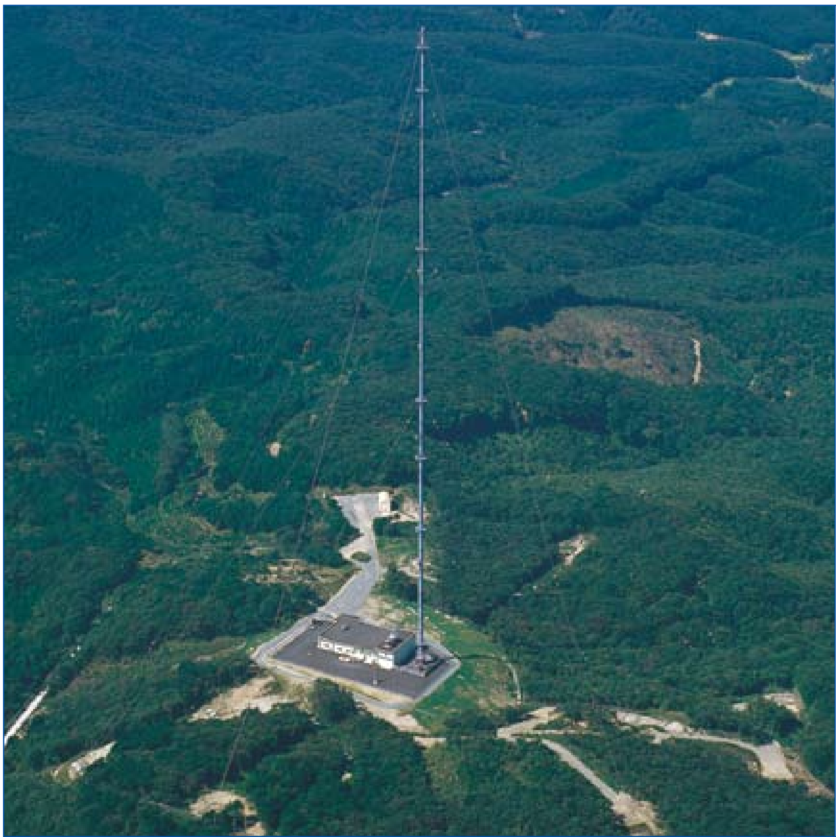
National Institute of Information and Communications Technology

Time and Frequency Transmission Facilities



▲Ohtakadoya-yama LF Standard Time and Frequency Transmission Station

Broadcasting accurate Japan Standard Time (JST)!

- Used in synchronization of radio clocks
- Used as a time standard for broadcasting and telephone time announcement services

Providing highly precise frequency standards!

- Used as a frequency standard for measuring instruments
- Frequency synchronization of radio instruments

