ISSN 1349-3531

NICT NEWS

独立行政法人
情報通信研究機構

National Institute of Information and Communications Technology

No.385
OCT
2009
10

Special Feature: Ten Years of Standard Time and Frequency Transmissions by Low-Frequency

NiCT

Leadoff Interview

A New Value in an ICT Society: Transmitting "Japan Standard Time (JST)" with the Highest Global Standards

One Second of Error per Million Years: Marking "Time" with Ultra-High Precision

Kuniyasu Imamura
Research Manager
Space-Time Standards Group
New Generation Network Research Center

Joined the Communications Research Laboratory (current NICT) in 1976. Engaged in development of certification and testing methods, as well as research comparing frequency and time-keeping internationally in wireless apparatus and applications. Currently, working on operations and development related to frequency standards and standard time.

Time has been the important basis for life in society since long ago. Creating and distributing "time" is a very important role in society. It has been now ten years since NICT initiated the standard time by low-frequency transmissions, which define Japan Standard Time. In our developing ICT society, "time" has taken on new meaning and given birth to new values in society. Upon this background, the Space-Time Standards Group is engaging in continual research and work to "generate," "compare" and "disseminate" high-precision time that allows less than one second of error in a million years. And still, we continue to strive for even one more digit of precision.

Tenth anniversary of low-frequency standard time and frequency transmissions

It has been now ten years since low-frequency standard time and frequency transmissions began. Can you describe specifically what this involves?

Imamura: Standard Time and Frequency Standards (National standards for frequencies, and the length of one second), are the basis for information and communications, and they are also an essential base for safe and secure life in society. NICT has the very important responsibility to decide values for frequency standards, and to disseminate standard time to all of Japan. In the Space-Time Standards Group, we conduct a wide range of research and development, including the core tasks of generating, maintaining and disseminating the Japan standard time and frequency standard, contributing to deciding global standard time, developing ultra-high-precision atomic clocks to realize even more-accurate 1-second measurement, and carrying out other practical research for application in industry and society.

As one part of these duties, we began operation of the Ohtakadoya-yama Standard Time and Frequency Transmission station in Fukushima prefecture on June 10 ("Time Day in Japan"), 1999. The station broadcasts a 40 kHz low-frequency standard signal to all of Japan. This year has marked exactly ten years since the start of that broadcast.

Before that time, how was the standard signal broadcasted?

Imamura: The Standard Time and Frequency Transmissions began on January 30, 1940 in Japan, with a high-frequency Standard Time and Frequency signal from the Kemigawa transmitter in Chiba prefecture. From that point, a high-frequency signal at 5 MHz or 10 MHz was transmitted continuously till 2001. One of the benefits of high-frequency signals is that they reflect off the ionosphere, allowing them to reach distant locations with minimal transmission power. However, this characteristic is also a demerit for a standard signal. The frequencies can change due to Doppler effects when transformed by the ionosphere, and can result in interference, as these frequencies are also used by many other countries.

Is that why ionosphere observations have been very important?

Imamura: That's right. For this reason, NICT spent many years researching the use of a low-frequency Standard Time and Frequency signal which would travel long distances directly over the Earth's surface. An experimental station (Call sign JG2AS) was opened transmitting a 40 kHz low-frequency signal in 1966, and was used for research increasing frequency accuracy. From 1988, it was also used in experiments broadcasting time-code transmissions for use with radio clocks. One result of this research was the opening of the Ohtakadoya-yama Standard Time and Frequency Transmission station, broadcasting at low frequency.

Is the Standard Time and Frequency Transmission only transmitted at low frequency now?

Imamura: After the Ohtakadoya-yama station was opened, the high-frequency transmissions in Japan were terminated, completing the move to low-frequency transmissions. Then, on October 1, 2001, the Hagane-yama Standard Time and Frequency Transmission station (on the border of Saga and Fukuoka prefectures) opened, becoming the second such facility in Japan. It transmits a low-frequency standard signal at 60 kHz.

The signals from these two stations cover the whole of Japan with Standard Time and Frequency Transmissions. Currently, five other countries besides Japan broadcast low-frequency standard signals (usable with radio clocks), including the U.K., Germany, Switzerland, the U.S.A. and China, but Japan is the only country with two such transmitter facilities.

With Cesium Atomic Clocks, time difference occurs only one second per hundred thousands years

Can you give a simple explanation of what standard time is to begin with?

