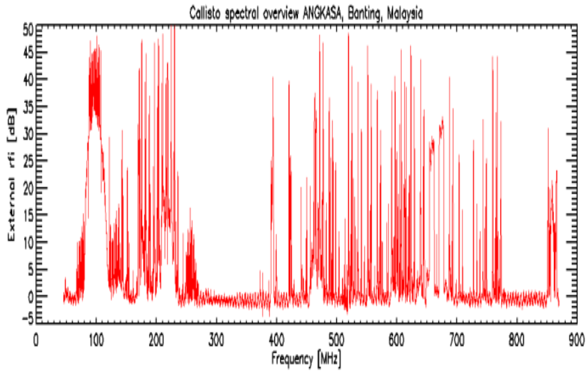

Fig. 1 Spectral overview measured in National Space Centre, Banting Selangor from 1-900 MHz in dB unit

It must be emphasized that there are different types of interference unpredictable, well-known interference, permanently and non-permanently interference. Figure 1 showed the spectral overview at ANGKASA, measured with a 20 dB preamplifier. It must be note that there are interference levels which are rather high with up to 50 dB. High level interference is received from FM-band (80 MHz – 108 MHz), from VHF-band and from UHF-band. In the UHF-band we can recognize (beside a lot of analog-TV) two DVB-T channels between 650 MHz and 700 MHz. The ‘comb’ pattern of signals proves that the whole system is working correctly with good sensitivity. This feature can be used to check the system as part of periodic maintenance. We identify a noise floor at all frequencies below 3 dB is in fact not noise, but represents standing waves due to the fact that the LPD antenna is not matched to the 50Ω coaxial cable due to the small size of boom’s diameter. Total sensitivity can be improved by impedance matching of antenna and coaxial cable.

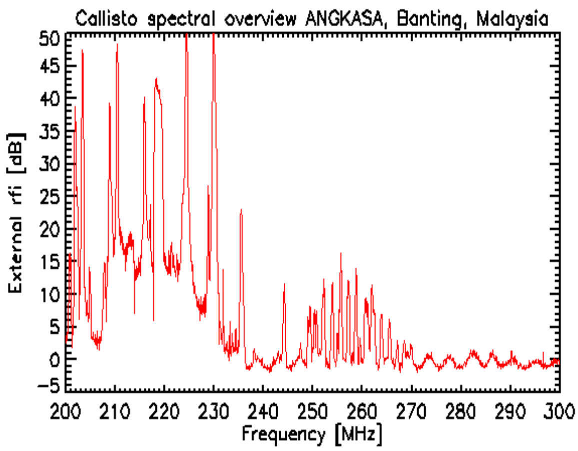

Fig. 2 External signal from local interference in dB unit

From the present Figure 2 one may derive several predictions. Due to the spectral overview, a lot of military satellites between 190 MHz and 270 MHz and a local oscillator at 296 MHz. Several bands of spectral ranges are almost free from interferences. We can clearly observe that in the range of 300 MHz till 400 MHz, this part of the spectrum is very clean and undisturbed. In addition, we can also use the range from 250 till 270 MHz although there is a moderate interference. All reserved frequencies are still free from interference. Unfortunately, most of the strong and fluctuate interferences are home made by local electronic devices and local oscillators and clearly been seen from 85 MHz till 150 MHz. However, it would be difficult or impossible to eliminate it completely. The growing number of radio applications is deteriorating the radio frequency spectrum every year, consequently continuous Signal monitoring is obligatory. In order to mitigate self-induced interferences we strongly recommend not to remote switch antennas electronically. But when needed then low pass filters and shielded cables should be used. Whenever possible, feed all coaxial cables down to the receivers.

CONCLUSION

Understanding the signal pattern help us to more alert on any kind of unwanted signal toward a more accurate data. One can we do is eliminate this noise by subtracting the background and avoid the range of frequency with have permanent interference. It will provide a quality data and best results of analysis process. To illustrate the conclusion, we can generally said that National Space Centre, Sg. Lang, Selangor Malaysia is one of the strategic countries to monitor the Sun due to consistent 12hours per day throughout the year. However, it is suggested that the antenna that will be constructed for e-CALLISTO system should have a higher gain and sensitivity in order to get a good data and eliminate unwanted signal. It should be noted that the cable that connected from the antenna to the spectrometer should be less than 5 meter.

Observations presented in this paper confirmed that Malaysia can be one of the potential country to focus on solar monitoring solar radio emission at low- broadband frequency (45-870) MHz using ground-based telescope due to the fact that they originate in the same layers of the solar atmosphere in which geo-effective disturbance probably originate. It is hope that the survey will continue from time to time in a consistent mode so that any polluted signal for radio astronomy purpose can be protected. This is not only a big issue in Malaysia, but also all over the world.

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