NICT National Institute of Information and Communications Technology

NICT NEWS

No.463 APR 2017

FEATURE

Electromagnetic Compatibility Technologies to Support Utilization of Radio Waves in the IoT Era

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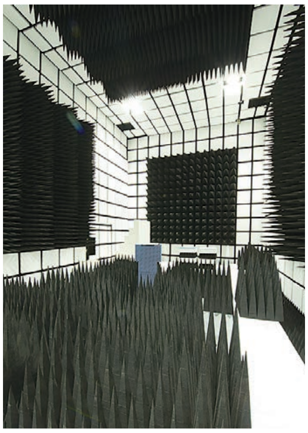


Cover photo: Millimeter-wave pyramidal radio absorbent material
The black, pyramid-shaped objects are radio wave absorbers that absorb incident radio waves and suppress reflection. They are installed on inner walls of a radio anechoic chamber used to make accurate millimeter-wave band measurements. Combining radio wave absorbers of differing lengths gives excellent absorption characteristics for wideband and obliquely incident radio waves.

INTERVIEW

Realizing a Safe, Reliable Electromagnetic Environment

Yasushi MATSUMOTO
Director of Electromagnetic Compatibility Laboratory
Applied Electromagnetic Research Institute
Joined the Communications Research Laboratory (currently NICT) in 1985. Engaged in R&D on mobile satellite communications, and later, after working at NASDA (now JAXA) and Tohoku University, engaged in R&D on satellite-mounted antennas and electromagnetic environment technologies. Ph.D. (Engineering).

From smartphones and other mobile information terminals to consumer electronics devices—. Currently most of our "life's conveniences" have been made possible through developments in radio communications technology. The tools of this life of convenience are electronic devices that use radio, and all of them, without exception, emit electromagnetic waves. It is not an exaggeration to say that we live immersed in electromagnetic waves. What effect do these electromagnetic waves have on our surroundings? We spoke with Dr. Yasushi MATSUMOTO, Director of the Electromagnetic Compatibility Laboratory, Applied Electromagnetic Research Institute, which evaluates interactions between electromagnetic waves and the surrounding environment and conducts research on countermeasures to the effects of electromagnetic waves.

NICT and the pursuit of electromagnetic compatibility

— The name of your laboratory refers to "electromagnetic compatibility." Can you tell us what that means?

MATSUMOTO: Many electromagnetic waves emanate from the abundance of electronic devices around us. Some of these are emitted intentionally, but there are also others that are unintentionally emitted as electromagnetic noise.

Electro-Magnetic Compatibility, or EMC, refers to ability of an equipment or system to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to anything in that environment. This compatibility is the theme of electromagnetic environment technology.

Recently in particular, the use of radio by IoT and 5G mobile communications systems is increasing more and more quickly. As a national research institute working under the jurisdiction of the Ministry of Internal Affairs and Communications, research on the electromagnetic environment or electromagnetic compatibility is a particular focus of NICT.

We operate based on five-year Medium- to Long-Term Plan, and our current plan (2016-2020) established two main pillars of focus. The first was "Advanced EMC measurement," and the second was "Biological EMC technology." In simple terms, the first involves research on EMC between different objects, while the second involves research on EMC between humans and objects. We currently have three teams working on advanced EMC measurement, and two teams working on biological EMC technology.

Ever-increasing electromagnetic noise

— So what sort of research are you doing in "Advanced EMC measurement," related to compatibility between objects?

MATSUMOTO: There are several themes even within Advanced EMC measurement.

One example is electromagnetic noise emitted by energy-saving devices. Energy-saving devices such as LED lighting use switching power supplies to convert AC to DC. And similarly, solar power generation uses switching converters to convert the other way, from DC to AC.

These converters switch between ON and OFF as quickly as possible to reduce energy loss, and as a result, they emit wide-band electromagnetic noise. There is concern that this causes some disruption to wireless communications and digital terrestrial broadcasting, and a few examples have been reported.

