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Application of Log Periodic Dipole Antenna (LPDA) in Monitoring Solar Burst at Low Region Frequencies Region

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ABSTRACT

The Sun is considered as one of the strongest radio sources and observation in radio region can provide information on structures throughout the solar atmosphere. In radio wavelengths, we could possible to investigate high quality images within an arc second resolution at different layers of the solar atmosphere. Solar monitoring in this wavelength makes various demands on the used antennas. Therefore, Logarithmic Periodic dipole Antenna (LPDA) was constructed for monitoring Sun in the range of (45 – 870) MHz to precisely match the environmental requirements. Our work focuses on preparation and performance of the antenna. Observation results of the site will also be highlighted. From the analysis, we found that the signal to noise ratio is 3.9 dB. We also make an effort analyze a y-factor of a data by select a range of frequency from 220 MHz till 250 MHz due to this range consists burst. By constructing and understanding the principle of the log dipole periodic antenna and then connect it to the CALLISTO spectrometer as receiver, some solar activities observations such as solar flares and Coronal Mass Ejections (CMEs) can be done. In conclusion, the log-periodic dipole antenna (LPDA) is remains the simplest antenna with reliable bandwidth and gain estimates.

Key words: Log Periodic Dipole Antenna (LPDA), CALLISTO, solar burst, solar activities
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INTRODUCTION

The Sun is considered as one of the strongest radio sources and observation in radio region can provide information on structures throughout the solar atmosphere. Characteristic studies of solar radio bursts are a great importance for determining the solar flare and Coronal Mass Ejections (CMEs) phenomenon in radio wavelengths, we could possible to investigate high quality images within an arc second resolution at different layers of the solar atmosphere. Observations of solar burst by low spectral and spatial resolution instruments can provide us only the light curve and a crude spectrum of the whole flare which may consist of many distinct sources with different characteristics. Indirectly, solar burst potentially produced many negative impacts to the Earth. By very-high-energy particles that release from intense solar bursts can be as injurious to humans as the lower energy radiation from nuclear blasts. These solar bursts will give an impact toward our satellites. Not only that, their powerful UV and X- rays radiation will shortening the orbital life of our satellites and lowering the orbital of satellites. As a result, our communication systems also will be affected. Due to this issue, it is very important to monitor the Sun activities especially during solar cycle maximum. In general, this work is purposely for monitoring a space weather event or solar activity observations specifically the radio flux observation of solar flares and solar bursts are caused coherently by electron beam, shocks, possibly trapped electrons, and high-frequency waves in the plasma. The role of constructing a good antenna is very important for us to solve several issues that relates to solar flares such as (i) to identify active flare sources, (ii) to find out their nature and emission mechanisms, and (iii) to relate their properties with parameters of plasmas and accelerated particles in flaring regions. Turning to solar observation, the surprising development of observational tools has greatly contributed to our understanding of magnetic and gaseous fine structure of solar bursts. Antenna arrays have been excellent solutions for operating bandwidth expansion (Ioushkine., 1998; Jeong-II, 2000; Jeong, 1999). Logarithmic periodic dipole antenna (LPDA) is a well-known scientific instrumentation for power spectrum radio data monitoring used wideband antennas at its front end (Campbell C. K., 1977). It plays a key role in the successful detection of solar radiation as they provide the sensitive component of the radio detector (Carrel, 1961). Without a doubt, the dimension of log-periodic antenna vary with frequency is well known as best type for this purpose because it's normally exhibit different radiation properties at different frequency and can be designed for any band, from HF till UHF. This type of antenna is considered as basic receiving element used in the present system which has an almost continuous coverage of a wide range of frequencies and one of the broadband antennas that suitable for many applications (Butson, 1976).

It is well known that LPDA arrays have been excellent solutions for operating bandwidth expansion (Jeong-II, 2000). It's also possible to design in order to obtain a gain much better (5-10 dB) and it is sensitive to a radio signal of the Sun (Jaleel, 2008). Here, we focus on setup and preparation of performance of the antenna and observable results of the site. Objectively we plan to construct log periodic antenna by using standard design for monitoring solar in the range of 45MHz-870 MHz. Mathematically, it is a ratio of the radiation intensity in a given direction of the average radiation intensity overall direction (Rippin, 1963). In order to understand the principle of log periodic antenna and test performance of log periodic dipole antenna by evaluating signal to noise ratio (SNR) of this antenna. We then assemble the antenna by using standard design for monitoring solar in the range of 45MHz-870 MHz for solar monitoring at low frequency region.

METHODOLOGY

We strongly believed that it is important to have a proper method in order to have a standard and accuracy measurement of analysis the solar data sets and make comparative studies at different sites. Therefore, in order to design antenna that can monitor the Sun which need to cover from HF to UHF band, Yagi antenna is not suitable.

