Pre-seismic Phenomena and Observations of Naturally Radiated Electromagnetic Waves in VHF

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1. Introduction

The high reliability of communication networks is indispensable in our society. From a view point of communication network, the first research against the earthquake was carried out in 1970's [1]. After the Hyogo-ken Nanbu Earthquake on January 17th, 1995, a lot of precursory phenomena of the earthquake were reported [2]. Recently observations in electromagnetic fields have been considered as one of the most promising candidates for short-term earthquake prediction. There are two methods of observing the pre-seismic phenomena by the electromagnetic wave. One method is the direct observation of the intensity of a natural radiation electric wave and the other is indirectly observing the pre-seismic phenomena by reflection of an artificial electric wave from the ionized layer.

These researches in electromagnetic fields have been broadly made from a direct current to ULF, ELF, VLF, and LF band. However, in higher frequency bands such as VHF, there are a few observations and researches. In the indirect method in VHF band (30-300MHz) of a RF, the observation of reflection of FM broadcast waves by the ionized layer has been studied [3]. From a theoretical view point, the possibility of natural radiation electric waves in VHF was reported [4]. However, the observation data of naturally radiated electromagnetic wave in VHF have never been reported.

In this paper, we newly propose a simple observation method of natural radiation electromagnetic wave in VHF band. The new observation system using PLL (Phase Locked Loop) type FM digital tuners can receive the level of –110dBm [5]. We have been observing naturally radiated electromagnetic waves in VHF band since April 1998, in Yokosuka [6]. We have observed new phenomena of naturally radiated waves which levels have reduced about 4dB before a few days of earthquakes occurred under Tokyo-bay on August 29 and November 8, 1998. This paper describes the observation method and the characteristics of received levels of naturally radiated electromagnetic waves in Yokosuka.

2. Observation Method

We propose a new observation method of natural radiation electric waves using PLL type FM tuners in 76MHz - 90MHz frequency. This observation method has been expected following good features.

(1) Since this frequency band is a RF, it is seldom influenced by artificial noises, such as city noises and household-electric-products.

(2) Since this frequency band is specified as the band only for FM broadcasting stations, it seldom

receives interference with the electric wave of the other purposes.

(3) The highly sensitive observation can be performed in the clear band between FM broadcast spectra.

(4) It is hard to be influenced by the noise from remote places, because these frequency bands are not reflected by the ionized layer except during the higher electron density period.

(5) It can observe only the natural radiation electric wave near the observation site, because the ground radio wave propagation of VHF frequency bands is characterized into the spherical-earth reflective propagation, so the other natural radiation electric waves from far areas do not propagate to the observation site.

Therefore, we have constructed the observation system as shown in Figure 1 in Yokosuka. In this observation method, the antennas were directed toward the north, south, east and west, and the received wave levels were observed in each direction.

The system specifications are as follows:

Receiver : PLL type FM digital tuner
Receiving antenna : 5-element Yagi-antenna
Observation site : above sea level of 107m (E=139 ° 40' 00", N=35 ° 13' 20")
Observation frequency-band : VHF band (76MHz -90MHz)
Receiving frequency bandwidth of 3dB : 150kHz
Sampling frequency (time) : a maximum of 20Hz (50msec).

Figure 2 shows input-and-output performances of four tuners. These performances are the same each other. Received levels (dBm) are converted from the observed detection level (mV) by use of the input-and-output figures. This observation system can receive the natural radiation electric-wave intensities in the high sensitivity to -110dBm (0.01pw). Figure 3 shows the observation frequency adjustment in our method. The observation frequencies wave adjusted in clear bands between FM broadcast spectra so that they were not be influenced by FM broadcast signals. Before the observation, we detected the level of FM broadcast spectra in Yokosuka observation site. The detected levels of four directions in 76-90MHz bands are shown in Figure 4. Then, in the observation system in Yokosuka, the receiving frequencies were adjusted to 87.0MHz in east, west and south and to 85.6MHz in north. These adjusted frequencies are not affected by FM broadcast signals. Then, natural radiation levels can be received up to –110dBm.

3. Observation Results

The received natural radiation levels of north, south, east and west directions are shown in Figure 5 during the half of a year from July to December in 1998. In order to clearly identify each other, they are displayed by 10dB shifted respectively. By making and arranging the observed data from day to a half of year, we can find the long term characteristics.