One of our themes is to study how this sort of electromagnetic noise can be measured, and how to quantify any potential interfering effects on radio systems. It will be up to individual manufacturers to reduce noise from their devices, but based on that assumption, we are working to establish methods for evaluating electromagnetic noise and also to create international standards to regulate electromagnetic noise levels.

A second theme is to measure unwanted radio waves emitted by wireless devices. All radio devices emit unwanted radio waves in addition to the radio waves that they are intended to emit. As with unwanted radio waves, inter-

INTERVIEW

Realizing a Safe, Reliable Electromagnetic Environment

national rules are being created to keep these unwanted signals below set levels, but this also assumes that they can be measured accurately. We are developing technology to do so.

A third theme is closely related to this. NICT has a role of preserving accuracy when measuring such unwanted signals—verifying the accuracy of measurement instruments. This process is called "calibration," and it provides a weights and measures standard for instruments. In Japan, AIST has jurisdiction over national physical standards, but according to Radio Law, calibration by NICT is the standard for radio waves (Figure 1).

Human body impact assessments also fragmenting

—— So what is happening in the field of "Biological EMC technology"?

MATSUMOTO: As the name suggests, this deals with whether radio waves have any adverse effects on biology (humans), and how to maintain their safety. Specifically, this involves two aspects.

The first is "exposure evaluation technology," which evaluates quantitatively what happens when the human body is exposed to radio waves. Of course, we do not test on human subjects, but basically we do numerical simulations using human body models that reproduce a human body with digital data.

This also involves health effects, so there are areas we cannot cover as engineering researchers, and we collaborate with medical universities and other research institutions in those areas.

The other aspect deals with guidelines for controlling the levels of the various radio waves being emitted, so they do not have adverse health effects. (In Japan, a "Radio-Frequency Radiation Protection Guideline (RRPG)s" has been established, some of which was used in Radio Law Regulations). We are developing technology to accurately determine whether devices conform to such guidelines. This is called "technology to evaluate compliance with RRPG."

As an example in this area, smartphones are used mainly in the hands and not next to the ears, which is completely different from earlier mobile phones. Furthermore, they are used mainly to connect to the Internet, not just for talking, so communication time and content are also different. With the transition to multi-band systems, various frequencies are dynamically used on demand. In this way, there are many more relevant parameters, and such a situation makes compliance evaluation more difficult and complicated.

