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Study of Solar Activities using e-CALLISTO

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Abstract: The solar activities are monitored by different new ground radio spectrometer. Now a day, a worldwide network extended-Compound Astronomical Low-cost Low-frequency Instrument for Spectroscopy and Transportable Observatory (e-CALLISTO) is keeping watch on different solar activities. It was established by Zurich University. CALLISTO network collects data located in many countries and data is made available worldwide. The present work represents the details of e-CALLISTO station installation at KTHM college Nashik, Maharashtra (India). This installation is 6th in India and 2nd in Maharashtra state. It includes log periodic dipole antenna (LPDA), low noise amplifier (LNA), CALLISO receiver and Personnel Computer (PC). CALLISTO station captures data with the help of CALLISTO receiver which is programmable and works at frequency band of 45 MHz to 870 MHz. The system is useful for the study of solar activities, observation of solar radio bursts. This paper also includes the details of solar activities images captured by using the e-CALLISTO.

Keywords: *e-CALLISTO; LNA; LPDA; Solar flare; Solar burst*

1 Introduction

The life on earth is driven by the sunlight incident form the atmosphere. Therefore climate is critically sensitive to the solar activities. The variation in the sun climate has important role in changing the life on the earth. So it is necessary to study and understand the solar activities. These variations in solar irradiance have been studied from space for more than two decades. The ground observatories are increasing rapidly. The increase in solar activity is shown by increase in number of sunspot, increase in various related measures of solar magnetic fields, the changing flow, thermal and mass profiles near the surface of the sun (*Goode and Palle, 2007*). In the 16th century, the first description of the Earth's magnetic field was given by De Magnete, William Gilbert, showing that the Earth itself is a great magnet. The changes in the superficial, random magnetic field were first tried to calculate by *Goldreich et al in 1991.*

Gauss and William Weber studied Earth's magnetic field which showed systematic variations and random fluctuations, suggested that the Earth was not an isolated body, but was influenced by external forces, which we called magnetic storms (*Grigis and Benz, 2008*). The first powerful geomagnetic solar storm was observed by Richard Carrington on 1st September 1859 (Carrington, 1859).

The frequency of occurrence of solar flares varies from several per day when the sun is particularly active to less than one every week when the sun is following the 11-year cycle. Since the mid of 1970, The Geostationary Operational Environmental Satellite (GOES) spacecraft in geostationary orbits around the Earth have been measuring the soft X-ray flux from the sun.

The Yohkoh (Solar-A) spacecraft has been observed the Sun with various instruments from 1991 to 2001. Another large solar flares also occurred on April 2, 2001 (X20- X-RAY flare) (*NASA, 2012*). On 4 November 2003, the largest solar flare recorded by GOES satellite that exploded from the surface of the Sun (*Edward et al., 1859*). According to NASA, On July 23, 2012, a massive, and potentially damaging, solar super storm (solar flare, coronal mass ejection, solar electromagnetic pulse (EMP) barely missed Earth (Phillips, 2014). These solar events are continuously occurring till today.

The e-CALLISTO is worldwide network that watch different solar activities which was established by Zurich University. CALLISTO network collects data located in many countries and data is made available worldwide. For full coverage of the solar radio emission, the number of stations is being connected to Callisto network using a public web interface (*www.e-calistro.org*).

All over the world there are 116 e-CALLISTO instruments. For installation LPDA, LNA, CALLISTO instrument and a Computer is required (*http://www.e-callisto.org/General Documents / Callisto-General*). The LPDA is used because of it high gain, directivity, and wide frequency band. CALLISTO station captures data with the help of CALLISTO receiver which is programmable and functions at frequency band of 45 MHz to 870 MHz (*Hamidi et al., 2013*).

2 Materials and Methods

Experimental setup

The block diagram of e-CALLISTO setup is shown in Figure 1. It includes LPDA antenna, low noise amplifier (LNA), a CALLISTO receiver and PC. The LPDA antenna is used to capture the Sun radiations and it is connected to CALLISTO receiver via LNA. A CALLISTO is a heterodyne receiver used to receive data, which is connected to personnel computer via RS232 serial cable. A low loss co-axial cable (RG58BU) is used to connect antenna and LNA.