Table.1 Specifications of Log Periodic Dipole Antenna

No of elements	L(m)	L/2 (m)	R(m)	D(m)
1	3.965	1.982	3.172	0.634
2	3.172	1.586	2.537	0.507
3	2.537	1.268	2.030	0.406
4	2.030	1.015	1.624	0.324
5	1.624	0.812	1.299	0.259
6	1.299	0.649	1.039	0.207
7	1.039	0.519	0.831	0.166
8	0.831	0.415	0.665	0.133
9	0.665	0.332	0.532	0.106
10	0.532	0.266	0.425	0.085
11	0.425	0.212	0.340	0.068
12	0.340	0.170	0.272	0.054
13	0.272	0.136	0.217	0.043
14	0.217	0.108	0.174	0.034
15	0.174	0.087	0.139	0.027
16	0.139	0.069	0.111	0.022
17	0.111	0.055	0.089	0.017
18	0.089	0.044	0.071	0.014
19	0.071	0.035	0.057	0.011

As noted above, the antenna elements are based on the size of the waves they're designed to receive, and the lower the frequency, the waves are long, requiring a larger antenna surface to receive them. Here, we are constructing the log periodic antenna that covers the broadband range $(45 - 870)$ MHz. By doing this and understanding the principle of log periodic antenna and then connect it to spectrometer, some solar activity observation can be done for application purposed of log periodic antenna. As indicated in Table 1, we construct a 3.1 meter boom that possible to obtain 10 dB gains. We have selected a linear polarization because the antenna radiates the electric field of the emitted radio wave to a particular orientation.

RESULTS AND ANALYSIS

The measurements were performed using broadband Log-Periodic Dipole Antenna connected to the receiver, (Compact Astronomical Low-cost Low-frequency Instrument for Spectroscopy in Transportable Observatories) CALLISTO spectrometer to study the magnetic activity of a wide range (from 45 MHz to 870 MHz) of the Sun (Arnold O. Benz, 2004). E-Callisto research collaboration is one of as a follow up to the International Heliophysical Year of 2007 and successful program of under ISWI (International Space Weather Initiative). It is planned to carry out co-ordinated radio spectral observations of the solar corona from various locations around the world (C. Monstein, 2007). A part of measurement, we test the LPDA by initiate some observations from 7.30 am till 17.30 pm.

We need to consider the radiation pattern of an antenna which indicates the power or field strength radiated in any direction relative to that in the direction of maximum radiation. We then analyze a y-factor of a data by select a range of frequency from 228 MHz till 240 MHz. The reason we choose this range is because of the there is a burst detected within that frequency. We choose input impedance, R_0 50 ohm for this LPDA antenna. We also select element factor (τ) and spacing factor (σ) give in the subtended angle of 3.43 degrees. As a results bandwidth ratio (B = 870 MHz /45MHz) of 19.33 gives a bandwidth as 2.14. Meanwhile, we also calculate the power flux density of the burst represent as 1.85×10^{-21} W/Hz. At the final stage, we gain the Y-factor will be calculated by selecting a certain frequency considering hot and cold section of the data.

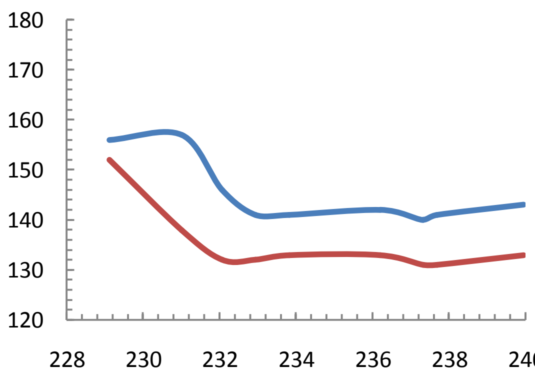

Fig.1 Distribution of digit hot (red) and digit cold (blue) from 228 MHz to 240 MHz

In order to calculate the signal to noise ratio (SNR), we need to calculate the effective area of the LPDA and power flux density (PFD) of the burst and the system as mentioned earlier. Figure 1 plot the distribution of hot and cold section from the range of 228 MHz till 240 MHz.

From the analysis, we found that the signal to noise ratio (SNR) is 3.9 dB. This value is significant to monitor the solar activities by connecting preamplifier in front of the CALLISTO spectrometer. The antenna is mounted horizontally on a steerable azimuth/elevation tower. The LPDA is controlled by the computer to automatically point the sun during the daytime. The input impedance, R0 50 ohm is chosen for this LPD antenna. For an efficient transfer of energy, the impedance of the antenna and the impedance of the transmission cable connecting them must be the same and matched. The chosen tau and sigma give in the subtended angle of 3.43 degrees. As indicated in the figure, this LP antenna will have 19 elements.