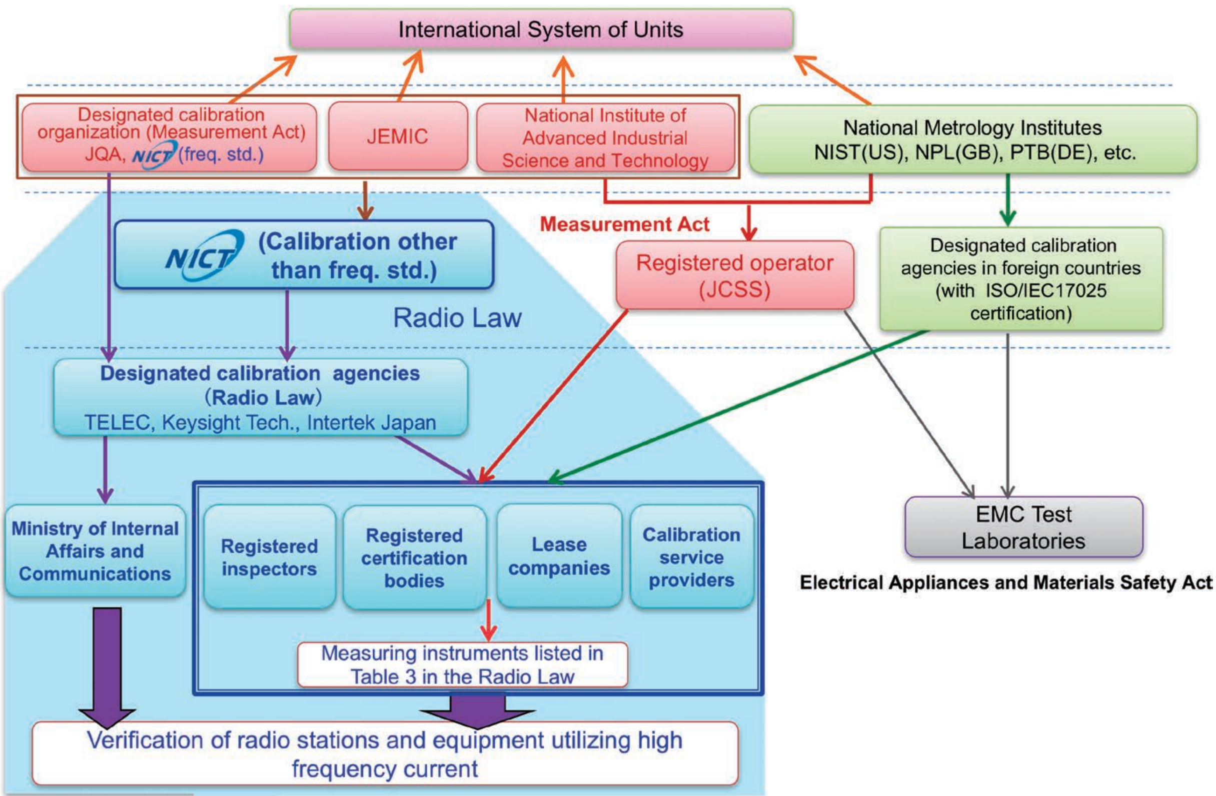
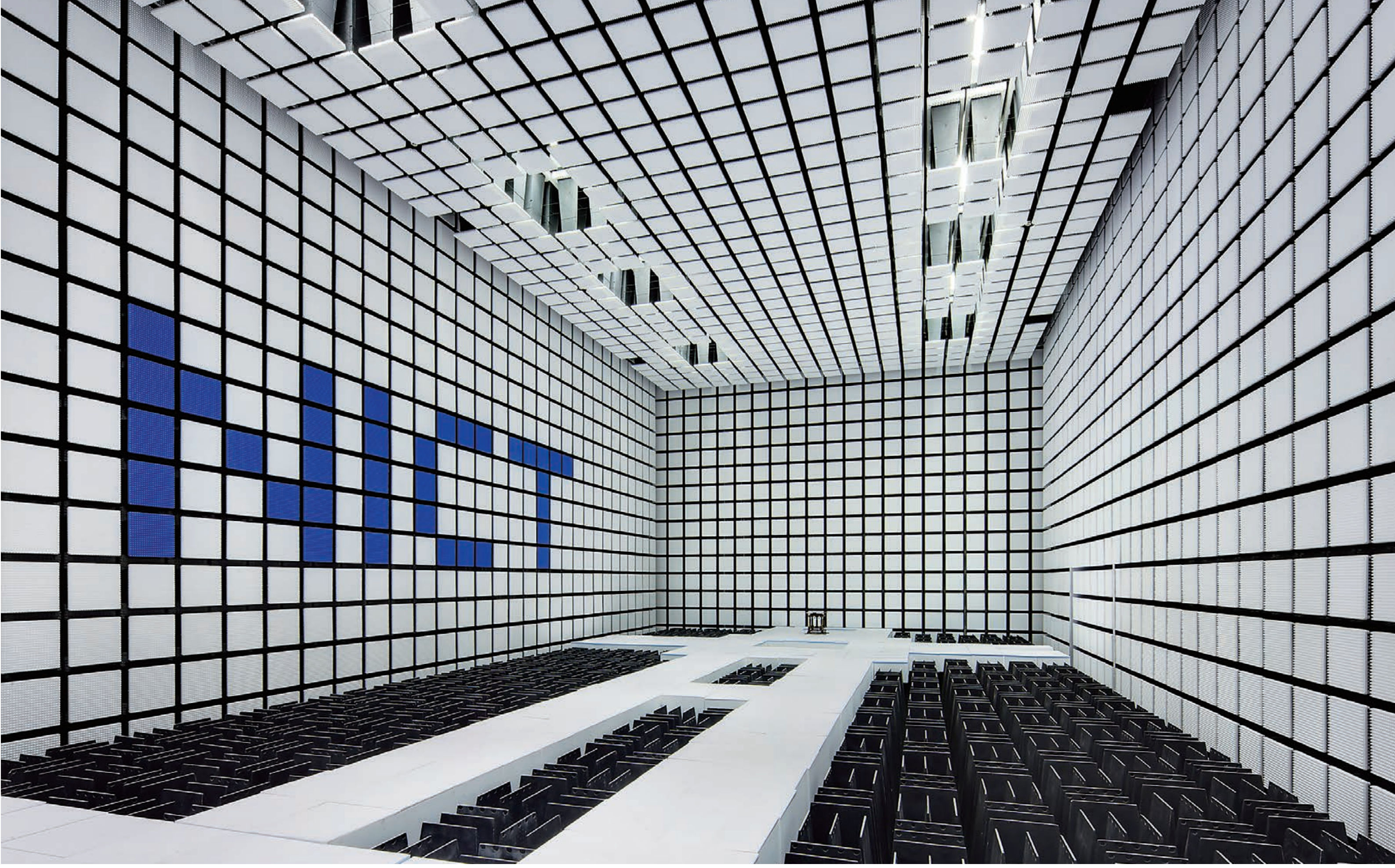


