Report of the Oblique Ionospheric Sounding Results from Korea to Japan

Seok-Hee Bae, Chung-Rim Choi, Kyu-Jin Wee

Radio Research Laboratory, the Ministry of Communications, Korea

and

Akira Ohtani, Mikitoshi Nagayama, Kiyoshi Igarashi

Communications Research Laboratory, the Ministry of Posts & Telecommunications, Japan

(Manuscript received 28 August 1994)

Abstract

Ionospheric sounding experiments have been conducted at RRL (Radio Research Laboratory), Ministry of Communications, using Digisonde 256 since its installation in 1990. Routine observations of the vertical sounding are carried out 48 times (or 39 times) a day, at every 24 hour. In addition, we also made oblique sounding experiments to obtain the real time data of Maximum Usable Frequency (MUF) and detect the anomalous HF propagation, as a part of the joint study between RRL and CRL (Communications Research Laboratory) of Japan. The two stations involved in the study were Anyang (RRL, Korea) and Kokubunji (CRL, Japan). The ionosondes used in both stations were Digisonde 256, developed by ULCAR (University of Lowell, Center for Atmospheric Research), U. S. A., and the synchronization of time was accomplished with the help of GPS receiver. During most part of the experiments RRL transmitted non-modulated pulses, and CRL received them. The experiment was scheduled from October 25 through October 29, 1993. However, the ionosphere was not developed well enough to conduct the experiment with pre-set operation parameters. The experiment became successful (from 0500 UT to 0800 UT, October 29) only after the operation parameters had been changed, and the continuous ionograms were obtained by CRL at 0718 UT and 0733 UT in October 29, 1993. We believe this type of experiment will ensure the qualitative enhancement of solar-terrestrial physics research and a routine observation of the oblique ionospheric sounding. In this report, we present the results of the fore-mentioned oblique sounding as well as the vertical sounding results obtained by Digisonde 256 at Anyang station of RRL.

1. Introduction

The vertical ionospheric sounding for HF communication service has been conducted by RRL (Radio Research Laboratory) since its inauguration in 1966. The orginal system NTZ-134 was upgraded in 1972 to NJZ-502A, and replaced by IPS-42 in 1983. In December 1990, RRL installed a new digital ionopheric sounding system (Digisonde 256), which was developed by Bibl, Reinisch, and Kitrosser at ULCAR (University of Lowell, Center for Atmospheric Research) in Massachusetts, U. S. A. Digisonde 256 is a suitable tool for con-

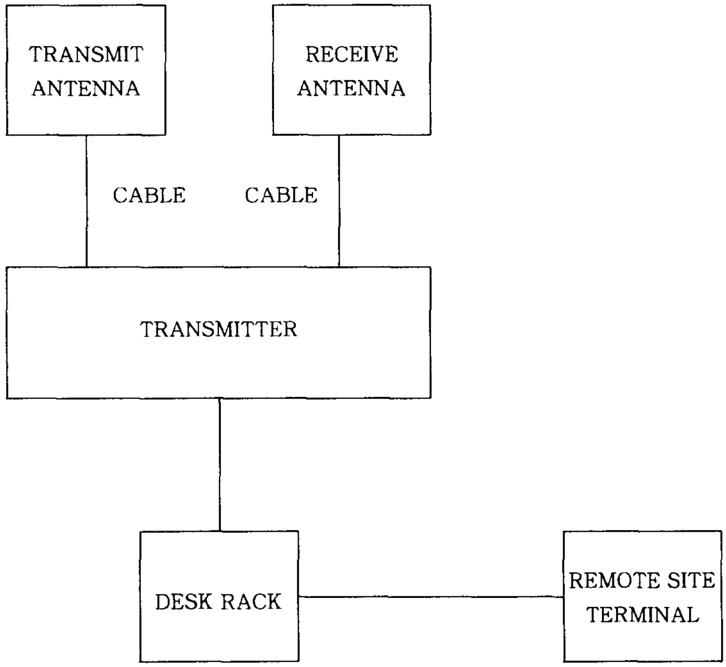

Fig. 1. Block diagram of Digisonde 256

tinuous monitoring of the ionosphere with regard to vertical and horizontal electron density distributions and to the motions of ionospheric irregularities 〔*Bibl and Reinisch,* 1978〕. The block diagram of the Digisonde 256 is shown in Figure 1, and Figure 2 shows an example of the vertical sounding with Digisonde 256.

