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DESIGNING AND CONSTRUCTING A VLF RADIO TELESCOPE WITH AN EXTERNAL FILTER TO RECEIVE THE SUDDEN IONOSPHERIC DISTURBANCES (SID) IN IRAN

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Abstract- In this paper after the design and construction of the radio telescope system in the VLF region, we study the effects of atmospheric disturbances, especially solar bursts (Solar flares) on earth's Ionosphere. Our radio telescope receives the 26.7 KHz signal of source station TBB (Bafa, Turkey). Then the radio signals of solar flares received by our radio telescope are investigated by software SSRT Robot2 and spectrum lab.

Keywords: VLF Signals, Solar Flare, Sudden Ionospheric Disturbances

I. INTRODUCTION

Ionosphere is the part of Earth's atmosphere at altitudes above about 60 km which is formed due to the x-ray and ultraviolet radiation of the sun. Due to the interaction between the radiation and earth's atmosphere, electrons are separated from molecules or atoms in that height and can move freely in the Earth's magnetic field. Therefore ionosphere can be summarized as a conductive layer.

On the other hand, ionosphere is divided into different layers because of various intensity and penetrating power of solar radiation: layers D, E, F1 and F2. The D layer only exists during day and F1 and F2 layer change to one F layer at night. The sun affects directly on the ionization of layers of the ionosphere. There are many VLF stations around the world, which these VLF stations send VLF waves to communicate with submarines.

These waves collide with layers on their way within Ionosphere and reflect due to the electron density gradient of these layers. Solar swings and bursts and also signal changes at sunrise and sunset can be observed via received signals from these stations.

II. SIGNAL ANALYSIS OF SIMILAR RADIO TELESCOPES

Regarding the changes in electron density in different layers in ionosphere at night and day and the sent waves from VLF stations toward this layer, the reflected waves from that layer and received signal on the ground change, consequently the solar fluctuations can be realized via observing the changes in received signal. During the night, the sun's radiation is less.

As a result, the ionization is less and D layer disappears and VLF signals reflect from E and F layers. This phenomenon increases the VLF signal strength at night. When sun rises, the D layer is ionized a little and this causes the D layer to absorb the VLF signals. After 1 or 2 hours its reflecting ability is again high. VLF signals sent daytime are reflected, although the reflection is not as strong as night. We all have experienced to receive higher quality the radio signals at night.

During a solar explosion (Solar Flare), hard x-ray is radiated and this radiation increases ionization of layer D, 100 times more than a day without solar flare. This event increases the electron density in the D layer and this cause to have a peak due to solar flares in the signals chart received from VLF stations: (Figures 1)

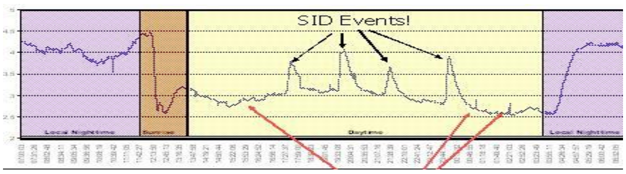

Figure 1. The VLF signal pattern during a day and night with solar flares

These phenomena are called SID (Sudden Ionospheric Disturbances). This paper aims to study the observed solar flares and the signal reductions during sunrise and sunsets [2, 3].

In order to receive VLF Radio waves we needed an antenna which is able to receive signal from each considered station. Loop antennas were used to receive these signals.

A. Methods and Formalism

1. The selection of desired transmitter to receive VLF frequency in Iranian location:
A good transmitter should have the following attributes to become an appropriate option to perform monitoring operations.

A. Possessing the highest transmission ability
We should try to select a transmitter with highest transmitting ability to be able to easily be distinguished from ground noise (unfortunately, due to the military reasons, the ability and power of many VLF stations is not given)
B. The ideal distance between 500 km to 5000 km related to the power of transmitter

If you sit at an unnecessary close distance to the transmitter, it is possible that you receive even the least disruptions of the ionosphere, if you are at an unnecessary farther distance from transmitter, it is possible that the received signals are weakest; these two phenomena are not appropriate. So the legal or acceptable distance should be maintained for this task. [5] After carrying out all necessary evaluations and studies, we reached the conclusion and understanding by using the Movable Type Scripts' software, that the TBB transmitter located in Bafa, Turkey is an appropriate transmitter for our objective, which possesses a working frequency of 26.7 kHz.