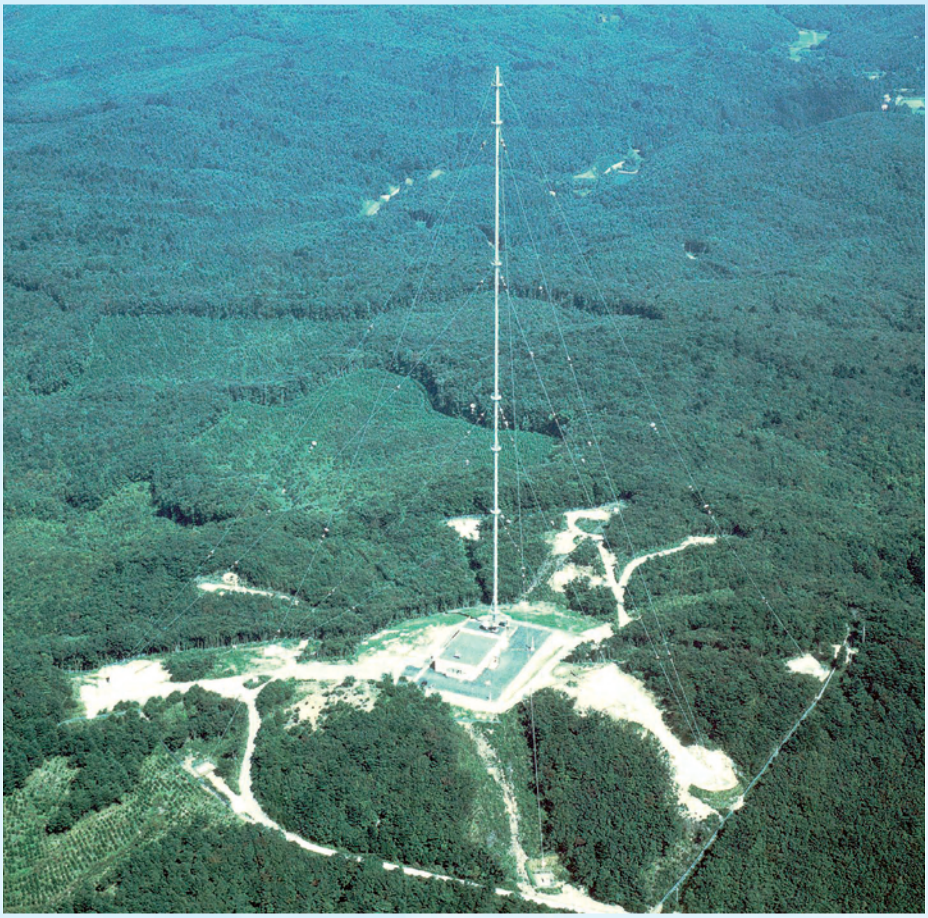
Imamura: There are probably still many people who think that Japan Standard Time is defined by Akaishi city in Hyogo prefecture passing the meridian. Originally, standard time was defined based on the rotation of the Earth, which is closely connected to the people's everyday life. One revolution of the Earth defines one day, which is subdivided to give hours, minutes and seconds, and the time when the Sun is positioned at due-south in the sky is defined as noon. This is called astronomical time and the global reference point for it is the observatory in Greenwich, U.K.

However, as science has progressed and more precise observations of the Earth's rotation were possible, it became clear that for various reasons such as the ebb and flow of the tides, the rotation of the Earth is not uniform, but includes a wobble. Since there are a number of problems that would arise if seconds and minutes, our basic units of time, varied throughout the day, this led to the need for a more stable second. It was decided to base the second on the oscillating frequency of a certain atom.

So, specifically how is one second currently defined?

Imamura: In the latter 1950s, various atomic clocks were developed and studied, and in 1967, the General Conference on Weights and Measures (CGPM) defined one second as "a second is the duration of 9,192,631,770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the cesium 133 atom." Simply put, they decided that one second would be the time for 9,192,631,770 oscillations of a cesium atom.

When a cesium atom is struck with a particular frequency of microwave radiation, the stable oscillations of the atomic nucleus become unstable. Then, when it returns from the unstable state to a stable one, electromagnetic radiation of a specific frequency is emitted. A cesium atomic clock uses this principle, and it allows commercially available atomic clocks to have error of less than one second over periods of several hundred thousand years.



● Ohtakadoya-yama Transmission Station Reaching Tenth Anniversary

● Impedance-Matching Room of Ohtakadoya-yama Transmission Station

Ohtakadoya-yama LF Standard Time and Frequency Transmission Station

Location: Boundary of Tamura City and Kawauchi Villiage, Futabagun, Fukushima Prefecture

Elevation: approx. 790 m

Coordinates: lat. 37°22' 21" N. long. 140°50' 56" E

Start of Transmission: June 10, 1999

Transmission Frequency: 40 kHz

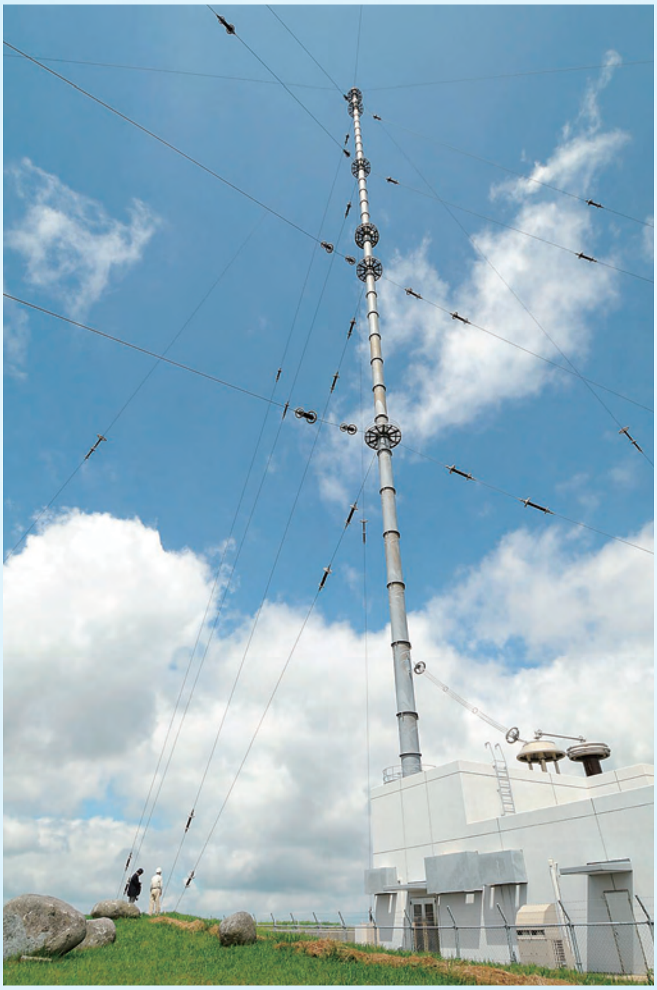
Transmission Power: 50 kW

Starting in 1967, we have used standard time based on atomic clocks (atomic time) instead of the astronomical time used earlier. Actually, in order to minimize the difference between atomic time and astronomical time we know intuitively in daily life to no more than 0.9 seconds, a single second called a leap-second is occasionally added or subtracted at the same time around the world. This year on January 1st, the 24th leap second was added.

