# DEVELOPMENT OF AN EXTREMELY LOW POWER RADIO STATION FOR GENERATING STANDARD TIME SIGNAL USING NTP

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**Abstract**

***Radio controlled watches and clocks and automatically adjust the time by receiving the LF time and frequency standards. These watches are in wide use mainly in U.S.A., Germany, and Japan. In Japan, it is said that more than fifty or sixty million watches have been sold so far. There is, however, a big problem that it is rather difficult to receive radio waves in inappropriate environments such as inside of buildings, undergrounds, and places where electromagnetic noise is predominant and consequently, it is unsuitable to use them in the above places. NICT has developed an extremely low power radio station for radio controlled watches and clocks which disseminates the LF time standard acquired by the NTP server. Radio watches would be available even in unsuitable places such as airports, subway stations, sports stadiums and so forth. In addition, it makes it possible to use Japanese-made radio watches not only in Japan, but in other countries by setting the local time zone.***

## I. INTRODUCTION

In recent years, precise time services have rapidly become very important. We need to improve communication speed, computer data processing and utilization of the Electronic Time Authentication, etc. The National Institute of Information and Communications Technology (NICT) has provided Japan Standard Time (JST) and National Frequency Standard by disseminating signals from LF Standard Time and Frequency Transmission Stations shown in Figure 1 **[1]**, the time service by the telephone line, and Network Time Protocol (NTP). Time service in the network society, however, implies more possibilities. The standard time signal is mainly used by radio control watches and clocks. In addition, we want to propose other application of frequency. This research and development realizes JST service to the broad Internet users. Using time and frequency (T&F) signal and the service in fusion with the Internet technology becomes more important. NTP, which can be used easily, is one of the JST service infrastructures. Automatic clock adjustment of all the machines connected to the Internet is promoted, and time precision is expected to be improved. Wall clocks, alarm clocks, etc., with Internet connectivity are available in the commercial market. In order to solve the problem that the range of radio waves is restricted, NICT has developed an extremely low power radio station for radio controlled watches and clocks which disseminates the LF T&F standards acquired by the NTP server (Table 1) **[2]**.

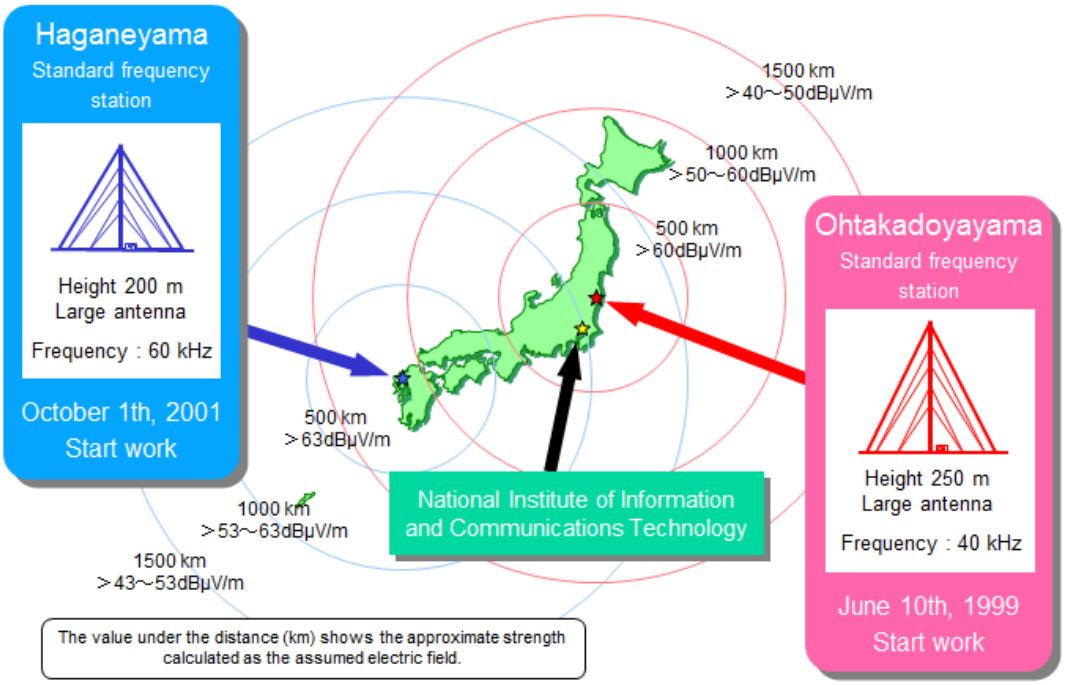



Figure 1. Low Frequency Standard Time and Transmission Station (JJY).