▲Hagane-yama LF Standard Time and Frequency Transmission Station

Low Frequency Standard Time and Frequency Transmission

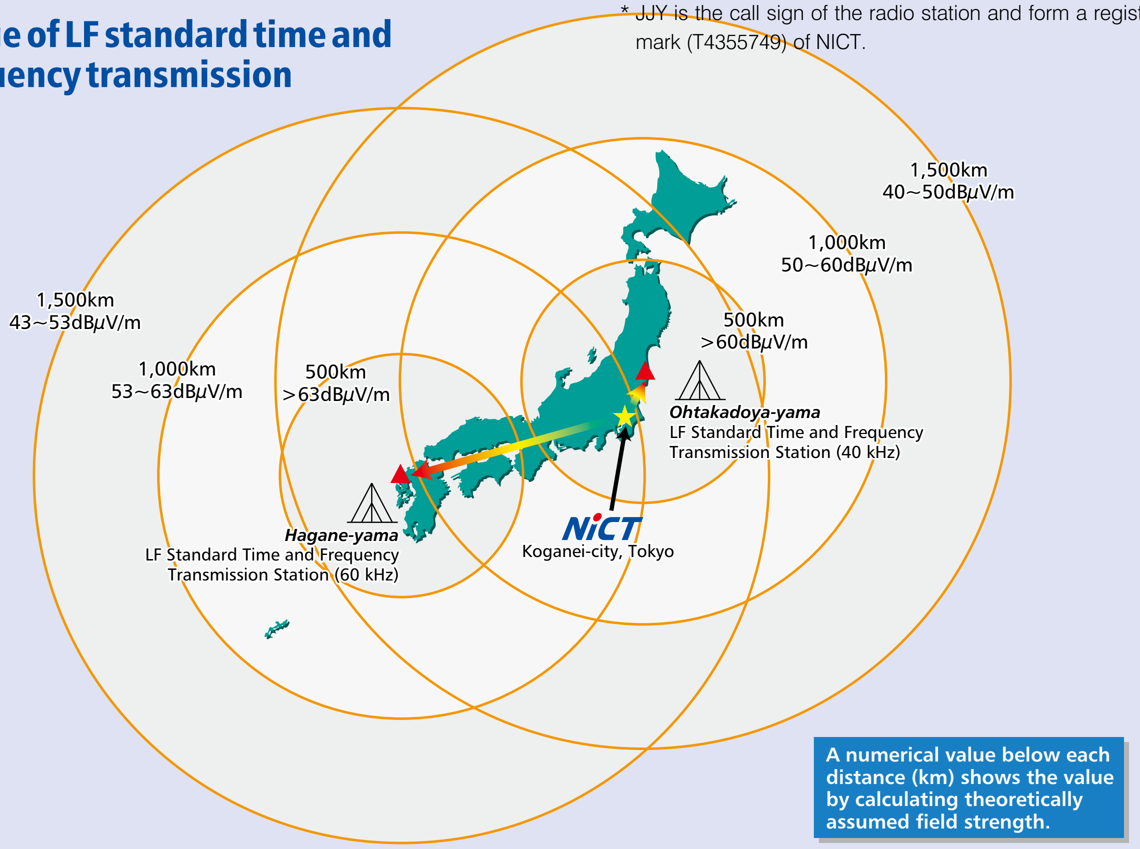
National Institute of Information and Communications Technology (NICT) is the only organization in Japan responsible for the determination of the national frequency standard, the transmission of the time and frequency standard, and the dissemination of Japan Standard Time.
Japan Standard Time and Frequency generated by NICT are transmitted throughout Japan via standard radio waves (JJY*). The master clocks of the time announcement services provided by broadcasting stations or through the telephone are synchronized to Japan Standard Time. Standard radio waves transmitted from low frequency (LF) stations contain time-coded information on time, which is superposed on a highly precise carrier frequency signal.

The standard time and frequency signal are synchronized with the national standard maintained by NICT. However, even when transmission is precise, the precision of the received signal may be reduced by factors such as conditions in the ionosphere. Such effects are particularly enhanced in the HF region, causing the frequency precision of the received wave to deteriorate to nearly 1×10^{-8} (i.e., the frequency differs from the standard frequency by 1/100,000,000). Therefore, low frequencies, which are not as susceptible to ionospheric conditions, are used for standard transmissions, allowing received signals to be used as more precise frequency standards. The precision obtained in LF transmissions, calculated as a 24-hour average of frequency comparison, is to 1×10^{-11} (i.e., the frequency differs from the standard frequency by 1/100,000,000,000). Descriptions of the Ohtakadoya-yama and Hagane-yama LF Standard Time and Frequency Transmission Stations are given on the last page.
Please note that although standard signals are continuously transmitted, they may be interrupted for maintenance and inspection of instruments and antennas or for thunder damage evasion.

For detailed information on the standard radio transmission, please contact Japan Standard Time Project, Space-Time Standards Group of NICT

* JJY is the call sign of the radio station and form a registered trademark (T4355749) of NICT.

Range of LF standard time and frequency transmission



Applications of LF standard time and frequency transmission

Observations

Standard time and frequency transmissions are used to record the times of astronomical observations (meteors, occultations, etc.) and for time synchronization of seismometers and meteorological observation instruments.

Radio Clock

A radio clock automatically corrects time through reception of the standard time and frequency transmission signal.
In Japan, time is synchronized to JST through reception either of 40kHz transmission from Ohtakadoya-yama or 60kHz transmission from Hagane-yama LF Standard Time and Frequency Transmission Station of NICT.