These received levels are detected around -105dBm in the ordinary days. As shown in Figure 5, the received levels were calmly rising during several weeks, and decreased of 3-4dB abruptly on August 27 and November 6. These phenomena were especially remarkable in the three directions of east, west and south. One example of the level falls is shown in Figure 6 for three days from August 27 to August 29. The received levels were gradually changed during two hours at around 18 o'clock on August 27. It was hard to consider that these observed characteristics were artificial changes or weather events, so that they might possibly show pre-seismic signals. Then, the Tokyo bay earthquake, magnitude of 5.4, occurred at 8:46 on August 29, 1998. There were no co-seismic

signals at just earthquake occurring time as shown in Figure 6. For a reference in Figure 6, a lot of thunder occurred at early morning of August 28, which performed spike noises. Therefore, they are distinguished from naturally radiated waves, which performed for several weeks.

There were 19 earthquakes of the magnitude of 4.0 more over during the half of year in Kanto area. Except for 2 examples of the Tokyo bay earthquakes, other earthquakes were not visible enough on the observation data in Figure 5. This cause might include the observation limits (distance, scale of an earthquake) of this observation system.

4. Conclusions

We have proposed the new observation system of naturally radiated electromagnetic waves using PLL type FM digital tuners and have been observing. Naturally radiated electromagnetic waves in VHF bands have been quantitatively and first observed by the system. In our method, the detected frequencies are adjusted in the clear bands between FM broadcast spectra so that the observation is carried out not be influenced by FM broadcast signals. It has shown that the PLL type FM digital tuners can receive up to –110dBm in our experiment.

Why are we interested in 76-90MHz frequency band? Because, this frequency band is specified as the band only for FM broadcasting stations, it seldom receives interference with the electric wave of the other purposes. Then, we have been observed naturally radiated electromagnetic waves in this band since April 1998, in Yokosuka.. The observation results are summarized as follows;

(1) natural radiation levels are around –105dBm in the ordinary days

(2) the new phenomena of naturally radiated waves which levels have reduced about 4dB before a few days of earthquakes occurred under Tokyo-bay on August 29 and November 8, 1998

(3) naturally radiated waves calmly perform for several weeks

It was hard to consider that these observed characteristics were artificial changes or weather events, so that they might possibly show pre-seismic signals.

This paper has described the observation method and the characteristics of receiving levels of naturally radiated electromagnetic waves in Yokosuka. We hope to extend the observation sites as an observation network, and endeavor to more accurately detect pre-seismic signals by the network. We will continue the observations of naturally radiated electromagnetic waves using PLL type FM digital tuners carefully and precisely.

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[5] T. Yoshida and A. Sato, “Observations of Naturally Radiated Electromagnetic Waves in VHF”, Technical Reports of IEICE, AP98-22, pp.39-45, 1998.

[6] T. Yoshida and A. Sato, “Pre-seismic Phenomena and Observations of Naturally Radiated Electromagnetic Waves in VHF”, Technical Reports of IEICE, AP99-94, pp.15-21, 1999.

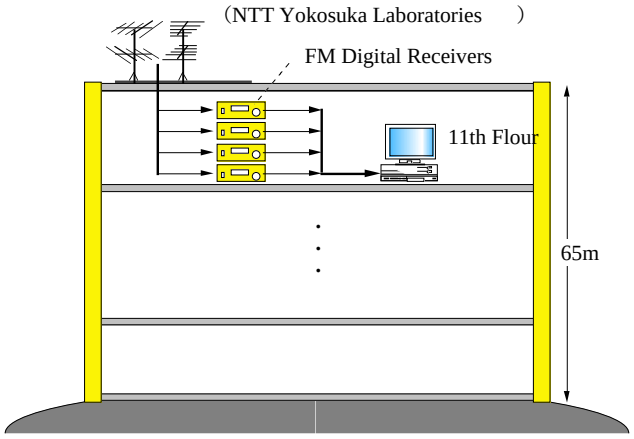

Figure 1 : Observation system configurations of natural radiation electromagnetic waves in Yokosuka.