Table 1. Procedures of Development: an Extremely Low Power Radio Station.

| |
|---|
| NICT distributes Japan Standard Time and National Frequency Standard. |
| ↓ (Distribution Method) |
| LF standard time and frequency station, Telephone Time service, NTP |
| ↓ (Problems) |
| Correspondence to the blind zone of the radio controlled watches and clocks |
| Support some countries in the process of improving (Thailand etc.) |
| ↓ (Concrete plan) |
| Promotion of distribution by network |
| ↓ (Research subject) |
| Development of a prototype and a miniaturization of extremely low power radio station using NTP |

## II. THREE RETRANSMISSION METHODS

Three retransmission methods have been developed: Time Link, Repeater, and Inside of the Building Shared System. They have already been put into practical use (Figure 2). Here, three typical methods are introduced.

1) Time Link Method
The SEIKO PRECISION INC. developed this method. With this system, a T&F Standards signal is received and time information is sent out by the protocol of exclusive use of the frequency of a 400 MHz band. If there are more identical clock equipments for a time link, more links will be made, one after another, and time supply will be performed.

2) Repeater Method
Citizen Holdings Co., Ltd. (with subsidiary of Rhythm Watch Co., Ltd.) developed this method. The T&F Standards signal is received with 40 kHz or 60 kHz and retransmitted after changing the it into 60 kHz or 40 kHz with the repeater. A time code is disseminated as it is. The frequency of transmission and reception can be easily changed. With this equipment, time information can be supplied within about 20 m. Measurement of field strength is introduced in Section VI.

3) Inside of the Building Shared System Method
Nippon Antenna developed this method. With this system, T&F Standards signal is received at the roof of the building. After modulating to the FM signal, it is piled up with a MATV (IF) line and broadcast again as a standard electric wave in a building.