Generating, comparing and disseminating Japan Standard Time

How is Japan Standard Time actually generated?

Imamura: Currently, Japan Standard time is generated at NICT headquarters by using 18 cesium atomic clocks with good frequency stability for longer periods (greater than one day), and four hydrogen masers with good frequency stability for short-term periods (one day or less). A cesium atomic clock has error less than one second over 300,000 years, but by using the average combined result from 18 such clocks, we are able to improve the stability and accuracy to within one second over approximately one million years. These clocks are kept in temperature and humidity-controlled "clock rooms" that are shielded from electromagnetic radiation to avoid any environmental effects on the frequency from surrounding factors like temperature or the Earth's magnetic field. There are four separate clock rooms which complement each other, creating a system that does not stop for maintenance or any other unlikely problem that could occur.



●Hagane-yama Transmission Station Inaugulated as, the second station in Japan

Hagane-yama LF Standard Time and Frequency Transmission Station

Location: Boundary between Saga City in Saga Prefecture and Itoshima City in Fukuoka Prefecture
Elevation: approx. 900 m
Coordinates: lat. 33°27' 56" N.
long. 130°10' 32" E.
Start of Transmission: October 1, 2001
Transmission Frequency: 60 kHz
Transmission Power: 50 kW

It would be quite a problem if standard time was to stop or slip, wouldn't it?

Imamura: That's right. Any tiny difference between the cesium atomic clocks and hydrogen masers in the four clock rooms at NICT headquarters is measured by the measurement systems. The atomic-clock time is averaged based on this data, and synthesized once per day to generate the Coordinated Universal Time (UTC) generated by NICT (UTC (NICT)). Japan Standard Time (JST) is given by advancing UTC (NICT), which we generate, by 9 hours (135 deg. East longitude).

What sort of relationship is there between Japan Standard Time and other standard times in the world?

Imamura: The GPS satellites contain atomic clocks, and their signal is synchronized with our atomic clocks. The national standard time agencies in countries around the world compare their times by using these signals, and by aggregating this data, the differences between each of their standard signals and UTC can be calculated.

Also, in cooperation with standards agencies in some principal countries, time comparison by using commercial communications satellites is also done regularly, as with time comparisons done with the GPS satellites, and this data is also sent to the International Bureau of Weights and Measures (BIPM). At the BIPM, International Atomic Time (TAI) and Coordinated Universal Time (UTC) are set based on time comparison data sent from facilities around the world. At NICT, we operate our system with the goal of less than ten nanoseconds difference between the UTC generated by NICT and the UTC set by BIPM.

How is the Japan Standard Time, generated by NICT, then transmitted to the rest of Japan as the Standard Time and Frequency Transmissions?

Imamura: The Standard Time and Frequency Transmission is sent to the whole of Japan from two transmitters located on Mount Ohtakadoya and Mount Hagane. This standard time signal generated at NICT Headquarters must be sent to the transmitters before transmission, however, and this introduces delay and possibly some variance that could cause loss of stability or accuracy. Thus, each transmitter is also equipped with a clock room like the ones at NICT Headquarters, and the Standard Time and Frequency signal is generated based on the reference signal from a cesium atomic clock. This creates a structure capable of transmitting the standard signal accurately.

Of course, this signal is constantly compared with the Japan Standard Time generated at NICT Headquarters, for a stable system transmitting a Standard Time and Frequency Transmission consistent with Japan Standard Time.

Chronology of Standard Time

1886 (Meiji 19)	Standard Time Regulated to Time at East Longitude 135° (Officially on July 13)
1888 (Meiji 21)	Standard time as described above adopted as of January 1.
1940 (Showa 15)	Kemigawa Radio Transmitting Station in Chiba City, Chiba Prefecture is opened, as the second oldest high frequency standard transmission station in the world, after one in the U.S.A.
1945 (Showa 20)	August 15, Transmission is suspended due to the end of the war.
1946 (Showa 21)	April 1, Standard Time and Frequency Transmission Resumed
1949 (Showa 24)	High-frequency Standard Time and Frequency Transmission Station is moved to Koganei City in Tokyo.
1967 (Showa 42)	Definition of the second is changed by the General Conference on Weights and Measures (CGPM).
1972 (Showa 47)	A new UTC format, based on the definition of the second, is recommended, and standard time bulletins are changed accordingly.
1977 (Showa 52)	Standard Time and Frequency Transmissions are moved to the NTT Nasaki transmission station (Sanwa-machi, Sashima-gun, Ibaraki Prefecture).
1999 (Heisei 11)	June 10, Ohtakadoya-yama Transmission Station (on the boundary between Tamura City and Kawauchi Villiage, Futabagun in Fukushima Prefecture) is opened and begins Standard Time and Frequency Transmissions
2001 (Heisei 13)	As of March 31, high-frequency standard transmissions are ceased. On October 1, the second station, the Hagane-yama Transmission Station (boundary between Saga City in Saga Prefecture and Itoshima City in Fukuoka Prefecture) is opened and begins Standard Time and Frequency Transmissions.

New Initiatives to match a changing social environment

Is Japan Standard Time being supplied in other ways besides the low-frequency transmissions?

Imamura: Our life in society has changed greatly due to the progress of technology and changes in the industrial establishment. Because of this, providing the supply systems to meet these changes is another important role we must fill.

One of these is "Telephone JJY," which distributes the time through telephone lines. This is a mechanism that allows automatic time synchronization through a public telephone line connection. It is an essential system for providing accurate time, so it is used by NTT's time reporting service and the master clocks at broadcasting stations. The system is also available for use by the general public.

Has the need for this service increased with the switch to terrestrial digital television and the removal of the time signal?