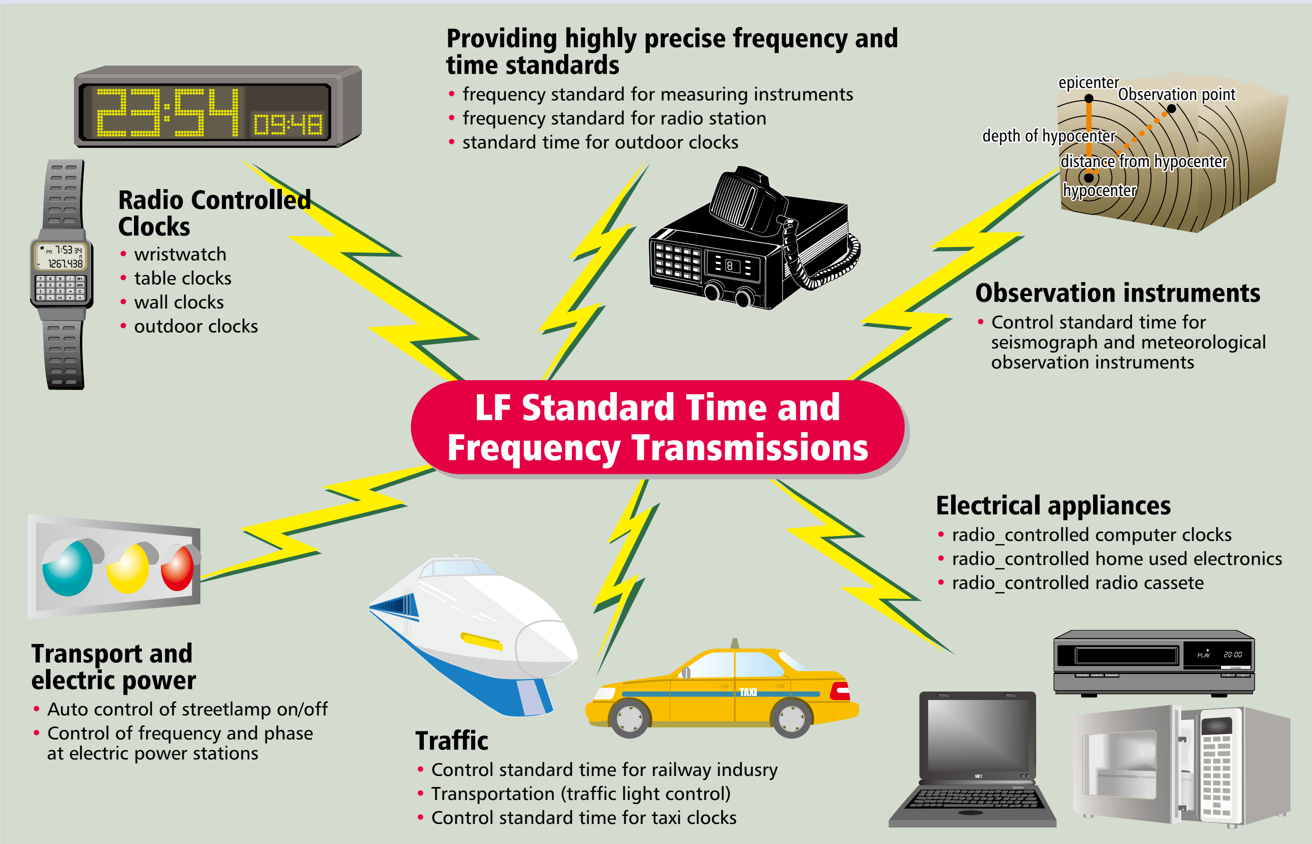
High-Precision Frequency Calibration

Using the received LF standard time and frequency transmission signal and the data released by NICT, it is possible to calibrate the standard frequencies of radio instruments and measuring instruments with precision on the order of 10^{-11}.