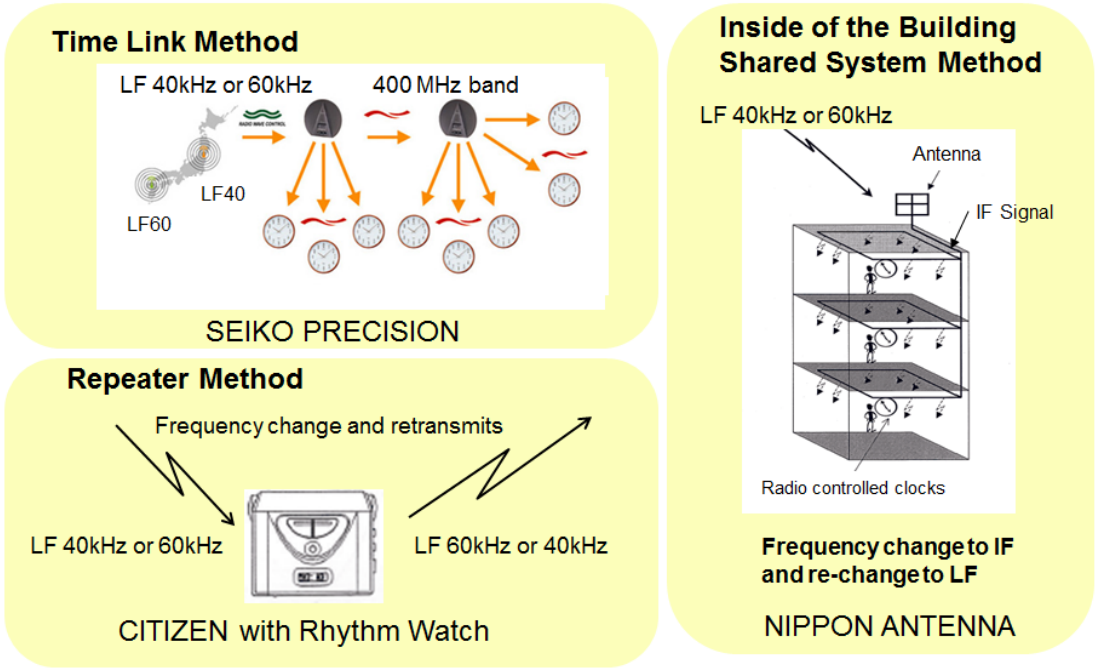



Figure 2. Some Retransmission Methods.

## III. EXTREMELY LOW POWER RADIO STATION USING NTP

NICT planned development of an extremely low power radio station for generating standard time signal using NTP since 2006 **[3]**. This equipment devised the prototype transmitter as an object for an examination at the beginning of development. The personal computer (PC) generated the time code of JJY, it was transmitted to the transmitting section, and the electric wave of low electric power was sent out. This transmitter was developed in order to use it in blind zones, such as the interior of a room. In 2007, the radio station with CPU board, which the server is equipped, and with small-sized transmitter was developed. The frequency can be choosen as 40 kHz or 60 kHz from a serial port. A local time can also be set in consideration for use in foreign countries.

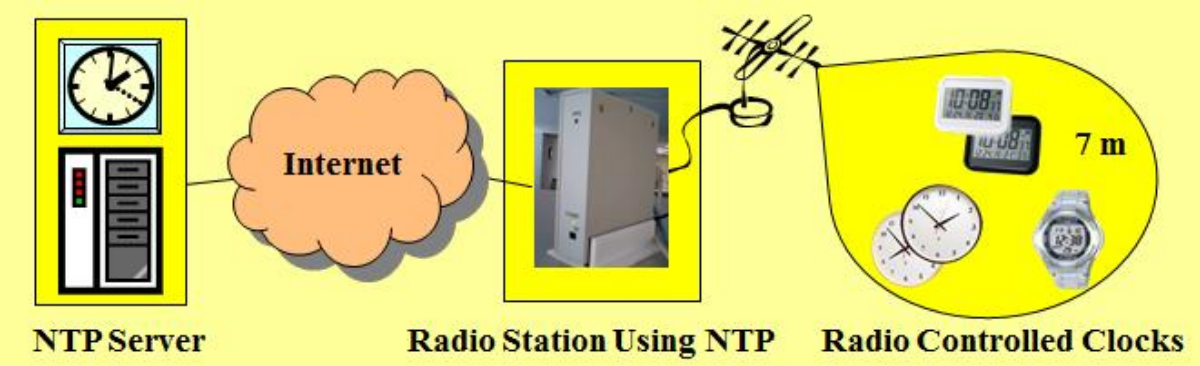



Figure 3. Extremely Low Power Radio Station Using NTP.

## IV. PROTOTYPE EXTREMELY LOW POWER RADIO STATION

The system outline of this prototype extremely low power radio station is as follows (Figures 4, 5, Table 2).

1) Generate a time code in the program which operates by Linux OS on a Personal Computer (PC). The timing from the PC is maintained for the accuracy of NTP.

2) Transmit the time code and timing which were received by D/A of a transmitter.

3) Transmit almost the same time code as JJY from an external test transmitting antenna. The Morse code is not being sent, and the modified signal istransmitted at 0% and 100%. Correspondence of a leap second and summer time was not carried out.

This prototype transmitter carried out the basic operation check and measured regular transmitted electric power (field strength).