Figure 1 Calibration system for radio equipment measurement instruments in Japan



Large scale radio anechoic chamber: Test facility that secures a large space where accurate measurements of radio waves of frequencies from 30 MHz to 40 GHz can be made and in which radio reflections are suppressed. (Anechoic room with absorbers on six faces, including floor, and internal dimensions 23.4 m (D) x 11.9 m (W) x 7.9 m (H) (photo))

■ Advancing radio technology and EMC research are two sides of the same coin

── It seems like your work is very difficult, with investigation spanning very diverse aspects that all need to be accounted for meticulously.

MATSUMOTO: This research is to ensure that nothing goes wrong with this ever-expanding use of radio waves, anticipating worst-case scenarios, imagining what could happen and what needs to be considered, and carefully investigating each of them thoroughly.

In particular, as wireless communication technology advances, EMC R&D is always the other side of the coin. The various information terminals and wireless devices are great conveniences in our lives, but we must also ensure that they do not cause accidents or other problems. I believe this research is our mandate as a national research institute.

Of course, it is still very difficult to prove that there are no adverse effects.

■ Safe use of continuously advancing radio technology

── As the IoT age develops, more new directions in radio use will appear in the future. How do you think we need to prepare for this?

MATSUMOTO: In short, I think we can expect to see radio and wireless being used in an increasingly wide range of scenarios.

Beyond automation in factories, devices in our homes will even be exchanging data with each other. Use will also expand into areas such as watching over the elderly and remote medicine and social welfare. In infrastructure, such as the smart-grid, we will see more detailed control, with radio being used for that as well.

This will also bring many unwanted electromagnetic waves as well. We expect that the potential for trouble due to electromagnetic interference will increase in homes, offices, and on-site in industry.

As we use radio more, radio frequency resources are also consumed, so we move to even higher frequencies and wider bands. With these changes, of course we will also need new measurement technologies, calibration technologies, and technologies to evaluate their effects on the human body. Use of radio signals for mobile terminals and other applications is expanding on a global scale, so international collaboration and standardization is also becoming much more important when conducting EMC R&D.

To ensure that we can all use radio devices safely, we are always carefully examining future trends in radio technology, anticipating any problems that could occur, and handling them before they do occur. This is the sort of research we believe is needed from us.

Approaches to EMC Issues for Smart Houses and Communities

Ifong WU
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After receiving the D.E. degree in electrical engineering and electronics, he joined NICT in 2007 as a researcher. He has been engaged in research on the electromagnetic compatibility of radio communication systems. Ph.D. (Engineering).

The introduction of the next-generation power transmission network, or Smart Grid, is progressing actively. This network controls the efficient flow of power between generating systems such as solar power plants (the supply side) and homes and offices (the demand side), optimizing the balance between power supply and demand. However, it has been pointed out that unwanted electromagnetic noise (EM noise) from energy-saving appliances connected to the smart grid, such as LED lighting and inverter air conditioners, could cause the smart grid to malfunction (see Figure 1).