Imamura: Yes, it has. Another system is that of Network Time Protocol (NTP) Servers, which are used on-line through networks to synchronize the internal clocks of computers. Users from public agencies and private companies operating Internet-related and other businesses connect their servers with our NTP servers through dedicated lines, and we provide them with time-keeping information services. We also provide time-keeping services over the Internet (Public NTP), which is currently spreading very rapidly. The service is available to the public for direct use through our NTP servers (ntp.nict.jp). The service currently gets an average of over 50 million accesses per day.

Furthermore, with the recent growth of the Internet, various electronic documents such as commercial papers and patent applications are increasing in importance. Because of this, so-called "Time Businesses," which provide third-party certification of document creation times, are gaining attention as a means to help prevent document falsification. Accordingly, NICT is also providing accurate Japan Standard Time distribution services for these types of third-party Time Authority businesses.

What other types of services do you offer?

Imamura: As one part of Standard Time and Frequency at NICT, we also perform calibration for frequency standards. This is done by measuring the difference between frequency standards and the national frequency standard, and providing services for on-site and remote calibration via satellite.

Thank you very much for speaking with us today.

Manipulating "Hikari" Skillfully

Extremely High-Capacity Communications and Space-Observation Technology Explored by High-Speed, High-Precision Light Modulation Technology

Profile

Tetsuya Kawanishi

Research Manager
Advanced Device Research Group
New Generation Network Research Center

After completing a doctorate, worked at Kyoto University's Venture Business Laboratory as a guest researcher and then joined the Communications Research Laboratory (current NICT) in 1998. Engaged in research on lightwave modulation devices, milliwave and microwave photonics, and high-speed optical transmission technologies, etc. Guest researcher at University of California, San Diego in 2004. Doctor of Engineering.

Striving to send even more data by "Hikari"

In the past, when people in Japan heard the word "Hikari", which means "Light", they would think of a model of bullet train which is named Hikari. More recently, though, the Internet and fiber-optic broadband come to mind. Everyone, whether by mobile phone or the Internet, is communicating somewhere with "Hikari" and reaping the benefits of optical communications. Using optical fiber, information can be carried by light over long distance, and usually, a type of infrared light easily transmitted by optical fiber is used instead of visible light for optical communications. People change aspects of sounds that they produce, such as pitch, volume and duration, to convey information when they speak with each other, and in the same way, aspects of light are changed for use in optical communication. Creating light waves with these changes is called lightwave modulation. The simplest form of lightwave modulation, called On-Off Keying (OOK), sends a digital signal using only two values, "on" and "off," and was used in the past. More recently, e-mail continues to accumulate rapidly, video fills up hard-disk recorders, digital audio players fill up with music and digital cameras produce evermore photographs. A lifestyle of storing data and retrieving the desired data when necessary is spreading, and there is increasing demand for technology to deal smoothly with these large amounts of data. At NICT, we are advancing research and development on lightwave modulation technologies for supporting high-speed optical communications to meet these types of high-capacity communications needs. We are not only persuing high-speed lightwave modulation, but are also producing world top-class results in precision manipulation of light. This technology holds promise for use in a wide range of fields, and we are also researching applications in radio astronomy, which demands the utmost performance. Below, we give an introduction to the latest high-speed, high-precision lightwave modulation technology used to realize high-capacity communications, as well as technology used to generate reference signals supporting enormous radio telescopes.

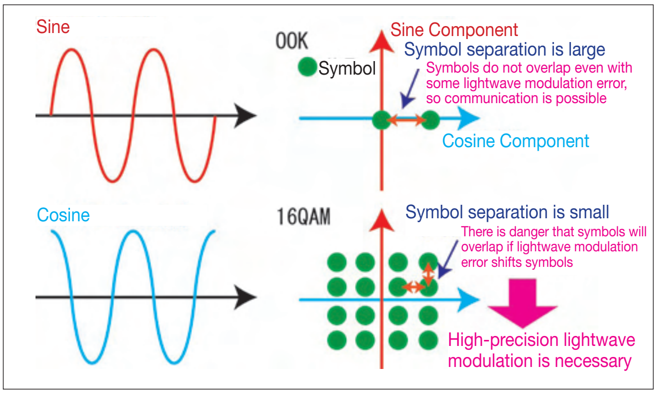


Figure 1: (Left) Light Waveforms: Sine and Cosine. (Right) OOK and 16QAM Constellation Diagrams

Lightwave Modulation --- Manipulating "Hikari"

We also refer to light as lightwave, as it is a type of electromagnetic wave, like radio wave. Electromagnetic waves are characterized by three elements: their size (amplitude), the speed of their vibration (frequency), and the timing of their waves (phase). We can transmit information by changing any of these elements. For the OOK modulation mentioned earlier, two states, "1" and "0" (called symbols or codes) of the amplitude are used, so for each modulation of the light, a single bit of the digital signal can be transmitted. The amount of information transmitted can be increased by either (1) modulating the lightwave more quickly, or (2) transmitting more bits with each modulation of the lightwave. High-speed technology is needed for (1), and high-precision lightwave modulation is needed for (2). For many years, research focused on increasing speed for (1), but NICT has led the world in initiatives to improve both (1) and (2) at the same time. Below, we describe some of the high-precision modulation techniques developed for (2). If two values for each of phase and amplitude are used, combinations yield a total of four possible symbols, so that with each modulation two bits can be sent. For every n bits sent, 2^n individual symbols are needed. The accuracy of the modulation is very important for increasing the number of symbols. If we use the Japanese syllabary as an example, we have 50 syllables. If we then make a distinction between quiet (low amplitude) and loud (high amplitude) syllables, this would allow us to convey more information with fewer words, but we would require more skill to distinguish the words correctly when speaking and listening. The same can be said for lightwave modulation. If the state of the lightwave is not controlled accurately, the information sent will no longer be distinguishable. Lightwaves, as any wave, can be expressed in terms of sine and cosine as shown on the left in Figure 1 (Sine and cosine differ in phase by 90 degrees). For a given frequency, all lightwaves can be separated into two components, sine and cosine. If we place the cosine component on the horizontal axis and the sine component on the vertical axis, the states of the lightwave, or the lightwave-modulation format, can be expressed as points on a two-dimensional plane. To send more information at the same time, many more symbols are needed. A diagram showing the symbols as points on a two-dimensional plane is called a constellation diagram. The ability to send a signal with a complex constellation at high speed is the key to achieving high-capacity transmission. The right of Figure 1 shows the constellation diagrams for conventional OOK modulation and 16-value Quadrature-Amplitude Modulation (16QAM), which uses 16 symbols and is able to send four bits at once. The distance between symbols for 16QAM is smaller than for OOK, so we know that highly accurate modulation is very important.