The oblique ionospheric sounding is a useful tool to obtain the information of Maximum Observable Frequency (MOF) and the prediction of Maximum Usable Frequency (MUF) for HF communication. It is also an adaptable method for detecting anomalous HF propagation 〔*Igarashi and Takeuchi,* 1992〕. RRL studied the propriety for the oblique ionospheric sounding between Korea and Japan in 1987. As a result of the study, the first joint experiment was attempted by RRL and CRL in August 1992, but due to the insufficiency of operation technique and problem of the time synchronization, it was failed. The second experiment was carried out from October 25 to October 29, 1993. This report is the summary of the processes and the results of the second one.

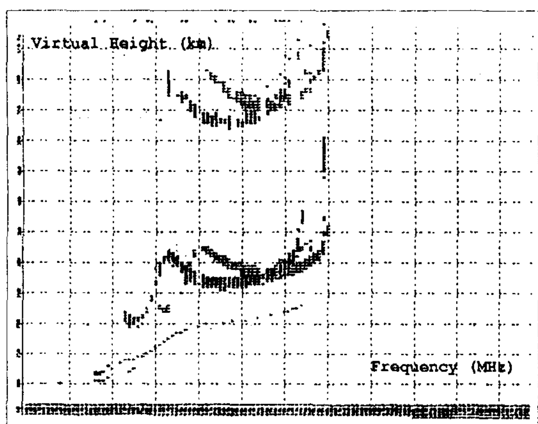

Fig. 2. An example of the ionogram obtained from the vertical sounding.

2. Experimental Setup

As shown in Figure 3, oblique ionospheric sounding has been conducted by five radio observatories of the CRL in Japan. These observatories constitute a north-to-south observation chain [*Igarashi and Takeuchi*, 1992]. On the other hand, the location of RRL (37.23°N, 126.56°E) is very appropriate in that the line connecting between RRL and CRL (35.71°N, 139.49°E) can serve as an east-to-west observation chain. The great circle distance between the two sites is about 1167.5 Km and it belongs to the one hop (2000 Km) of ionospheric propagation mode [CCIR Report 894-2, 1990].

Due to the schedule of domestic oblique sounding of CRL, the observation time and method in this experiment was obliged to be restricted. The observation times were set at 03, 18, 33 and 48 minitues during the daytime (from 0000 UT to 0900 UT). For the first three days, RRL transmitted non-modulated pulse to be recevied by CRL, and both stations transmitted and received signals simultaneously for the rest of the period.

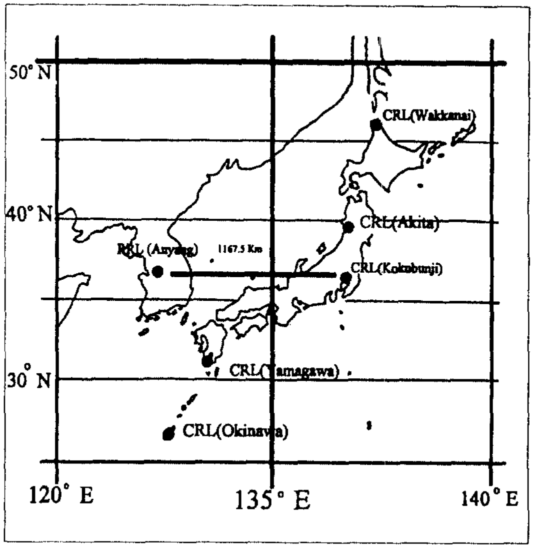

Fig. 3. Map of oblique ionospheric sounding between Korea and Japan and domestic oblique sounding of CRL [*Igarashi and Takeuchi*, 1992]

Table 1. Comparison of installed Digisonde 256's environments between RRL and CRL

	RRL	CRL
Location	Anyang (37.23N, 126.56E)	Kokubunji, Tokyo (35.71N, 139.49E)
Transmitter - Antena - Pulse power - Frquency	 △ type antenna (Half rhombic) 5 Kw (Operating pulse power) 0.5-30.0 MHz	 △type antenna (Half rhombic) 10 Kw 0.5 - 30.0 MHz
Receiver - antenna - configuration	 Active Crossed Loop antenna 4 Inner type	 Turnstile Loop antenna full (7) type
Time synchronization - System - Operation Mode - Input - 10 MHz	 Astech GPS receiver Manually 1 pulse per second (pps) Rb clock (Internal)	 Trimble GPS reciever Automatically 1 pps & Time code Rb clock (external)
ARTIST*	ARTIST2B (old version)	ARTIST3 (new version)

* ARTIST : Automatic Real-Time Ionogram Scaler with True height

Table 2. Limitation of operating parameters for oblique ionospheric sounding.