Introduction

To build a highly reliable smart electrical power infrastructure, it is necessary to anticipate the EM environment in which the smart grid is installed, and the smart grid must be implemented to operate correctly under any EM environment. Therefore, technology to accurately measure EM noise radiated from devices connected to power lines, and to appropriately evaluate any effect this EM noise will have on the surroundings is critical. To solve electromagnetic compatibility (EMC) issues related to the smart grid, we are developing measurement technologies that easily and reliably measure wide-band EM noise radiated from electrical and electronic devices, and are conducting studies to establish technologies for evaluating any effects of EM noise on communications and broadcasting. This article examines photovoltaic (PV) power generation systems as an example of energy saving devices, and introduces results from studying the radiation mechanisms of EM noise from PV power generation systems.

Radiation mechanisms of EM noise from PV power generation systems

One issue with PV power generation systems is that switching is used to convert the direct current (DC) from the PV panels to alter-

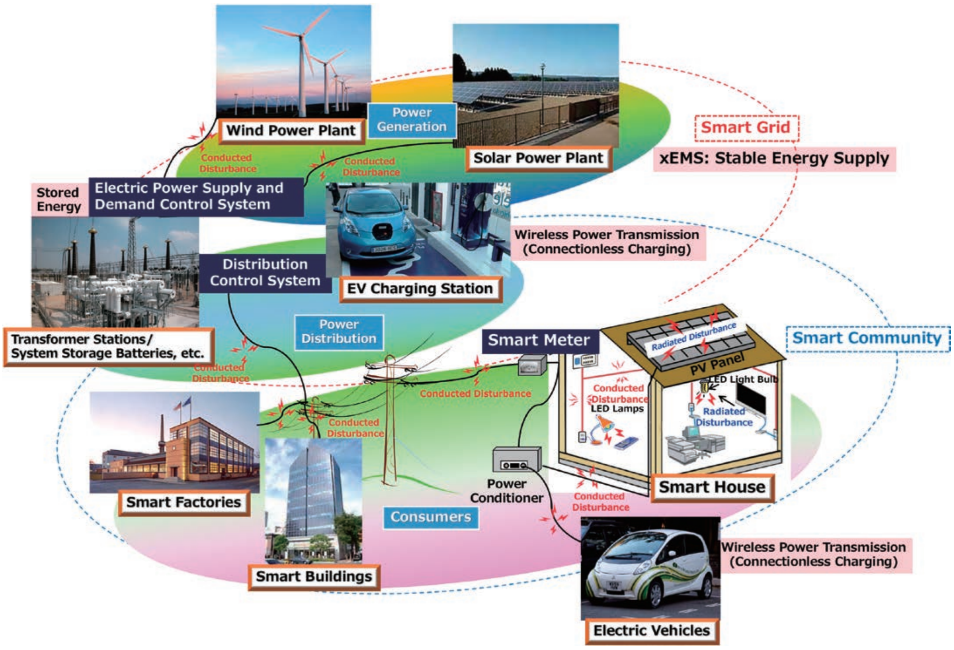

Figure 1 Smart house*1 and Smart community*2 EMC issues

*1 Smart house: Houses that conserve energy and reduce CO_2 emissions by using IT technology to control the balance between supply of green energy from sources such as PV power generation systems, and power consumption from energy saving consumer electrical appliances and other devices.

*2 Smart community: Next-generation community building to establish both a comfortable lifestyle and consideration of environmental issues by using IT to integrate management of all infrastructure in the overall community, to use electricity more efficiently and utilize renewable energy, for example.

nating current (AC), and this process produces EM noise (switching noise). This switching noise is transmitted over the DC power lines of the PV power generation system to the panels, but some of it is radiated into space as EM noise. To avoid poor reception due to EM noise radiated from a PV power generation system, we must first clarify the radiation mechanisms of the EM noise, which depend on the construction of the PV power generation system.