In 2004, NICT announced that the first-ever technology achieving both high speed and Quadrature Phase-Shift Keying (QPSK), able to send two bits at once. Since then, achieving transmission speeds of 100 Gbps on a single frequency in the laboratory has not been unusual. In 2007, we achieved a high-capacity transmission of 25.6 Tbps (data equivalent to over 250 DVDs per second) over a single optical fiber by using several carriers at the same time (in collaboration between Bell Laboratories and NICT). We also achieved the world's first integrated optical modulation device capable of 50-Gbps 16QAM. Various complex modulation formats have been used in the wireless field for some time, but optical frequencies are 100 thousand times higher than those used for mobile phone signals, and the complexity of such methods is well known. We are steadily overcoming these difficulties by using high-speed, high-accuracy modulation and other high-speed signal processing technologies.

Applications towards Extreme Technology---Reference Signals for Radio Astronomy

The Atacama Large Millimeter/Submillimeter Array (ALMA) is a radio telescope developed as an international project in the high mountains of Chile, which has the highest sensitivity and resolving power in the world (Figure 2). It is composed of over 66 parabolic antennas separated, at the longest distance of 18.5 km. In order to link these antennas together, an optical reference signal is needed. NICT, in cooperation with the National Astronomical Observatory of Japan, is conducting research and development on optical signal generators that will create the reference signal for signal measurements at ALMA. An important index of the accuracy of lightwave modulation is the extinction ratio, which indicates the magnitude of the remaining light when the source is turned off. We have achieved a 10,000-fold improvement over earlier technology (Figure 3). We have implemented a signal generator meeting ALMA's various requirements, such as high stability and wide frequency range, by using the high-extinction-ratio technology.

The high-extiction-ratio modulation is not only for the ALMA signal generator, however, but it clearly will be important for achieving even higher-level modulation schemes. We believe that this result shows the importance of consistently and steadily advancing research from the basic through to applied areas.

Doesn't it seem like a dream, to be drawing constellations inside optical fibers for high-capacity communications, while using it to connect technology for viewing the stars?...

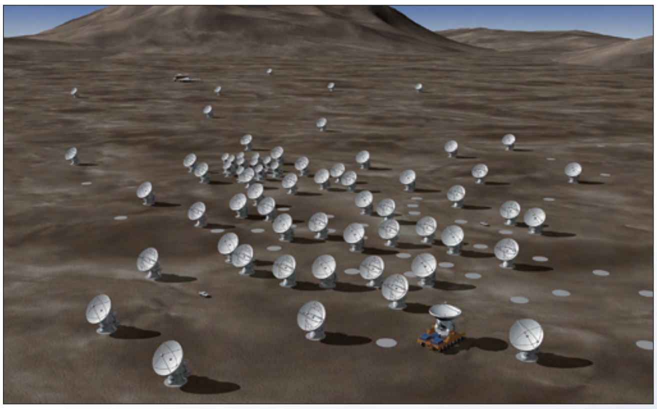


Figure 2: Graphic Conception of ALMA (provided by National Astronomical Observatory of Japan)

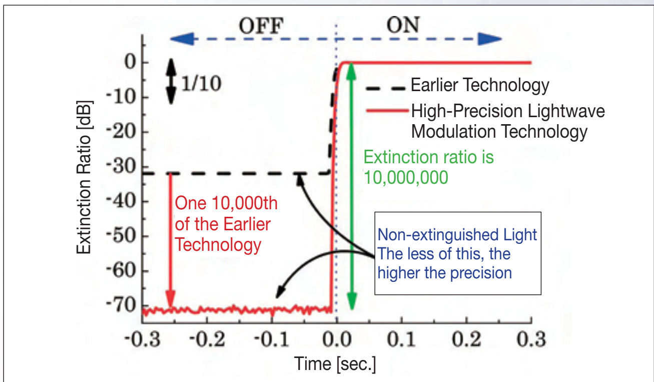


Figure 3: Optical On and Off Levels with High Extinction Ratio

Gratitude

Research related to high-speed, high-precision lightwave modulation technology has been carried out with cooperation and in collaboration with researchers in Japan and around the world. We would like to express thanks to contributors from universities and research organizations including the University of Tokyo, Osaka University, University of Hyogo, Waseda University, Keio University, Doshisha University, National Astronomical Observatory of Japan, National Institute of Advanced Industrial Science and Technology (AIST), KDDI R&D Laboratories, New Technology Research Laboratory, Sumitomo Osaka Cement Co., Ltd., and Bell Laboratories, Inc.

Spinning a Thread of Accurate Time from a Single Ion

Research of Optical-Frequency Standards by Using Calcium (Ca^+) Ions

Profile

Kensuke Matsubara

Senior Researcher
Space-Time Standards Group
New Generation Network Research Center

After completing graduate school, worked at the Science and Technology Academy as a guest researcher and then joined Communications Research Laboratory (current NICT) in 1998. Conducted precision spectroscopy research on ion traps at Kansai Advanced Research Center (current Kobe Research Laboratories) before being engaged in development on Optical Frequency Standards at his current position. Doctor of Science.