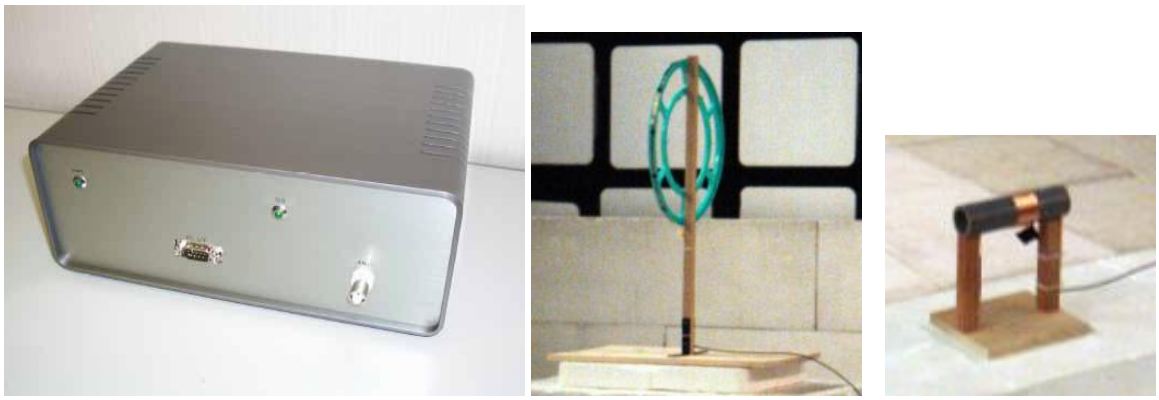


Figure 4. Prototype Extremely Low Power Radio Station and Test Antennas.