We identified the primary causes of EM noise radiated from PV power generation systems and clarified the differences in EM noise radiation characteristics from components of the PV power generation system (e.g. solar panels, power lines, etc.). An example is given below. A simplified model of a PV power generation system is shown in Figure 2(a). When power lines are connected to the PV panels without a frame wire, the two parallel power lines produce a branching line at the PV panel, destroying the balance between forward and reverse current in the two lines. Because of this, a part of the current flows in the same direction in both lines, causing the power line to behave as a single conductor antenna and resulting in radiation of noise as shown by the measurement results in Figure 2(b). When a frame wire is installed, another peak appears in the low-frequency region in addition to the main resonance peak. This may be because a large current-path loop is formed between the power lines, the PV panel, the frame wire, and the ground. This shows that the layout of wiring is a dominant factor in the EM noise radiated from PV power generation systems. It also clarifies some basic behavior of EM noise radiated from PV power generation systems, providing knowledge that will be helpful in predicting and reducing EM noise radiation caused by switching.

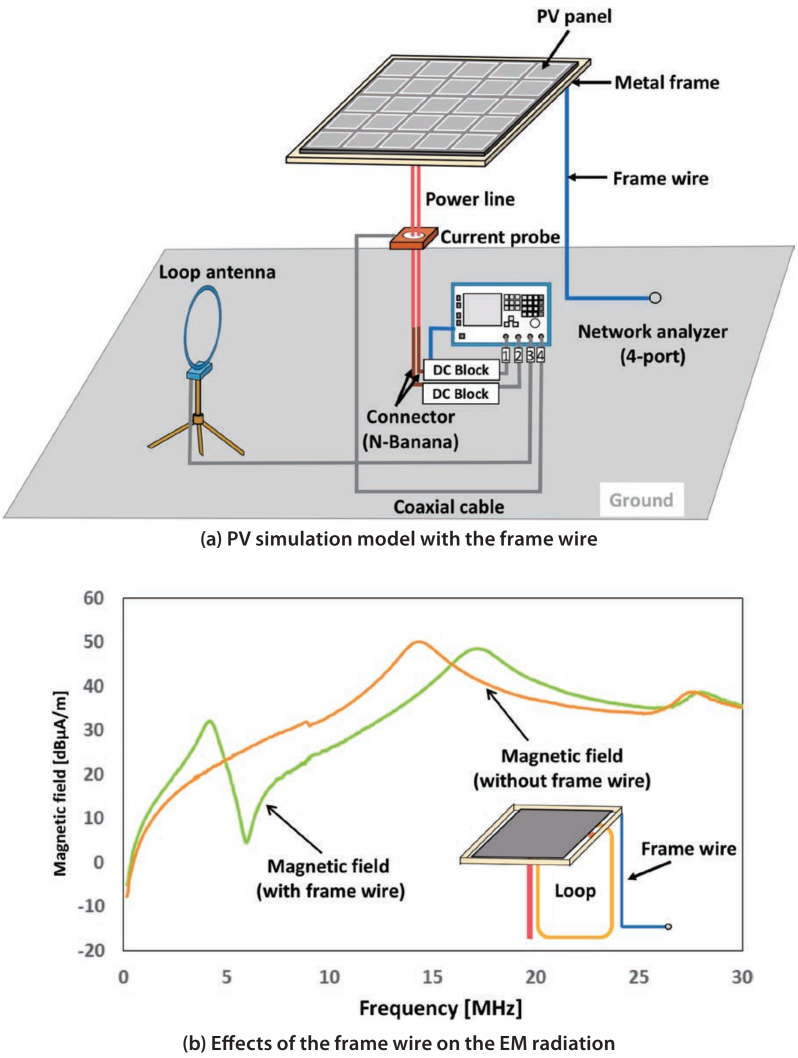

Figure 2 Radiation characteristics of EM noise from the PV model with the frame wire connected to PV power generation system

Future prospects

The Internet of things (IoT) era is arriving, with the spread of the smart grid and all kinds of household items connected to the Internet, by both wired and wireless connections. To ensure reliability of the IoT, it will be extremely important to clarify what EMC issues will envelope this new technological society, and to develop technologies to evaluate any risks they pose. This article has introduced a potential source of interference to communications systems using PV power generation systems as an example; by showing a radiation mechanism of EM noise. As IoT permeates society more in the future, we will work on technologies to analyze and evaluate the mechanisms of EM noise, which will provide basic technology for controlling EM noise and avoiding EM interference.