Clocks with error under one second in 30 million years

One of the important roles of NICT is to generate, maintain and supply Japan Standard Time and Standard Frequencies, and atomic clocks provide a foundation for fulfilling this role. Currently, Japan Standard Time is generated by using cesium atomic clocks, which generate error of less than a second in hundreds of thousands of years, but NICT is also participating in international efforts to maintain International Atomic Time (TAI), in which atomic clocks with an order of magnitude, one digit more accuracy are used for the primary frequency standard. Development is also proceeding on optical atomic clocks with still higher precision. Kensuke Matsubara, Senior Researcher is one of the researchers vital to this Optical-Frequency Standards research.

"Currently, we define about 9.2 billion oscillations of a cesium atom as one second. In principle, the higher the oscillation frequency, the more precise the definition of the second can be, so calcium ions, with a frequency a hundred-thousand times higher than cesium atoms, are being studied in efforts to measure the second with accuracy never before attained."

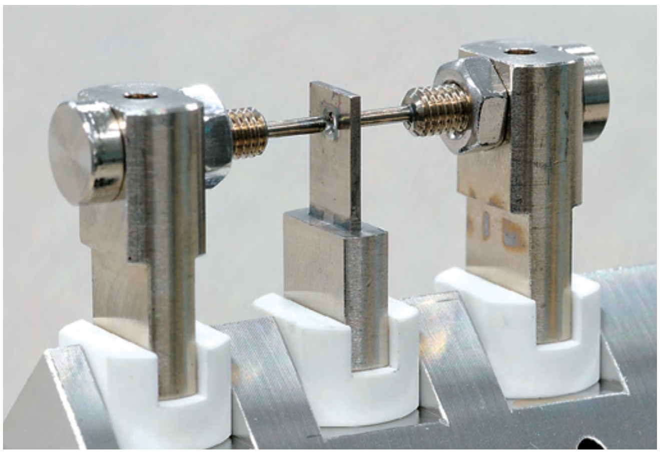
Research has been advancing in research organizations in various countries on ion traps, which are able to confine charged particles to a limited space for an extended period of time, and this is expected to contribute soon to a new definition for the second. However, NICT was the first to demonstrate an optical atomic clock by using a calcium ion as the charged particle. An additional benefit of this development is that it is able to use of a compact, highly reliable semiconductor laser.

Improving Precision by Trial and Error

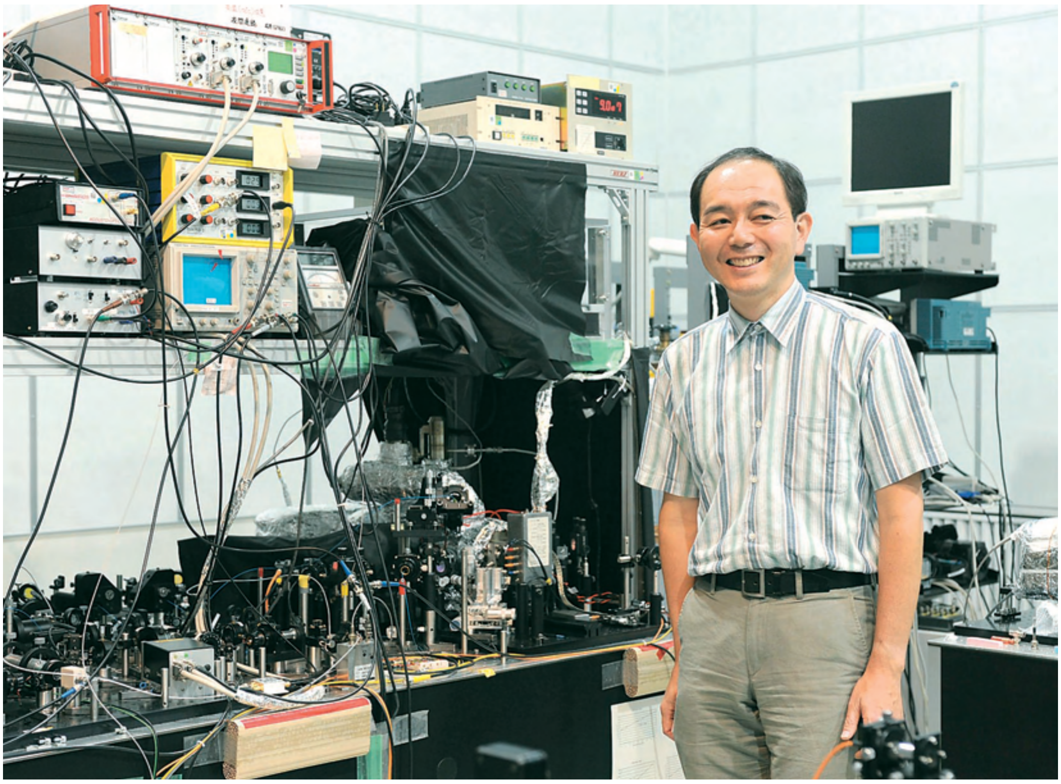
"When we first began development, we had absolutely no equipment for optical frequency standards. We had to build laser equipment and vacuum chamber before starting, which took quite some time. We also used the laser cooling method to stop the motion of the calcium ion, which involved trial and error before achieving a nearly complete stop."

The calcium ions used for the frequency reference have a quadrupole transition with an oscillation frequency of 411 THz (4.11×10^{14} Hz). Naturally, its spectral linewidth is less than 1 Hz, but when we were first making observations, there was a linewidth near 1 MHz (10^6 Hz), and we could not use it for a very precise clock.

"Even being able to acquire the technique to hold a single ion exactly in the trap, it would not be useful for



Ion Trap: An ion is captured in the hole in the center metal plate the works of a clock unless we could trap it in the very center. Any small motion could increase or decrease the oscillation frequency, introducing a frequency fluctuation. We steadily made improvements to each of the elements in the equipment, including the quality of the vacuum, the magnetic field, the balance of electrode voltages, and shape of the electrodes, achieving 'one digit more order of magnitude' with each step." Matsubara, Senior Researcher describes his research in this way while holding a piece of equipment used in the experiments.