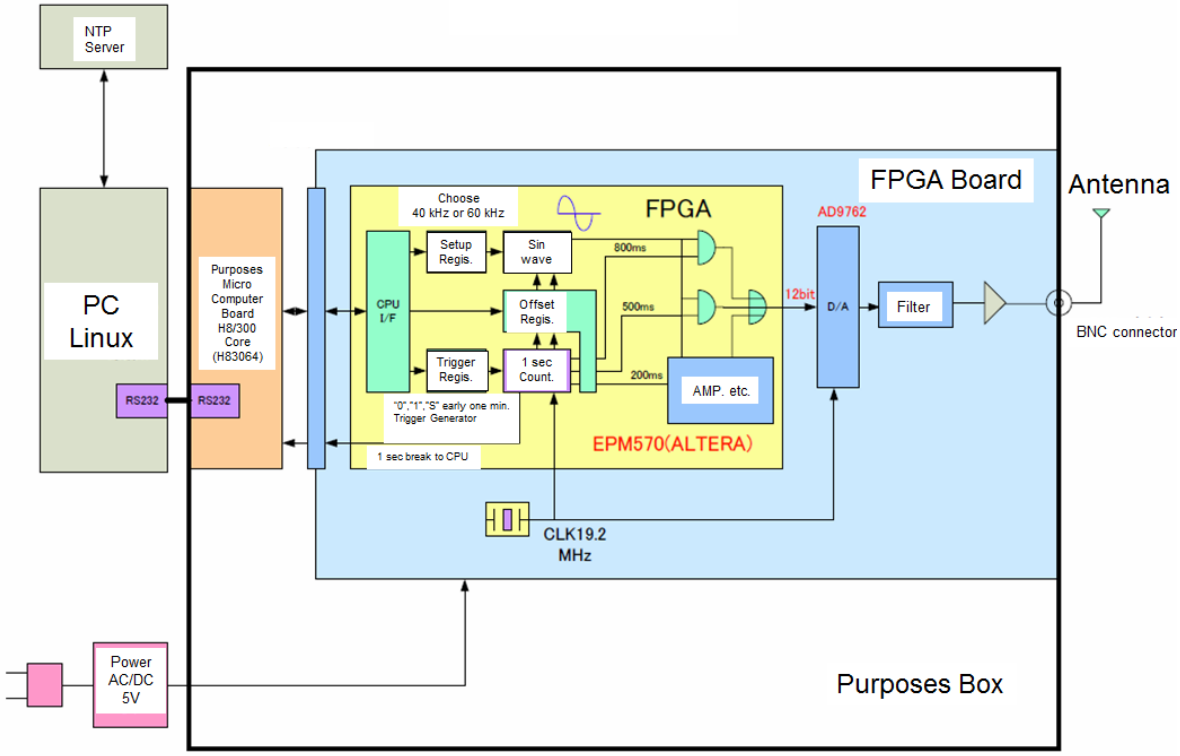


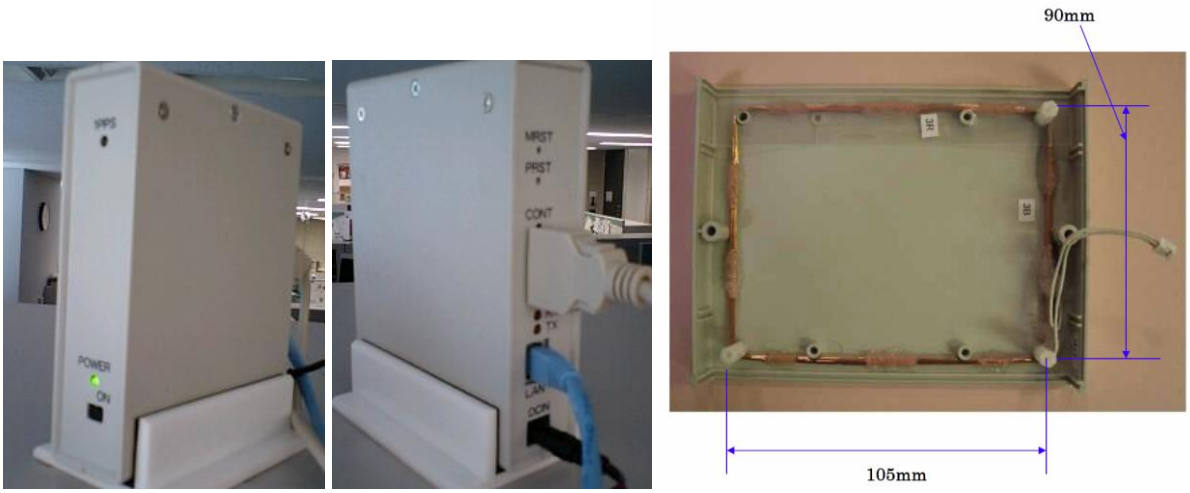

Figure 5. Prototype Extremely Low Power Radio Station Block Diagram.

Table 2. Characteristics of the Prototype Extremely Low Power Radio Station.

| | |
|---|---|
| Frequency stability | ±10 ppm Following |
| Output Power | 40 kHz and 60kHz |
| Antenna Terminal Output Level | +20 dBm - 0 dBm (manual variable), 50 Ω |
| Time code | Time code to transmit with 100 % and 0 %, no JJY Call sign, no leap second and no summer time correspondence |
| Transmitting Antenna Type | External Air Core Coil Type and Loop Type Antenna |
| Time Information | Supplied from Outside PC |

## V. SMALL-SIZED EXTREMELY LOW POWER RADIO STATION

NICT developed a small-sized extremely low power radio station (an integrated model) based on the know-how acquired with the prototype transmitter (Figures 6, 7, Table 3). In this transmitter, the software of the NTP client, which was operating in the external PC, was ported to the general-purpose CPU card. Moreover, the antenna was also set up inside of the box. Therefore, this transmitter operates only by connecting with an Ethernet cable.




Box size: 140 x 110 x 35 mm

Figure 6. Small-sized Extremely Low Power Radio Station and Antennas.