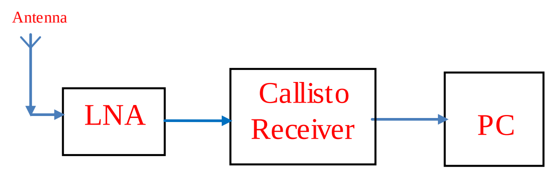

Figure 1. Block diagram of e-CALLISTO

LPDA antenna receives sun radiations i.e. electromagnetic (EM) radiations. A scale factor (τ) that specifies the relative lengths and spacing factor (σ) that specifies the relative spacing of the antenna elements and the apex angle α are three important parameters while designing crisscross structure of a LPDA antenna. The advantage of LPDA is that it is frequency independent, highly directional, high gain antenna having broadband frequency characteristic. LPDA designed using developed MATLAB program (*Constantine, 2005; Hamidi et al., 2012*). The constructed LPDA specifications are given in Table 1.

Low Noise Amplifier (LNA) is a device that converts weak signal captured by an LPDA antenna to strong electrical signal ZX60-33LN+ is used for amplifying the signal (*http://www.e-callisto.org/GeneralDocuments/ Callisto-General)*. It is shown in Figure 2.

Table 1. Specifications of LPDA antenna

No.	Parameters	Values
1	Lowe frequency	160MHz
2	Upper frequency	1900MHz
3	Diameter of the elements	0.40 in
4	Geometric constant, τ	0.876
5	Spacing factor, σ	0.161
6	Half apex angle, α	10.90^0
7	Width of antenna	1.82 meter
8	Height of structure	2.33 meter
9	No. Of elements	24
10	Centre to centre spacing of feeder line	1.14 cm
11	Mounted Location	$N73.77885^0$ $E20.00775^0$

Figure 2. The photograph of LNA

Callisto receiver was established by the Swiss Federal Institute of Technology Zürich (ETHZ Zürich) and works with local institutions collaboration. The picture of Callisto front and rear panel is shown in Figure 3 (a) and 3 (b) respectively.

Figure 3(a). Front panel of the CALLISTO

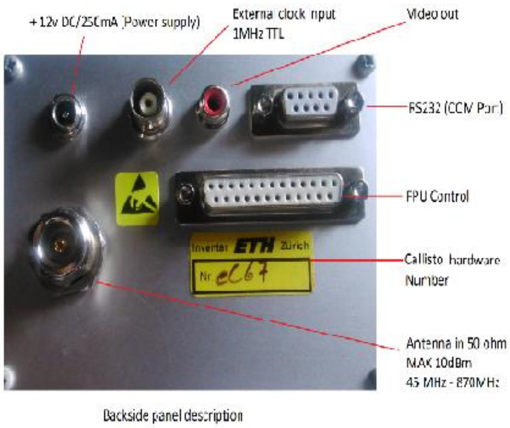

Figure 3(b). The rare panel of the CALLISTO

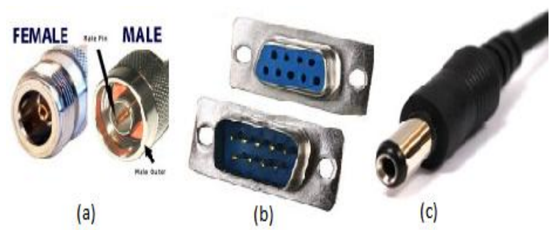

Figure 4. (a) N-Type M and F connector (b)DB9 M and F connector and (c) DC Female connector.

Table 2: Specifications of cable RG56BU

Sr. No.	Parameters	Description
1.	RGType	RG58BU
2.	Conductor Type	TC
3.	Conductor Area	19/0.18
4.	Insulation	Polythene
5.	Insulation Diameter	2.95
6.	Screen Braid	TC
7.	Screen Diameter	3.50
8.	Sheath	PVC
9.	Sheath Diameter	4.95
10.	Weight Kg/100m	40
11.	Capacitance (pF/m)	101.5
12.	Impendence (Ω)	50
13.	Attenuation dB/100 m	39.5
14.	Vel, propagation	65.9

The instrument operates in frequency range 45MHz and 870 MHz.

Different connectors are available in market. Form those connectors appropriate connectors are required to be chosen. Figure 4 shows different connectors used to connect callisto with antenna and computer.

Low loss coaxial cable RG56BU technical specifications are given in table 2 *(http://www. epanorama. net/ documents/ wiring/ cable_impedance. html; http://www.madisoncable.com /RFCoaxialCables.asp)*.