In parallel with development of the ion trap, other members of Space-Time Standards Group were developing an ultra-stable semiconductor laser for observing the quadrupole transition and an optical frequency-comb counter for counting optical frequencies at high speed and precision. Both of these developments provide world-class performance and get ready for contributing to improved conditions for research on optical frequency standards.

Approval by International Bureau of Weights and Measures (BIPM)

Once Matsubara, Senior Researcher and his collegues found an optical frequency that could be used for a clock, they succeeded in measuring it with 14-digit (10^{-14}) accuracy for the first time last year. They were able to measure the 411 THz oscillation frequency with an uncertainty of about 5 Hz. As well, at Consultative Committee for Time and Frequency, held at the International Bureau of Weights and Measures in France in June of this year, the oscillation frequency of calcium ions was decided to add to the list of standard frequencies recommended by the committee, thus achieving one of the intermediate goals of the research. Our current objective is to increase accuracy by one digit more order of magnitude. With accuracy exceeding 10^{-15}, we will achieve error of less than 1 second per 30 million years.

It is not possible to measure the accuracy of an optical atomic clock without being able to compare times from more than one optical atomic clock. For this reason, Space-Time Standards Group is also researching another type of atomic clock, called an optical lattice clock, which traps atoms in the optical intensity pattern of a lattice produced by interference of lasers. They hope to demonstrate measurements of unprecidented accuracy in the near future by comparing output from these two clocks.

Research prompted by a visit to the research center

When Matsubara, Senior Researcher was in graduate school, he visited Kansai Advanced Research Center (Current Kobe Research Laboratories), and this visit became the impetus for the current research. He was apparently struck by the ion-trap research they were doing and the technology for capturing a single ion.

"I was interested in that a piece of the most advanced modern technology, single-ion trapping, would be applied to a clock, which is an instrument so close to daily life."

Even now, having had one success, he is continuing his interest in observing this single tiny ion to spin thread of more-accurate time. Further improving the accuracy of clocks will also be promising for far-reaching measurements such as positioning in space.

Terminology

Ion Trap

Equipment for confining a charged particle within a limited space for an extended period of time. There are two types: the Penning trap, which uses static electrical and magnetic fields, and the Paul trap, which uses a radio-frequency alternating electric field.

Quadrupole Transition

A state transition that occurs by an electric field gradient in an atom. The frequency at which it occurs is extremely low so it is called a forbidden transition, and because the natural width of the transition frequency is extremely small, it can be applied to a frequency standard.

Prize Winner ● **Naoto Iwahashi** Expert Researcher, Spoken Language Communication Group, Knowledge Creating Communication Research Center
Komei Sugiura Expert Researcher, Spoken Language Communication Group, Knowledge Creating Communication Research Center
(Team Name: eR@sers)

Joint Prize Winners: Tamagawa University, the University of Electro-Communications

◎DATE: 5.10.2009

◎NAME OF THE PRIZE: The Japanese Society for Artificial Intelligence Award in RoboCup Japan Open 2009

◎DETAILS OF THE PRIZE: A Real-Time Learning Method for Object-Manipulation Based on Probabilistic Models Dependent on Reference-Point

◎NAME OF THE GROUP: The Japanese Society for Artificial Intelligence

◎Comments by the Winner:

We are honored to receive this award, which validates our efforts in developing an innovative motion learning method based on probabilistic models. We would like to thank Dr. Satoshi Nakamura and Dr. Hideki Kashioka of the MASTAR project for their persistent guidance, and all the laboratory members for their generous support. This great honor will continue to inspire us to work vigorously and collaboratively to create innovative systems.

From the left: Naoto Iwahashi, Komei Sugiura

Prize Winner ● **Naoto Iwahashi** Expert Researcher, Spoken Language Communication Group, Knowledge Creating Communication Research Center
Komei Sugiura Expert Researcher, Spoken Language Communication Group, Knowledge Creating Communication Research Center
(Team Name: eR@sers)

Joint Prize Winners: Tamagawa University, the University of Electro-Communications

◎DATE: 5.10.2009

◎NAME OF THE PRIZE: First Place in the @Home League

◎NAME OF THE GROUP: RoboCup Japan Open 2009 OSAKA

◎Comments by the Winner:

We are proud to win the first place in the RoboCup@Home Japan Open. It validates our engineering efforts and application of learning motion and our-of-vocabulary words to realistic home domains. We have been fortunate to work with Professor Hiroyuki Okada of Tamagawa University, Professor Takayuki Nagai of the University of Electro-Communications, and all the members of our team. We look forward to continuing to collaborate with them to contribute to our respective research fields.

Team Name: eR@sers

Prize Winner ● **Shunsuke Yoshida** Expert Researcher, Multimodal Communication Group, Universal Media Research Center
Roberto Lopez-Gulliver Expert Researcher, Multimodal Communication Group, Universal Media Research Center
Sumio Yano Research Expert, 3D Spatial Image and Sound Group, Universal Media Research Center
Naomi Inoue Executive Researcher

◎DATE: 7.9.2009

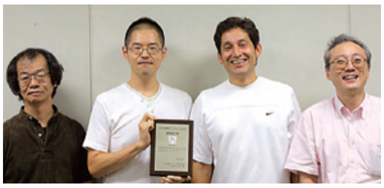
◎NAME OF THE PRIZE: Excellent Paper Award

◎DETAILS OF THE PRIZE: gCubik: A Cubic 3D Display for Multiuser Environments— An Early Study Using a 3-Face Prototype —

◎NAME OF THE GROUP: 3D Image Conference 2008

◎Comments by the Winner:

We have proposed the "gCubik", an auto-stereoscopic 3D display, that allows 3D imaging to be shared by a group of users and that can be grasped with your hands instead of just being appreciated from a distance. We are very much honored to be recognized at this time for the innovation of this concept and the research we have done on its implementation methods. In the future, we hope to continue research and development, including concrete examples of applications for the gCubik to promote its spread as a new media for 3D imaging.