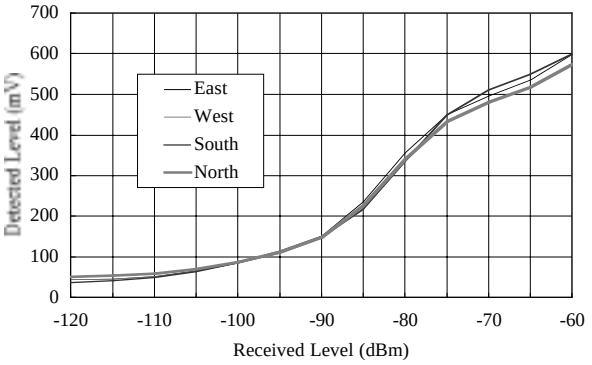

Figure 2 : Input-output performances of PLL type FM tuners at 81MHz

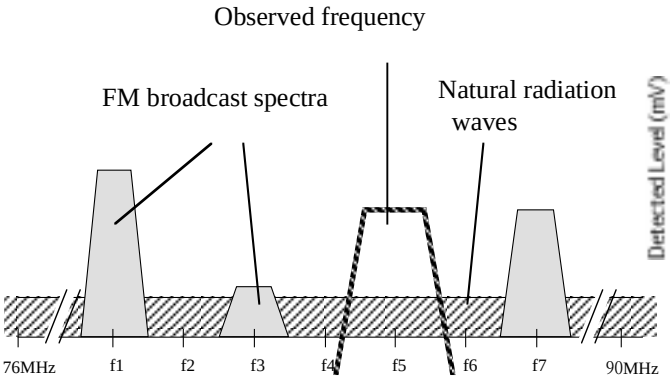

Figure 3 : Observation method of natural radiation electromagnetic waves

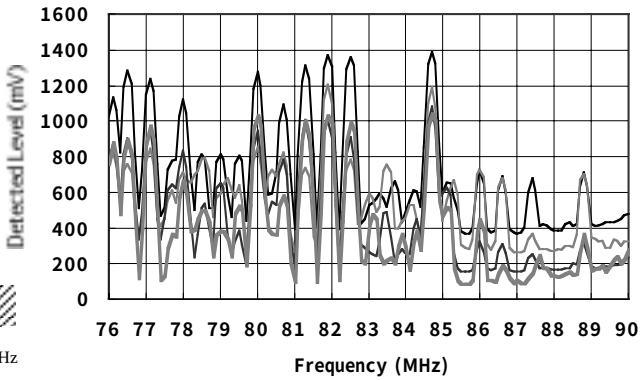

Figure 4 : Detected levels 76-90MHz bands in Yokosuka (4 directions, 100 mV shifted)

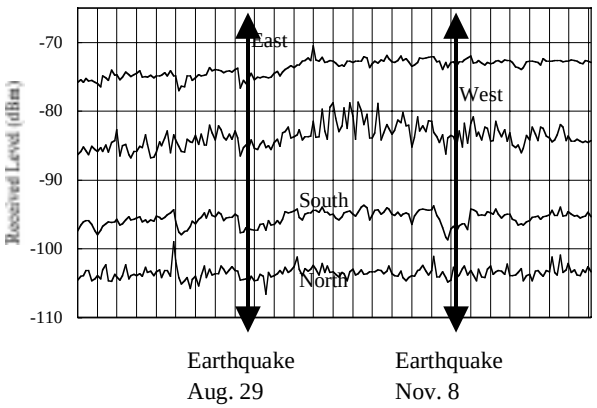

Figure 5 : Received natural radiation levels from July to December, 1998 (1 div. = 1 week)

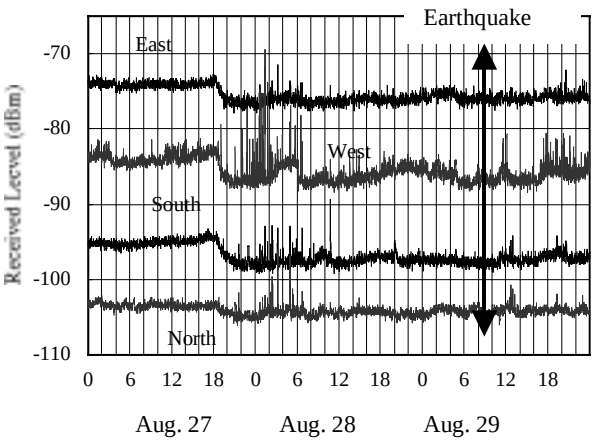

Figure 6 : Received natural radiation levels on August 27-29, 1998