2. The measurements and calculations, and related formulas to build loop shape antenna (Octagonal):
The frequency (f) of antenna resonance depends on inductance (L) of wire loop, and the capacitance capacity of total (C).

$$f = \frac{1}{2\pi\sqrt{LC}} \tag{1}$$

The inductance of a loop depends on using wire's thickness in antenna structure, its diameter and the number of wire rounds.

$$L = \mu r N^2 \ln\left(\frac{8r}{R}\right) - 1.75 \tag{2}$$

In view of this fact, that the VLF transmitter which will be used to receive frequency, uses a transmitting frequency of 26.7 kHz, therefore, we put f = 26700 Hz in Equation (1).

$$26700 = \frac{1}{2\pi\sqrt{LC}} \rightarrow \sqrt{LC} = \frac{1}{26700 \times 2\pi} \tag{3}$$

$LC = 3.55\mathrm{e}^{-11}$

Now we refer to Equation (2), and on the basis of the existing experience and the availability of the parts in market, arrange a, 0.55 mm diameter wire. We consider the radius of the antenna about, r = 0.4 m and N = 100 rounds, substitute these values in Equation (2), D = 0.55 mm, R = 0.275 mm so, we have: L = 38.2 mH.

This 'L' value is reasonable to continue the assignment. Now substitute L = 38.24 mH in the result of Equation (1), so we shall have the following:

LC=(3.55*10^{-11}) $\rightarrow$ 38.24*10^{-3}C=3.55*10^{-11}

$\rightarrow C = 3.55{*}10^{-11} / 38.24{*}10^{-3}$

$\rightarrow C = 919$ pf (Total capacitance capacity)

Considering the above calculations, the designed antenna will have the specifications in Table 1.

Table 1. Specifications of designed antenna

Antenna diameter (d)	Wire diameter (D)	L	C
80 cm	0.55 mm	38.24 MH	919 Pf

The C is called total capacity of the capacitance:

$$C = C' + C' \tag{4}$$

Each antenna has a C', which is specific to the antenna itself. To find the C', we arrange a Coil of equal diameter to antenna, which has fewer rounds of winding. Antenna and the coil are placed against each other at a distance of few meters, now we connect the two, 'first and last wire ends' of the coil to generator signal. From the other side, the two first and last wire ends of the antenna are connected to the oscilloscope, and the signals of the oscilloscope and generator are switched on, and frequencies are given to 1 kHz gorge or span for antenna, while the receiving voltage value is noted and registered by the help of oscilloscope described in Table 2.

Table 2. Transmitted frequency and receiving voltage in gorge of 1 kHz

Receiving voltage by antenna and oscilloscope (V)	Induced frequency to coil through generator signal (kHz)	Receiving voltage by antenna and oscilloscope (V)	Induced frequency to coil through generator signal (kHz)
0.85	23	0.2	3
0.95	24	0.25	4
1.10	25	0.3	5
1.2	26	0.35	6
1.5	27	0.38	7
2	28	0.4	8
2.8	29	0.41	9
4.6	30	0.41	10
18	31	0.42	11
5.8	32	0.42	12
3	33	0.44	13
1.8	34	0.48	14
1.4	35	0.5	15
1.1	36	0.55	16
0.9	37	0.58	17
0.7	38	0.6	18
0.6	39	0.62	19
0.5	40	0.65	20
		0.7	21
		0.8	22

It was observed that in 31 kHz frequency, a very high voltage is produced, hence, we noted that the antenna resonance frequency locates around 31 kHz. Repeat the above steps to have higher degree of precision for lesser gorges of 1 kHz shown in Table 3.

Table 3. Transmitted frequency and receiving voltage in gorge of 0.1 kHz

Induced frequency to coil through generator signal (kHz)	Receiving voltage by antenna and oscilloscope (V)	Induced frequency to coil through generator signal (kHz)	Receiving voltage by antenna and oscilloscope (V)
31	18	31.5	12
31.1	19	31.6	10
31.2	20	31.7	9
31.3	19	31.8	8
31.4	16	31.9	6

In view of the above data, the resonance frequency of antenna is 31.2 kHz. Now by noticing Equation (1), we calculate C', we have: $C = C' + C''$, 919 pf = 679.9 pf + $C'' \rightarrow C''$ = 239.1 pf.

Thus, in order to bring 31.2 kHz to 26.7 kHz value, the variables of about 239.1 Pf should be mounted on antenna to bring the frequency to 26.7 kHz.