3 Results and Discussion

LPDA was installed at KTHM college, Nashik, Maharashtra (India). The locations details are as follows: Latitude 20.000, Longitude 73.780 and Altitude 576 meter. CALLISTO installation and LPDA photograph is shown in Figure 5.

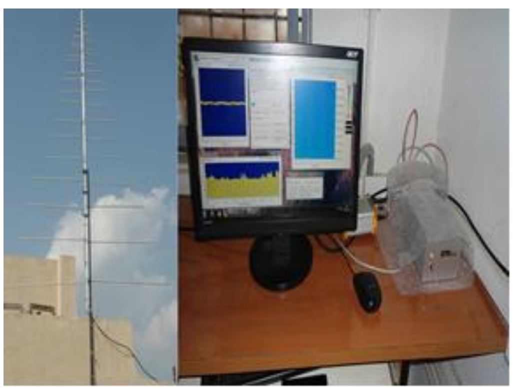

Figure 5. CALLISTO installation and LPDA

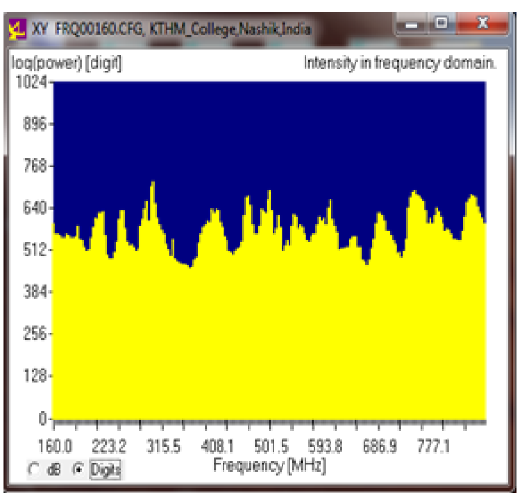

Figure 6. Spectrum (f) window

Light curve for a selected frequency [y(t)] is shown in figure 6. Figure shows the intensity variations with frequency.The values displayed are expressed in digits of the ADC, where the digits are proportional to the logarithm of intermediate frequency (IF) power. The values can be changed to dB scale by selecting radio buttons shown in left side bottom of the figure. A type III bursts typically occur in groups of 3 to 10 with duration less than 60 second is shown in figure 7.

Fast drifting bursts are commonly occurs with typical duration of a second. The duration increases at lower frequency and the drift rate (MHz/s) decreases.

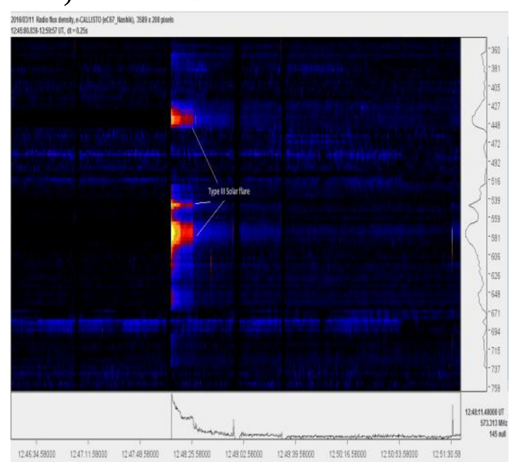

Figure 7: Type III solar burst

Sometime received data may not be appropriate. It may contains some losses. Figure 8 shows loss in received data. Data loss may occur due to insufficient resource of the PC that is connected to CALLISTO receiver. In most cases the virus-scanner took too much memory and too much processor resources. Generally, the main reasons are:

i. Bad quality of the RS-232 cable or a too long cable.

ii. Disconnection of Antenna cable.

iii. Bad selection of interrupt level

iv. Insufficient working (RAM) memory.

v. Too many applications running on the PC.

vi. DC power supply

The plot in figure 9 shows the frequency spectrum, evolving in time where time is expressed in seconds. The radio buttons shown at the bottom of the right side is used to subtract a fixed value or to smooth background. The scrollbars have influence to the color table. The color table is a linear interpolation between Low-value (Left scrollbar 0-255) and High-value (Right scrollbar 0-255).

