Measurement of ELF Emission in the Upper Atmosphere at Calcutta due to Schumann Resonances

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Abstract

The atmosphere between earth's surface and the ionosphere behaves like a wave guide when excited with ELF electromagnetic radiation. The discrete spectra of the transmission frequencies at 8, 14, 20,.... Hz due to Schumann resonance are generated by electromagnetic emission from the lightning strokes and can be regarded as excitation of an AC global circuit. An attempt has been made to detect experimentally at Calcutta (latitude 23°56′N) these discrete signals. Some frequency changes of 10% to 20% are found to be present in the observed data which may be attributed by the uncertainties arise from spatial distribution of lightning sources exciting the Schumann resonance modes.

Introduction

In the presence of the fair weather electric field between the ionosphere and the earth's surface, electric discharges take place through the atmosphere. It was understood that thunderstorm, dynamo interaction between solar wind and magnetosphere and the dynamo effect of the atmospheric tides in the thermosphere introduce electromotive force that drive the global electric circuit. Thunderstorms are considered to be the more powerful of these quasi-DC sources[1,2]. Moreover, the discrete spectrum of the transmission frequencies at 8, 14, 20 Hz due to Schumann resonance within the earth-ionosphere wave guide, generated by electromagnetic emission from the lightning strokes, can be regarded as excitation of an AC global circuit [3,4]. There are various models for both the DC and AC global circuits [1,2].

The power in the lower Schumann resonance of 8 Hz has been noted by some authors to correlate with global temperature changes in time scales of diurnal, seasonal and EL Nino Southern oscillation [5].

Experimental Set-up

The signal from the antenna is first received and pre-amplified by the receiver, which is further amplified by a wide band amplifier whose output is taken through an active low-pass filter having cut-off frequency nearly 35 Hz. This signal information is now stored in computer by the process of data acquisition in which a 40 Hz generator is used to convert the analog signal into digital signal. A wide band, very low input voltage sensitive and low frequency sensitive receiver has been designed which can detect input signal from 100 μv to 500 mv.

Recording System

The detected ELF signal is recorded by digital technique. The signal is sampled 40,000 times per second and the voltage was then converted to a 12 bit digital signal by analog to digital converter, i.e., one of the 4096 levels are recorded by the computer. Because of the choice of frequencies, no information is lost in the sampling process except for the quantization error.

Results

Data are collected from different vertical directions and stored in the computer. During rotation of the antenna, the nature of the signal changes slightly but resonance peaks are found to be nearly equal for different antenna positions. One such recording of signals at Calcutta is shown in Fig. 1.

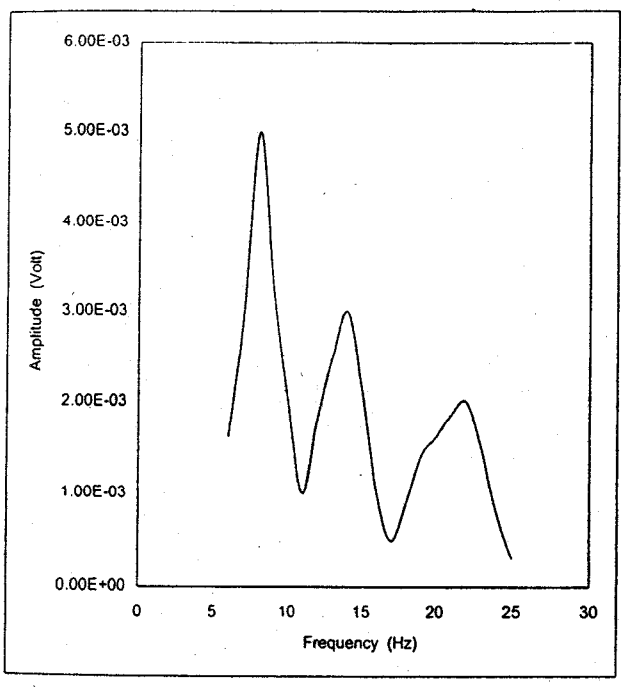

Fig. 1. Schumann spectra over Calcutta (latitude : 23°56′ N). Day-time amplitude versus frequency curve.

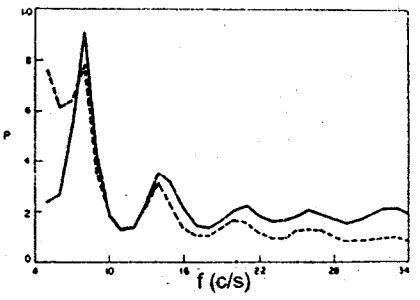

Fig. 2. Typical spectra of recorded noise (scale P is linear). Full line, day-time record; broken line, night-time record.

From the study of the graphs, which are obtained from different vertical directions, nearly at 8.2 Hz, a high amplitude peak is obtained and then the next peak is coming at about 14 Hz which has lower amplitude than the previous one. Next peak is coming near 20 Hz which also has a lower peak than the peak obtained at 14 Hz and so on. Figure 2 depicts one such recording made earlier [3] which almost agrees with the present observations. Similar results are found in the experimental record of Galejs [6].

Discussion

The signals are recorded for about six months by computerized method. Some frequency changes of 10% to 20% are found to be present in the observed data which may be attributed by the uncertainties arise from spatial distribution of lightning sources exciting the Schumann modes.

The selected frequencies and the absorption of the lower Schumann modes are dependent on the conductivity at various heights in the earth-ionosphere cavity. The dependence is more pronounced in the mesospheric height range where conductivity perturbations have prominent effect, giving rise to frequency shifts of 10% to 20% and changes in attenuation of Schumann modes. From Schumann resonance data, conductivity profile of the medium may be interpreted.

Thus the observational characteristics of Schumann spectra to definite conductivity profiles in the atmosphere provide a method of studying the electrical properties of the upper atmosphere and the ionization sources responsible for those properties [2, 3].

The East-West and North-South effects over the reception of ELF signals over Calcutta along with their diurnal and seasonal variations are being investigated.

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