Radio Clock Features

Radio clocks have an automatic time-correction function to adjust time periodically (depending on the product). The radio clock works as normal quartz until the next reception opportunity.
The time may be synchronized with high precision with error of only several milliseconds relative to JST. The radio clocks need to be placed where standard waves are easily received so as surely to adjust time. (It takes about several minutes to receive the signal and adjust its time.)
The automatic time-correction clocks do not work appropriately in radio noises (such as inside of buildings, in cars, near high-voltage power lines, and near electric appliances or OA devices).

Application Fields for LF Standard Time and Frequency Transmissions



Overview of LF Standard Time and Frequency Transmission Facilities

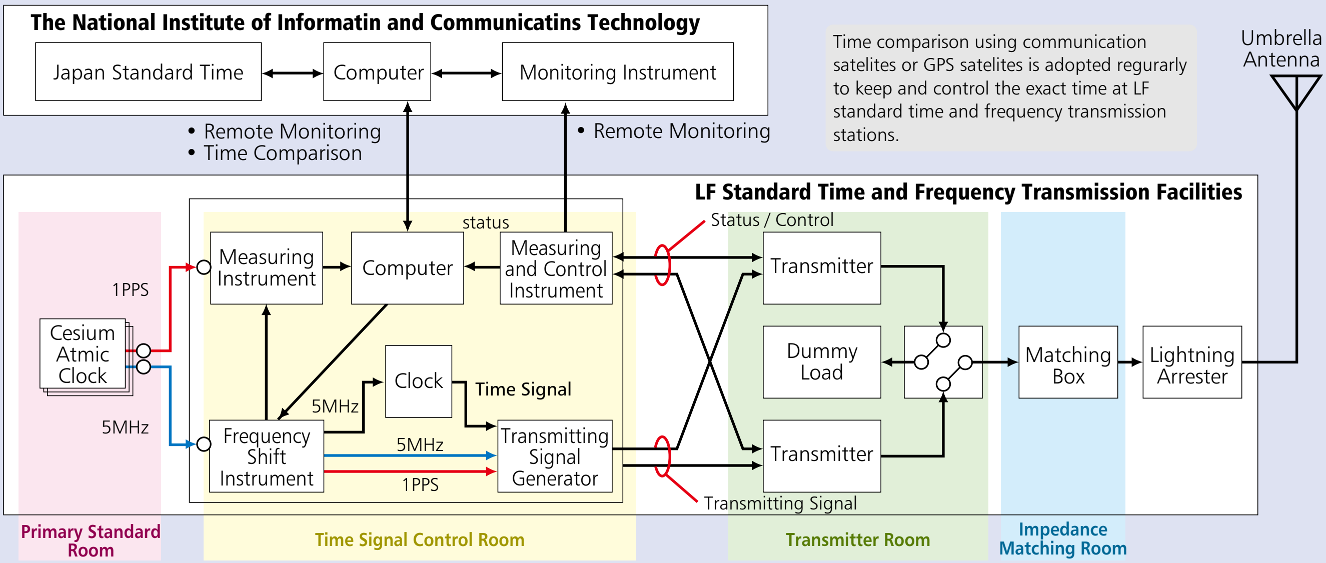
▲Top of the umbrella antenna

The standard frequency and time signal is generated by the high-performance cesium atomic clock operated in the clock room.
These signals are then amplified by the transmitter and impedance-matched to the antenna, and they are transmitted throughout Japan as the standard time and frequency transmission signal.

NICT generates, maintains, and Disseminates Japan Standard Time.

▲Standard time and frequency transmission station

Block diagram of the signal transmission system of the LF standard time and frequency transmission station



▲The LF standard time and frequency transmission stations are equipped with a private electric generator to provide backup power during power outages.

Clock Room

This room is specially designed to enable stable operation of the high-performance cesium atomic clocks, and is equipped with precision temperature and humidity control as well as electromagnetic-field shielding. These features completely isolate the atomic clocks from the effects of changes in the surrounding environment.