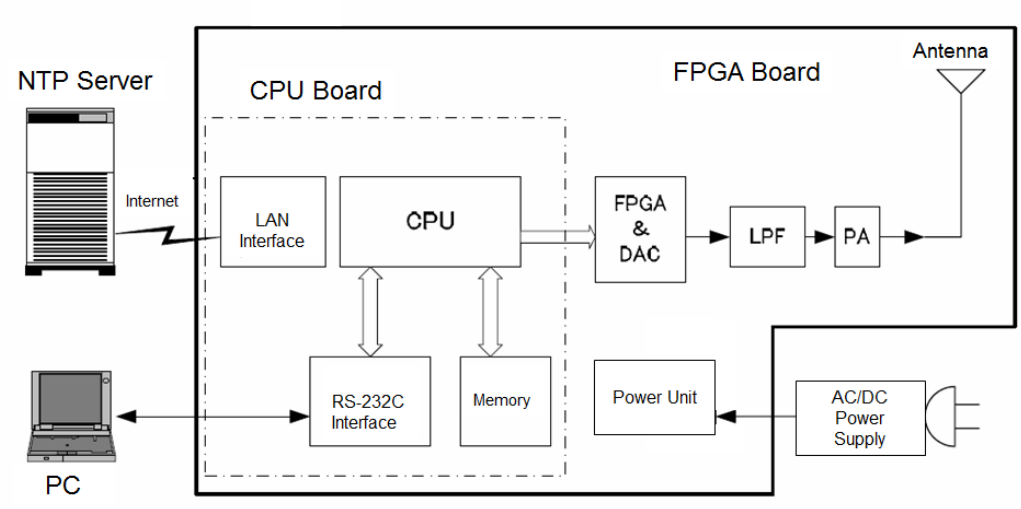



Figure 7. Block Diagram of Small-sized Extremely Low Power Radio Station.

Table 3 Characteristics of Small-sized Extremely Low Power Radio Station.

| | |
|---|---|
| Frequency stability | ±10 ppm Following |
| Output Power | 40 kHz and 60kHz |
| Antenna Terminal Output Level | +20 dBm - 0 dBm (manual variable), 50 Ω |
| Time code | Time code to transmit with 100 % and 0 %, no JJY Call sign, no leep second and no summer time correspondence |
| Transmitting Antenna Type | Internal Loop Type Antenna |
| Time Information | Supplied Directly from NTP Server. |

# VI. FIELD STRENGTH MEASUREMENT

We investigated the range of the field strength of the repeater (Figure 8), the developed prototype (Figure 9), and the small-sized transmitter (Figure 10) respectively, and concluded that they do not need to be licenced according to the Radio Law of Japan as an Extremely Low Power Radio Station. Measurements were performed using a measuring instrument for the field strength in the large-sized electric wave darkroom. Each transmitting output was under the value of the electric power regulated in the Radio Law. The maximum attainment distance of a repeater is about 15 m – 20 m. The range of the prototype transmitter with a 34 cm antenna was about 20 m. The range with a 3.2 cm antenna was about 10 m, and the range with the small-sized transmitter was about 7 m.