From the left: Yano, Yoshida, Lopez-Gulliver, Inoue

Prize Winner ● **Yasushi Matsumoto** Research Manager, Electromagnetic Compatibility Group, Applied Electromagnetic Research Center

Joint Prize Winners: Kia Wiklundh, Deputy Research Manager, Dept. of Communication Systems, Swedish Defence Research Agency (FOI)

◎DATE: 7.22.2009

◎NAME OF THE PRIZE: Excellent Paper Award, 2009 International Symposium on Electromagnetic Compatibility, Kyoto

◎DETAILS OF THE PRIZE: A Simple Expression for Bit Error Probability of Convolutional Codes under Class-A Interference

◎NAME OF THE GROUP: Organizing committee of the International Symposium on EMC

◎Comments by the Winner:

As electronic devices and wireless communication become more integrated and speeds increase, methods for evaluating the effect of emitted electromagnetic noise on communications are becoming more and more important. In this research, we have made a start in finding practical methods to estimate the impact of impulsive noises on various communication systems easily. We are very much honored to be recognized for this effort and express our appreciation to all those providing guidance in this work. We plan to continue this research towards finding practical methods for defining the noise emission limits.

From the left: Kia Wiklundh, Yasushi Matsumoto

Participation in the "Children's Kasumigaseki Tour Day"

Towards the end of summer holidays, on August 19 and 20, the government district in Kasumigaseki, normally busy with grown-ups coming and going, was filled with more-lively voices as many children visited the area.

The "Children's Kasumigaseki Tour Day" is one of the initiatives of the "Children's Tour Day" run mainly by the Ministry of Education, Culture, Sports, Science and Technology. This yearly event is held in collaboration with government agencies in Kasumigaseki by having them arrange visits and explain their roles, giving children a chance to learn and experience society widely during their summer holidays, and in the hope of promoting their understanding of various initiatives being undertaken by the government agencies, and helping to strengthen the relationships between children and parents.

NICT participates in this event each year, and this year we exhibited "Keepon", and also issued "Children's Tour Day Participation" certificates.

Keepon is a stuffed-toy robot developed for research. The robot's charming behavior, inclining and nodding its head when it recognizes someone's face, was very popular with the children, so that it continues to be exhibited, even though the research is now finished. Immediately after the event opened, children held back, watching from a distance, but as soon as one or two began to play with it, as if the floodgates had suddenly broken open, they swarmed around Keepon, lining-up for a try. Some children who delighted when Keepon recognized their faces immediately, while others tried all kinds of things, smiling and making faces, to try to catch it's attention when it did not. This brought much enjoyment to the child, of course, and also to those looking on.

The "Children's Tour Day Participation" certificates were created by setting the clock of a PC to Japan Standard Time generated by NICT, and printing the participation certificate with the exact time and a photograph of the child's face. Participants joined in, taking pictures with their friends, siblings and parents, and enjoying it like a photo-sticker booth.

A Child Playing with Keepon

Children Taking Their Picture and a "Children's Tour Day Participation Certificate"

How Accessible and Interesting the Science Is!

— Report on Exhibits at the Tokyo Youngster's Science Festival in Koganei —

The "Tokyo Youngster's Science Festival in Koganei 2009" was held on September 13 (Sun.) at the Koganei Campus of Tokyo Gakugei University, and NICT also exhibited in it..

The national "Youngster's Science Festival" has been held each year since 1992, providing a hands-on event that gives the opportunity to really experience the fascination of science. This event held in Tokyo was planned and developed to capture the purpose of the national festival, while maintaining roots in the local region. As such, it also attracts participation from many organizations, groups and volunteers from Koganei City to convey the enjoyment of science to elementary and junior high school students.

This year, NICT exhibited three themes: "Manipulating Imagery in the Air with a Floating Touch Display," "Communication Care Robot (Keepon)" and "Generating Japan Standard Time in Koganei." NICT Amateur Radio Club also exhibited "Playing with Short-Distance Radio Communications and the Total Solar Eclipse." "Floating Touch Display" particularly gave an opportunity to experience the latest technology from NICT. Its exhibit demonstrated technology using unique optical elements developed at NICT to display an image floating in the air, to manipulate it with the fingertips through a glassless infrared touch panel. Visitors were able to touch and push around images of a dandelion spore floating in the air and to play a piano keyboard floating in the air, listening to its sounds. They were surprised at it, wondering how it could work, and were immediately interested in the possible applications. As well, “Keepon" and "Generating Japan Standard Time at Koganei," which were also used at "Children's Tour Day in Kasumigaseki," were also very popular exhibits. The children interacted with Keepon in various ways, fascinated with seeing the basic starting points of communication. We also printed and gave out visitor certificates with the exact time, a face photograph, and using a photo taken at the leap second-moment of this New Year's Day as the background. Do you suppose that many visitors noticed this?

We hope that through this event a spark of something familiar will lead to enjoyment and interest in science and technology, and we would like to thank all of the visitors and all of the junior high school student volunteers that lent us their enthusiastic support for the exhibition.

Views of the Exhibits from NICT

A View of the Exhibit from NICT Amateur Radio Club

Information for Readers

The next issue will feature the NICT Super Event 2009 held at CEATEC JAPAN 2009.

NICT NEWS No. 385, October 2009

Published by
Public Relations Office, Strategic Planning Department,
National Institute of Information and Communications Technology
<NICT NEWS URL> http://www.nict.go.jp/news/nict-news.html

Editorial Cooperation: Create Crews, Ltd.

4-2-1 Nukui-Kitamachi, Koganei, Tokyo 184-8795, Japan
Tel: +81-42-327-5392   Fax: +81-42-327-7587
E-mail: publicity@nict.go.jp
URL: http://www.nict.go.jp/index.html