Transmitter Room

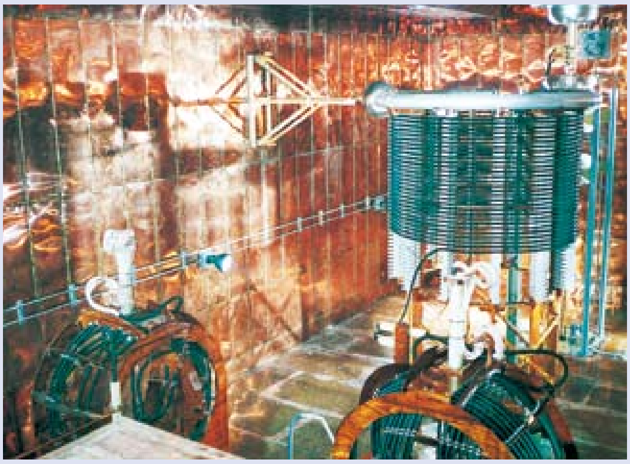
The room has two high-power transmitter systems (main/ back-up) to amplify the signals to 50 kW. During malfunction of the instruments comprising the main system or in the event of an emergency, the back-up system automatically takes over.

Time Signal Control Room

Here, the LF standard frequency signal and time code are generated using the standard signal from the cesium atomic clock. Automatic control, data collection, and image-based monitoring of various instruments within the station are also performed in this room.

Impedance-Matching Room

A matching transformer is installed in this room to perform impedance matching between the transmitter and the antenna for efficient transmission. Since high power radio waves pass through this room, generating a strong electric field, the inside walls are all copper-shielded and are off-limits during transmission.



Time Codes Provided by LF Standard Time and Frequency Transmissions

Time Codes of LF Standard Time and Frequency Transmissions

The time code of the LF standard time and frequency transmission contains information on the hour, minute, annual date, year (the last two digits of the dominical year), day of the week, leap second, parity for hours and minutes, and notification on future transmission interruptions. Time code is expressed by a pulse train that switches between pulse signal output levels of 100% and 10%. The transmission is designed for continual applicability as a frequency standard, with a continuous signal even during the low level pulse (10%). This time code is mainly used for synchronization of radio clocks.

The Year 2100 Problem

Since time code must represent a great deal of information in a limited number of bits, only the last two digits of the dominical year are used to represent the year and the day is represented only as an annual date. Since the year 2100 is not a leap year (it is indivisible by 400), radio clocks that are set for a leap year every four years will falsely recognize year 2100 as a leap year and will display Feb. 29. If this standard transmission is to be used beyond the next 100 years, radio clocks produced after 2000 must be programmed to recognize year 00 as a non-leap year.

Determining and Reading Time Code

1 Information Contained in Time Code

Hour, minute, annual date, year (the last two digits of the dominical year), day of the week, leap second, parity bits for hours and minutes, and notification on future transmission interruptions

The hour, minute, annual date, year (the last two digits of the dominical year), and day of the week are represented in binary terms [BCD (Binary Coded Decimal Notation) positive logic].

2 Second Signal

The start of each second corresponds to the rising of the leading edge of the pulse signal. The point at which the pulse reaches 55% of its full amplitude (midpoint between 10% and 100% amplitude) is synchronous with the second signal of standard time.

3 Pulse Width

Marker (M) and position markers (P0–P5) : 0.2 s ± 5 ms

Binary 0 : 0.8 s ± 5 ms

Binary 1 : 0.5 s ± 5 ms

4 Output Interval

A code with a period of 60 seconds (60 bits) is transmitted every second.

5 Standard Time of Time Code

The time (year, annual date, hour, and minute) of the first marker (M) in each period is encoded and transmitted.

6 Marker (M) Position

The marker (M) corresponds to the exact minute (the zero second of each minute).

7 Positions of the Position Markers (P0–P5)

The position marker P0 normally corresponds to the rise of the 59th second (for non-leap seconds). However, for a positive leap second (insertion of a second), P0 corresponds to the rise of the 60th second (in this case, the 59th second is represented by a binary 0). For a negative leap second (removal of a second), P0 corresponds to the rise of the 58th second. Position markers P1–P5 correspond to the rise of the 9th, 19th, 29th, 39th, and 49th seconds, respectively.