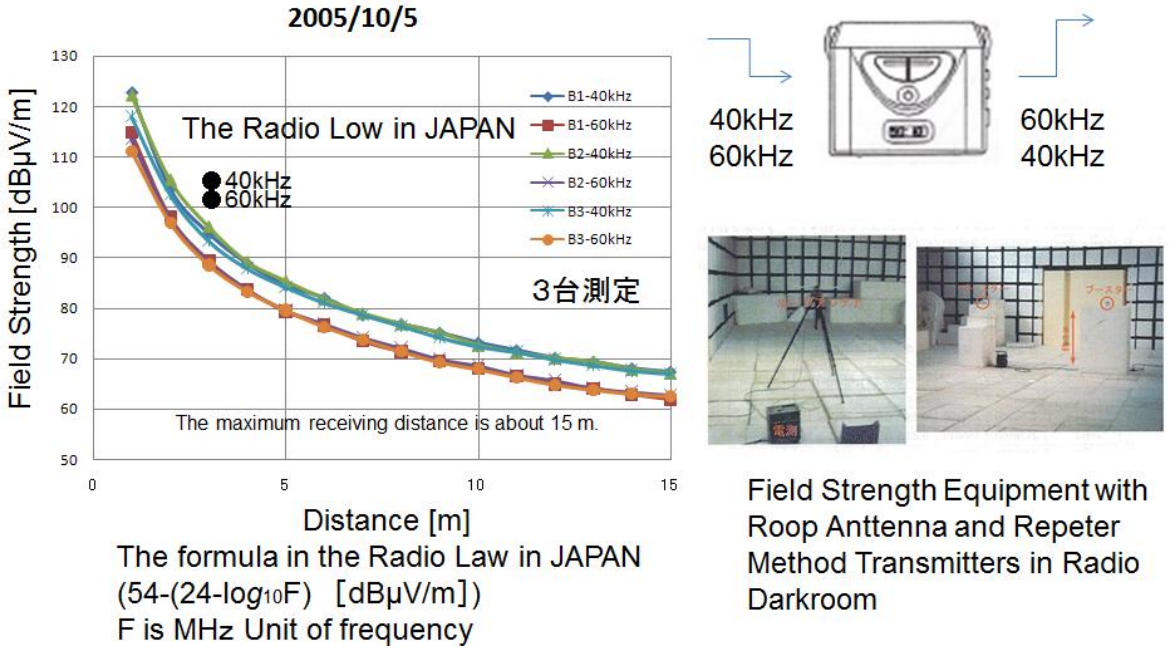



Figure 8. Repeater Method Transmitter Field Strength.

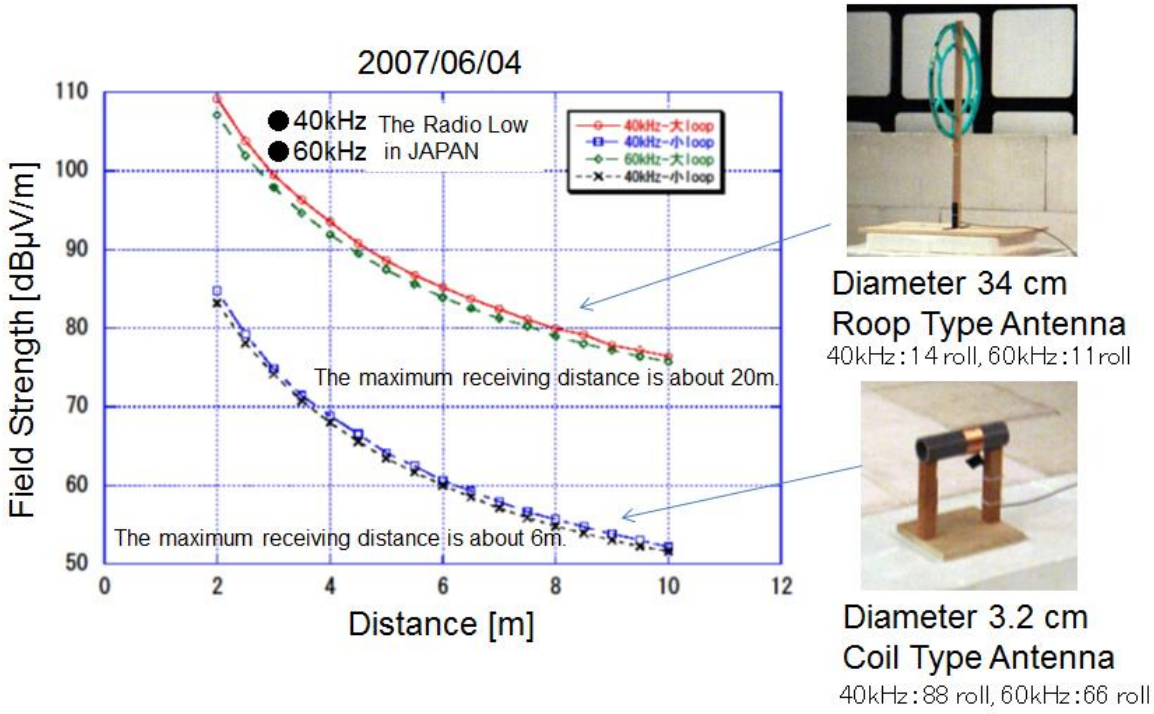



Figure 9. Prototype Extremely Low Power Radio Station Field Strength.