H	Range (km) Bins	E(km) 1	E(km) 2	E(km) 3	E(km) 4
2	10×128	10 - 1290	60 - 1340	160 - 1440	380 - 1660
9*	5×256	10 - 1290	60 - 1340	160 - 1440	380 - 1660
A*	10×256	10 - 2570	60 - 2620	160 - 2720	380 - 2940

* Drift mode for doppler observation
 Pulse Repetition Rate :
  1) shadow area:50+100 Hz
  2) non shadow area:50 Hz only
 H : Range Increment (height step size). Determines spacing.
 E : Range start and width (height start).
  Determines begining of range samples.

The environments of the Digisonde 256 systems installed in RRL and CRL are compared in Table 1. The operating parameters, such as the pulse repetition rate, pulse width, virtual height, antenna azimuth, frequency, phase code etc., were set suitable for the observation of the oblique sounding, and the time synchronization was done with the time delay effect included. The observation range of Digisonde 256 is limited by the pulse repetition rate. The operating parameter for the oblique sounding is shown in Table 2.

3. Results

No ionogram was obtained during the period from October 25 to October 27, 1933 because of the problems in setting up the suitable operating parameters and the time synchronization. The ionosphere was not well developed and we had to change the parameters. The operating parameters used for the next two days were as follows : the pulse repetition rate is 100 Hz, the range increment is (10 Km), and the range is (160 Km - 1440 Km). On the other hand, those for vertical sounding were 200 Hz pulse repetition rate, (10 Km) range increment, and (60 Km - 700 Km) range. The time offset was also changed from 485 ms to 520 ms, which included the effects of deviation of two Digisonde 256s in synchronizing the time (5 ms for CRL and 10 ms for RRL) as well as the time delay for the distance between two observation sites (about 4.2 ms).

With these changes the oblique ionograms were obtained during the experiments done on October 28 and October 29. The success of the experiment was confirmed by comparing the results with the ionograms obtained for the north-south oblique sounding in Japan. Figure 4 shows the oblique ionogram obtained in CRL at 0718 UT and 0733 UT on October 29, 1993. The time delay effects were 515 ms and 516 ms at 0718 UT and 0733 UT on October 29, 1993, respectively.

We found FMOF (F-mode Maximum Observable Frequency) from oblique ionogram because ionospheric status was not developed enough to observe the oblique sounding at that time [*Davies*, 1965]. FMOFs are about 9 MHz at 0718 UT on October 29 for average 25 sunspot number. For reference, the prediction of

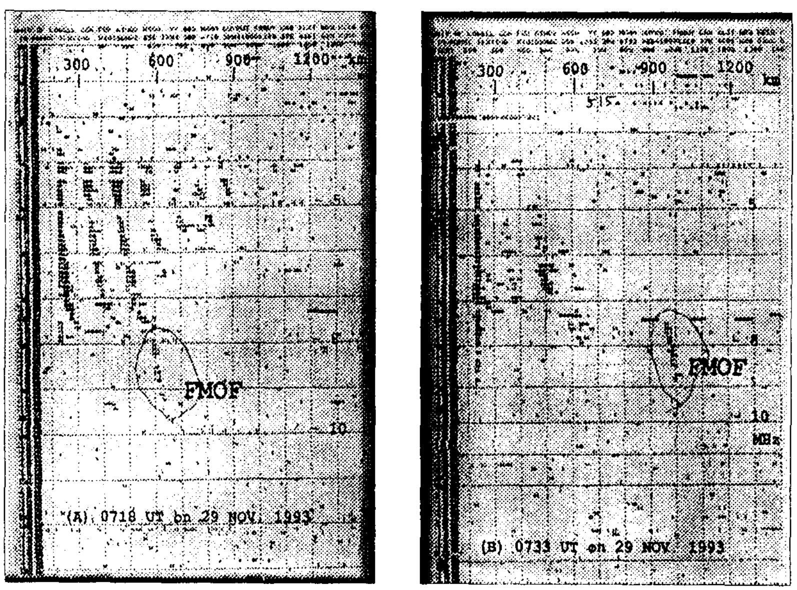

Fig. 4. Oblique ionograms at 0718UT and 0733UT on 29 October, 1993.

MUF in October, 1993 is form 17 MHz down to 4 MHz for 64 sunspot number.

4. Conclusion

From the experiment we obtained the basic technique of oblique sounding, which helps us to upgrade the reliability of observation. We performed another oblique sounding experiment during the summer of 1994, and the results is being analyzed now. We expect that the data is useful for monthly radio propagation prediction and real time HF communication and the experiment is expected to ensure the qualitative enhancement of solar-terrestrial physices research and a routine observation of the oblique ionospheric sounding.

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