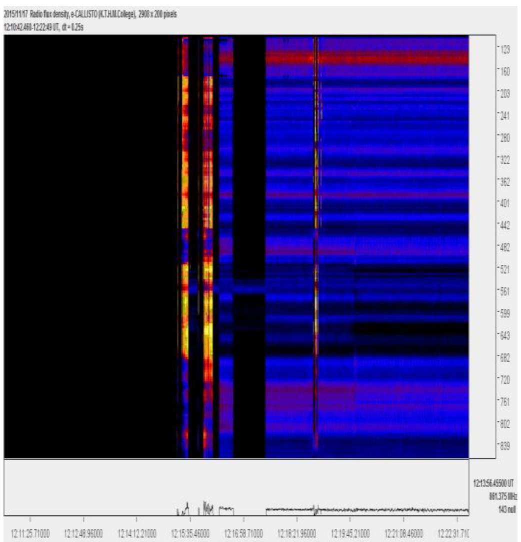

Figure 8: Data loss due to different reasons

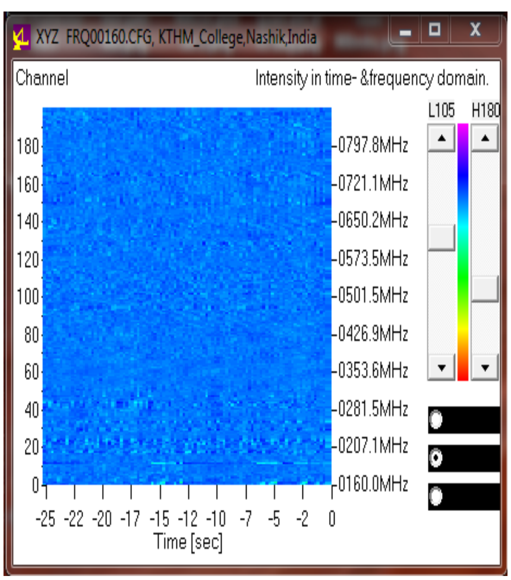

Figure 9: Frequency spectrum in time (Sec.)

Spectral Overview File (SOVF) is shown in figure 10. These files are generated once per day at the end of the day.

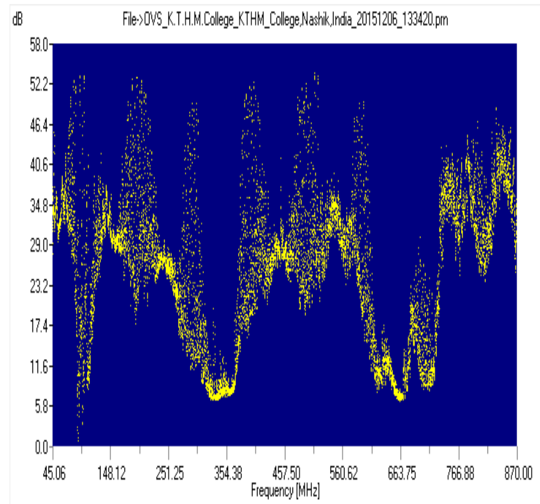

Figure 10. Spectral Overview (SOVF) File Generated by CALLISTO

4 Conclusions

From several years, logarithmically periodic antennas have been widely used due to their frequency response characteristics, simplicity of design and directivity. The geometric design of LPDA basically depends on higher frequency, lower frequency, and geometric scaling constant $\tau \leq 1$ typically $0.7 \leq \tau \leq 0.95$, and spacing factor σ. The lengths and spacing of the elements of a LPDA increases logarithmically from one end to the other.

Technological advantages in solar activities particularly in solar radio burst (type I, II, III, IV, V) in radio region have created a demand of designing and constructing of LPDA to monitor. The purpose of construction was to monitor solar radiation flux. Using e-CALLISTO, solar radiation data files (FITs) are created and the data is stored in PC.

The e-CALLISTO system has been successfully designed, configured and tested. Here CALLISTO receiver works in the frequency band of 160 MHz to 870 MHz. A Log Periodic Dipole Antenna is designed to work with

Callisto instrument. LPDA is designed for the range of 160 MHz to 1300 MHz. The location Longitude-N is 73.778850, Latitude-E 20.007750 and altitude of 562.00 m from sea level. Callisto has proven its importance in solar activity monitoring.

The Electromagnetic spectrum may have high impact on the human body according to wavelength. High exposure may cause photo-aging, sunburns and DNA mutations leading to skin cancer. The solar storms may affect the ozone layer that is the protective mechanism of the earth. This causes leads to study solar storms, CME etc.

5 Acknowledgement

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