3. Designing and building of an 'Amplifier Circuit':
The designed looped antenna receives 26.7 kHz frequency for us; for better reception of this frequency, this frequency should be boosted and amplified. An amplifier is necessary to reach this aim, In the previous step, the filtering process of receiving signal was conducted on 26.7 kHz; so, there is only a need of amplifying these signals (i.e. amplifier accompanied with outer filter). In fact, our circuit is comprised of two phases or stages of pomp so that each of the stages performs amplification to 20 gains (20×20=400). For our target It is enough to use first stage or phase of (20 gains) as shown in Figures 2 and 3.

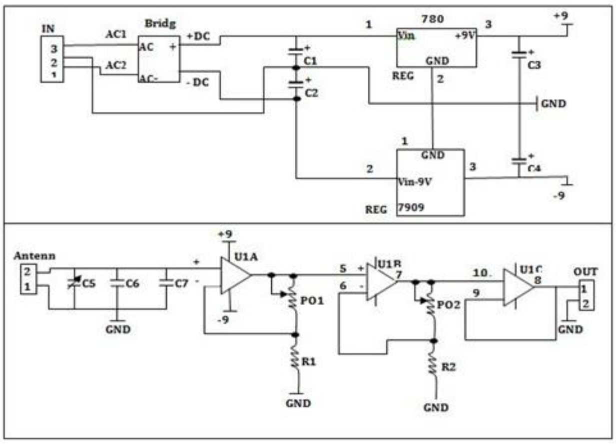

Figure 2. Amplifying schematic circuit with outer filter

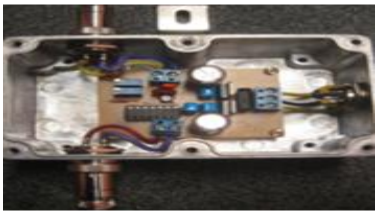

Figure 3. Constructed circuit

4. Connectivity of the amplifying circuit to antenna and its testing (by generator signal in laboratory):

In this stage, 2x0.7 kHz frequency was transmitted to designed antenna by generator's signal and the coil, expecting to observe the 'noise less' signal on the oscilloscope as shown in Figure 4.

Figure 4. Signal observation without noise by generator signal in laboratory

5. Connectivity of the amplifying circuit to antenna and its testing (without connectivity to generator's signal and in open atmosphere):
This step was performed like stage 2.4 with a difference that we shifted and transferred the set of antenna and amplifier circuit to open atmosphere where we directly received the signal from sky as shown in Figure 5.

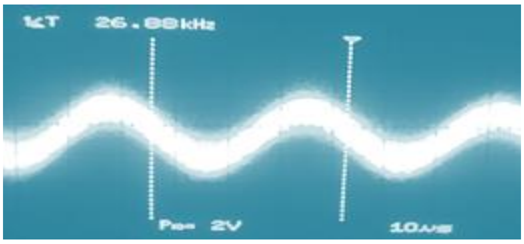

Figure 5. Signal receiving on oscilloscope in open atmosphere

6. The connectivity of SSRT to sound card, installing of Spectrum Lab and SSRT Robot2 software, as well as output receiving through them

After connecting the system to the computer's sound card, Spectrum lab software installed on the computer gets the data in one-minute intervals as boarding began. We observed that the frequency of our system 26.7 KHz. Other high frequency VLF stations around the country will receive after we decided to get and charting stations would also are shown in Table 4 and Figure 6 [6].

Table 4. VLF transmitting stations, that SSRT has the ability to receive signals from them

Frequency	VLF transmitter	Transmitter location	Distance from Iran (km)
16.3 kHz	VTX	Vijayanarayanam, South India	4046.8096
26.7 kHz	TBB	Bafa, Turkey	2158.2455
45.9 kHZ	NSY	Nescimi, Italy	3297.0614

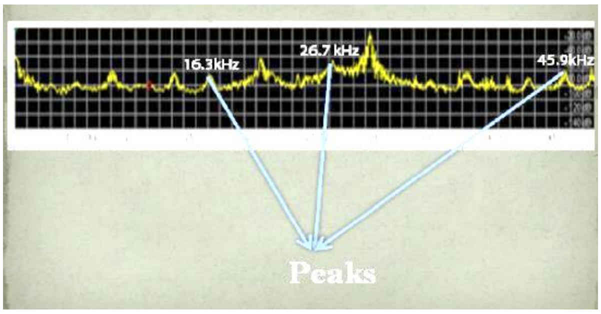

Figure 6. A picture from spectrum lab with flashes on picture which specified the signals of 16.3, 26.7 and 45.9