Fig.2 Logarithmic Periodic Dipole Antennas of e-CALLISTO

From the analysis, we found that the signal to noise ratio (SNR) is 3.9 dB. This value is significant to monitor the solar activities by connecting preamplifier in front of the CALLISTO spectrometer. The antenna is mounted horizontally on a steerable azimuth/elevation tower. The LPDA is controlled by the computer to automatically point the sun during the daytime. The input impedance, R0 50 ohm is chosen for this LPD antenna. For an efficient transfer of energy, the impedance of the antenna and the impedance of the transmission cable connecting them must be the same and matched. The chosen tau and sigma give in the subtended angle of 3.43 degrees.

As indicated in the figure, this LP antenna will have 19 elements. Coaxial cables are used to feeding the LP antenna from the longest element to the shortest one. It also connected to the radio frequency transformer or Baluns for impedance transformation between the antenna and the cable. Although there are still needs to be improved, this design of LPDA is our best construction so far. However, we realize that we need to develop the designing especially on how to maximize the gain and cable connection. In order to improve the bandwidth of an antenna, we used thicker wire coaxial cable. This coax cables have a core conductor wire surrounded by a non-conductive material called dielectric, or simply insulation. The main observation system consists of a log periodic dipole antenna, CALLISTO spectrometer and computer connected to the internet as shown in Figure 3a. For standardized the time, GPS clock is used to control the sampling time of the spectrometer and a tracking controller control the antenna direction. Our routine observations will start from 7.00 am till 7.00 pm, 12 hours every day.

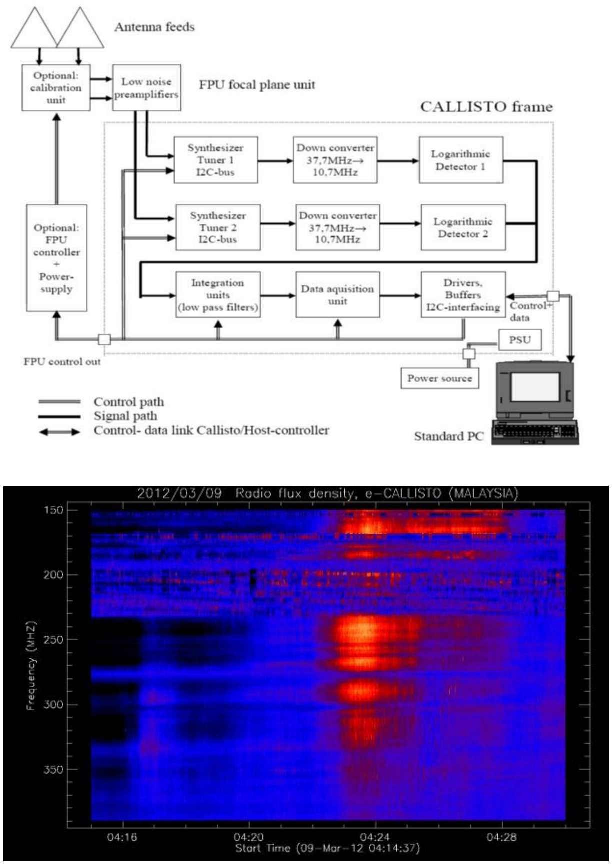

Fig.3 : a) CALLISTO Configuration and b) FITS data files on 9th March 2012 from 04:16UT to 04:28UT

Observations of low frequency solar type III radio bursts associated with the ejection of plasma oscillations localized disturbance is due to excited in the plasma frequency incoherent radiations play a dominant role at the meter and decimetre wavelengths. These bursts are associated with solar flare type M6 solar flare which suddenly ejected in the active region AR 1429 starting at 03:32 UT and ending at 5:00 UT with the peak at 04:12 UT. From the observation, it showed an initial strong burst occurred due to strong signal at the beginning of the phase. We also found that both solar burst and flares are tend to be a numerous on the same days and probability of chance coincidence is high. It is clearly seen an impulsive lace burst were detected at 4.24 UT and it is more plausible that the energies are confined to the top of the loop when we compared with X-ray results.

CONCLUSION

A single Log Periodic Dipole antenna system to observe solar activities has been discussed. Overall, our studies in the present work are based on the main objective to monitor solar burst in the lower region of frequencies. By constructing and understanding the principle of log dipole periodic antenna and then connect it to the CALLISTO spectrometer as receiver, some solar activities observations such as solar flares and Coronal Mass Ejections (CMEs) can be done. From the analysis, we found that the signal to noise ratio is 3.9 dB. The log-periodic dipole antenna (LPDA) is remains the simplest antenna with reliable bandwidth and gain estimates. We have also successfully obtained a good solar burst data using the antenna. Our next task is to modify the antenna relevant with different sites and set up the system at Jelebu, Negeri Sembilan and University of Malaya. We strongly believed that Malaysia has a very good potential to monitor solar activities due to the consistency of period observation throughout a year.

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