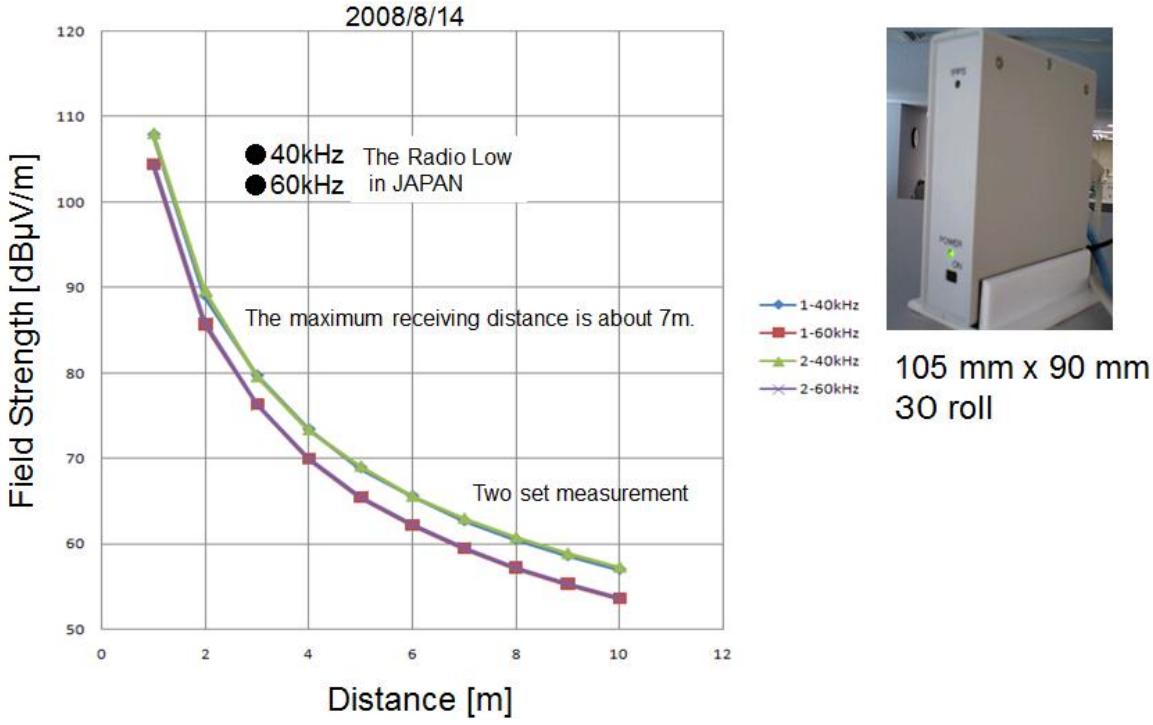



Figure 10. Small-sized Extremely Low Power Radio Station Field Strength.

## VII. SUMMARY

Radio watches would be available even in unsuitable places such as international airports, subway stations, sports stadiums and so forth. In addition, the extremely low power radio station makes it possible to use Japanese-made radio watches not only in Japan, but in other countries. The Extremely Low Power Radio Station which NICT has manufactured is extremely low power radio station which covers within the range of about 7 m. In order to cover more spacious range, there are two methods to be thought; one is to use more than one extremely low power radio station, and another is to develop Low Power Radio Station with lager power which is not required any license in Japan. In addition, it makes it possible to use Japanese-made radio watches not only in Japan, but in other countries by setting the local time zone.

## REFERENCES

[1] N. Kurihara, 2003, *"JJY,The National Standard on Time and Frequency in Japan,"* Special Issue on Time and Frequency Standard, **NICT Journal**, **Vol.50**, Nos.1/2, 179-186.

[2] T. Iwama, K. Imamura, F. Nakagawa, A. Machizawa, and H. Maeno, 2009, *"Development of the time dissemination technology for the radio controlled watches and clocks used by the network,"* The Asian Forum on Information and Communication Technology, 2009.

[3] K. Imamura, T. Gotoh, A. Kaneko, M Imae, and N. Kurihara, 2003, *"Time Distribution Using the Network,"* Special Issue on Time and Frequency Standard, **NICT Journal**, **Vol.50**, Nos.1/2, 221-229.