Representation of Information

(a) Hour (6 bits: 20h, 10h, 8h, 4h, 2h, 1h)
The hour in Japan Standard Time (JST) in 24-hour representation

(b) Minute (7 bits: 40m, 20m, 10m, 8m, 4m, 2m, 1m)
The JST minute

(c) Annual date (10 bits: 200d, 100d, 80d, 40d, 20d, 10d, 8d, 4d, 2d, 1d)
The annual date, counting January 1 as day 1. Thus Dec. 31 is day in a non-leap year and day 366 in a leap year.

(d) Year (8 bits: 80y, 40y, 20y, 10y, 8y, 4y, 2y, 1y)
The last 2 digits of the dominical year

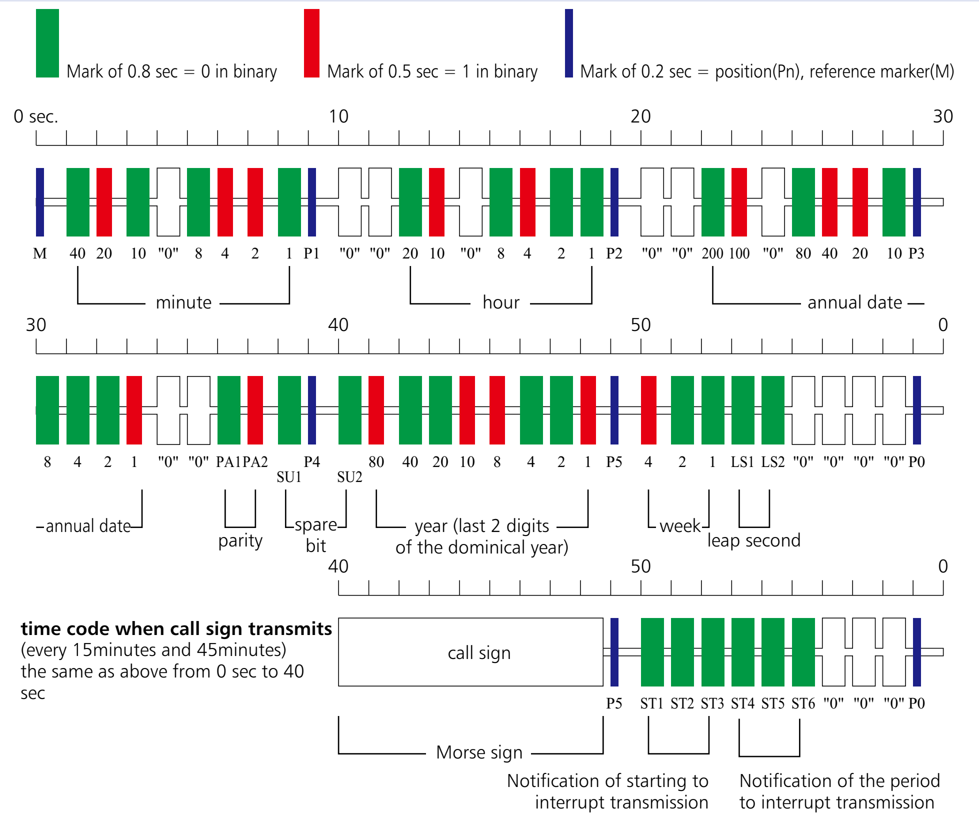
(e) Day of the week (3 bits: 4w, 2w, 1w)
The values 0–6 are allocated to Sunday–Saturday.

(f) Leap second information (2 bits: LS1, LS2)
The leap second is inserted immediately before 9:00 (Japan Standard Time) on the 1st day of the month that is to contain the leap second. Leap second information is continuously transmitted from 9:00 on day 2 of the previous month to 8:59 on day1 of the relevant month.

(g) Parity (2 bits: PA1, PA2)
Parity bits are signals to determine whether the hour and minute signals were correctly read. PA1 and PA2 correspond respectively to hour and minute and each represents an even parity of 1 bit.
PA1 = (20 h + 10 h + 8 h + 4 h + 2 h + 1 h) mod 2
PA2 = (40 m + 20 m + 10 m + 8 m + 4 m + 2 m + 1 m) mod 2
(mod 2 represents the remainder of division by 2)

(h) Spare bits (2 bits: SU1, SU2)
These spare bits are reserved for additions of items to be contained within the time code (such as daylight savings time) .
For the time being, these bits have transmitted with values of 0 in transmission.