III. RESULTS AND DISCUSSION

Simultaneous analysis of SSRT radio telescope's diagram and the diagram of X-ray solar flares for Iranian station:

In this section, the VLF transmitter in the city of Bafa of Turkey and the receiver SSRT in Tehran (Iran), are situated at a distance of 2158.2455 km from each other, while the SSRT in addition to receiving frequency of 26.7 kHz from TBB transmitter situated in Turkey (as pointed to it in previous sections), also receive the frequencies from VTX with a working frequency of 16.3 kHz situated in India, as well as, NSY transmitter with a working frequency of 45.9 kHz situated in Italy. Figure 7 of receiving diagram and depicted by Excel located in Iran, relates to 15/12/2011; has simultaneously received data from VTX and TBB as well as NSY stations, the effects of sunrise and sunset can be clearly observed.

Figure 8 as receiving diagram, with SSRT Robot2 from X-ray solar flares relates to the GOES satellite, downloaded on 15/12/2011 which is in correspondence with Hong Kong time and as per UT+8 world clock. By comparing these two Figures, we will observe that an X-ray Solar flare exists in Figure 9 at about 10 o'clock corresponding Iranian standard time.

As we know, the world time in accordance with Iranian time is in the form of UT+3.5; so, the time difference between Iran and Hong Kong ((UT+8)-(UT+3.5) =4.5h) is four hours and thirty minutes. As a result, we can receive the X-ray solar flares occurred at 10 o'clock in Iran; at 14:30 corresponding to Hong Kong time, four hours and thirty minutes after the occurrence of X-ray solar flares in Iran. By observing Figure 8, we find this phenomenon has been taken place.

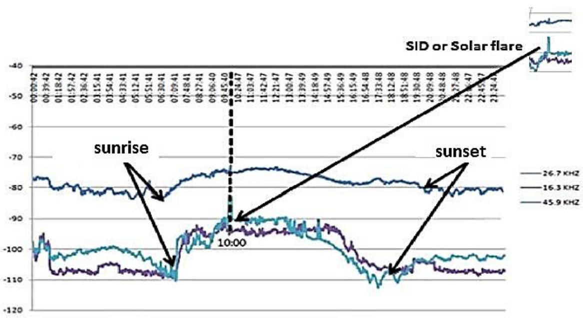

Figure 7. The occurrence of X-ray solar flares, at about 10 o'clock corresponding to Iranian standard time
(received by SSRT radio telescope in Iran)

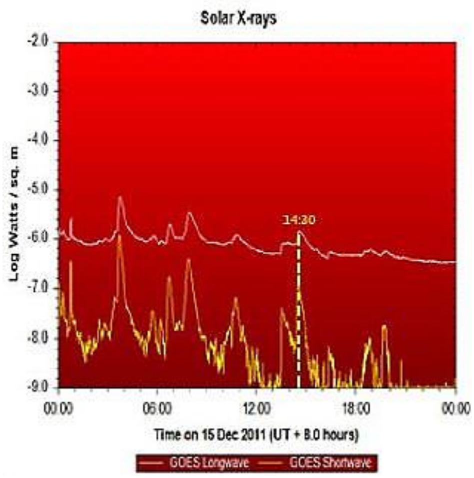

Figure 8. The occurrence of X-ray solar flares, at about 14:30 o'clock corresponding to Hong Kong standard time (received by Goes satellite)

IV. CONCLUSIONS

Permanent- The objective of this project was to design and build a SSRT radio telescope and receive the solar flares, furthermore to observe the effects of sunrise and sunset. After the studies were made during work process, it was noticed that the obtained result was in good conformity with the global data received from GOES satellites. Our next theme is to study the total effects of ionosphere on SSRT radio telescope. Some significant points of which are expressed as follows:

- Earthquake effect on the findings or receivables of SSRT (7)
- HARRP effect on the findings (or receivables) of SSRT
- Observing the occurring time of Thunder and the study of its intensity
- Meteor downfall
- Sun and Moon eclipses
- Phenomena influenced and effected by Gamma rays explosions
- The electrical disruptions effect rate on the findings or receivables of SSRT

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BIOGRAPHIES

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