(i) Notification of transmission interruption (6 bits: ST1, ST2, ST3, ST4, ST5, ST6)
When interruptions of Standard time and frequency transmission are scheduled (for maintenance and inspection, for example,) advance notice is given using these bits.. When there are no plans for interruption, all spare bits will have values of 0.



The time code communicates the time of the reference marker position for 60 seconds. For example, left figure shows 10th June (annual day: 161), 1999, Thursday, 14:26.

Descriptions of the LF Standard Time and Frequency Transmission Facilities

Ohtakadoya-yama LF Standard Time and Frequency Transmission Station

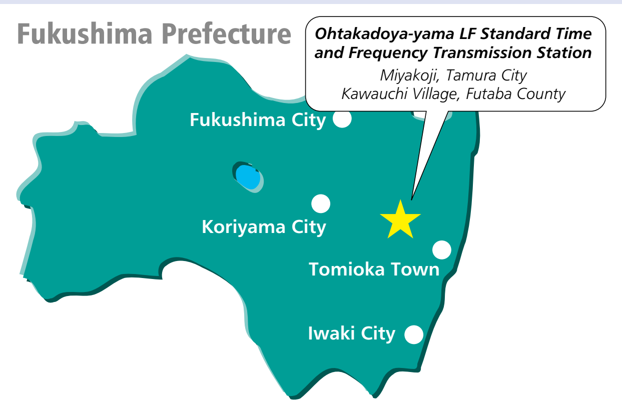
1. Location

Near the summit of Ohtakadoya-yama on the border between Miyakoji, Tamura City and Kawauchi Village in Futaba County of Fukushima Prefecture

Elevation : approximately 790 m
Latitude : 37° 22' 21" N
Longitude : 140° 50' 56" E

2. Specifications of the Transmission Station

Name of the Station :
Ohtakadoya-yama LF Standard Time and Frequency Transmission Station, National Institute of Information and Communications Technology (NICT)
Antenna Power : 50 kW
(antenna efficiency : approx. 25%)
Radio Wave Mode : A1B
Carrier frequency : 40 kHz
Total area of station : approx. 88,668 m^2
Antenna facility :
Umbrella antenna, 250 m above ground
Operation :
Continuous operation (except during maintenance and inspection of instruments and during lightning protection mode)



Hagane-yama LF Standard Time and Frequency Transmission Station

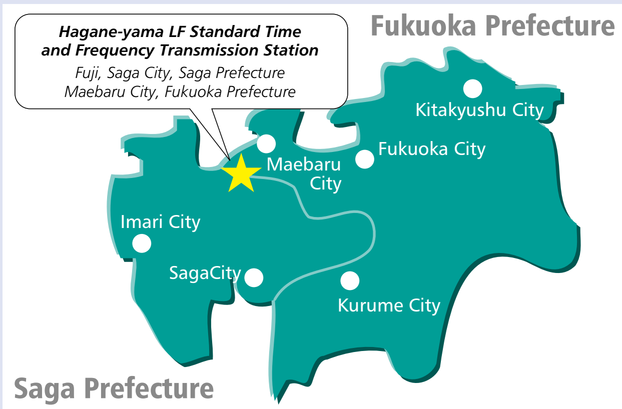
1. Location

Near the summit of Hagane-yama on the border between Fuji, Saga City of Saga Prefecture and Maebaru City in Fukuoka Prefecture

Elevation : approximately 900 m
Latitude : 33° 27' 56" N
Longitude : 130° 10' 32" E

2. Specifications of the Transmission Station

Name of the Station :
Hagane-yama LF Standard Time and Frequency Transmission Station, National Institute of Information and Communications Technology (NICT)
Antenna Power : 50 kW
(antenna efficiency: approx. 45%)
Radio Wave Mode : A1B
Carrier frequency : 60 kHz
Total area of station : approx. 115,803 m^2
Antenna facility :
Umbrella antenna, 200 m above ground
Operation :
Continuous operation (except during maintenance and inspection of instruments and during lightning protection mode)



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