Human Exposure Assessment of Wireless Power Transfer Systems in Intermediate Band

To achieve global standard of product safety evaluation

Chakarothai JERDVISANOP
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After graduation from a doctoral degree, the author joined the Electromagnetic Research Institute, National Institute of Information and Communications Technology in 2013. His research interest is safety assessment for wireless devices in intermediate frequency bands, such as wireless power transfer systems. Ph.D. (Engineering).

Wireless power transfer (WPT) systems using intermediate frequency bands (300 Hz to 10 MHz) are advancing rapidly and expected to become widespread in the near future. In our study, practical compliance evaluations of WPT systems with respect to the human body were conducted by using numerical analyses with detailed anatomical human models and a newly proposed coupling factor (CF), according to applications and use conditions of WPT systems. This article introduces this research and discusses related activities and future prospects for exposure evaluation standards related to WPT systems.

Research background

The need for WPT systems using electromagnetic waves in intermediate frequency bands has increased recently. WPT technologies have potential to reduce the size of batteries in electric vehicles and enable charging of mobile devices in various locations, increasing convenience of users. On the other hand, since WPT systems handle much more power than conventional wireless communication devices, the electromagnetic fields produced around them are much stronger. Consequently, evaluation of the safety with respect to the human body must be done based on a radio protection policy that regulates aspects such as quantity of radio wave energy, so that WPT devices do not cause adverse effects on people who are nearby.

Since intermediate frequency bands have not been used much in the vicinity of people, study on human safety issues has not been done adequately. In addition, exposure evaluation methods have not been established. Particularly, in a frequency range between 100 kHz and 10 MHz, evaluation of both the electric field (E_{in}) induced in the body, which is a metric for the dominant stimulus effect at low frequencies, and the specific absorption rate (SAR), which is a metric for the dominant thermal effect at high frequencies, is required. Since the position and posture of the human body are different for different conditions of use, evaluation according to the use conditions is also necessary. For example, a WPT system for electric vehicles (EV) would be installed in the bottom of the vehicle, but a WPT system for PCs or mobile devices could be placed very close to the body, so these factors must be considered (Figure 1).

As such, we performed a numerical analysis of WPT systems placed near the human body, and studied compliance evaluation methods for various systems.

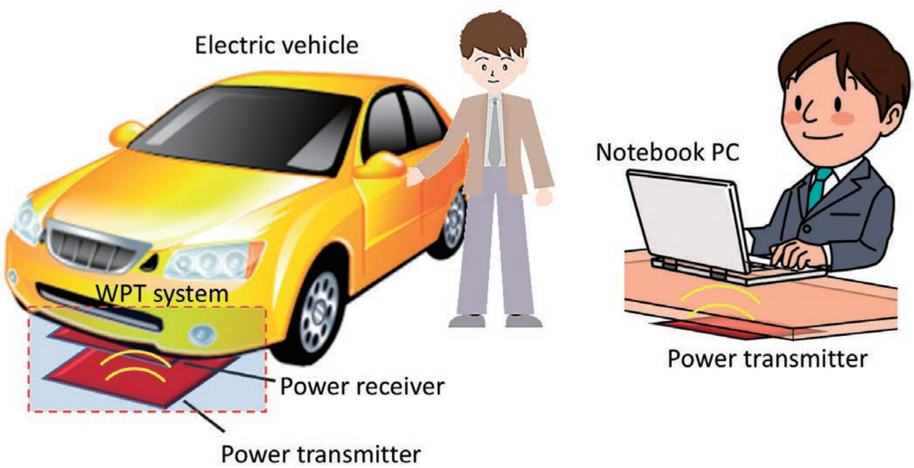

Figure 1 Use of wireless power transfer system to charge an electric vehicle and notebook PC

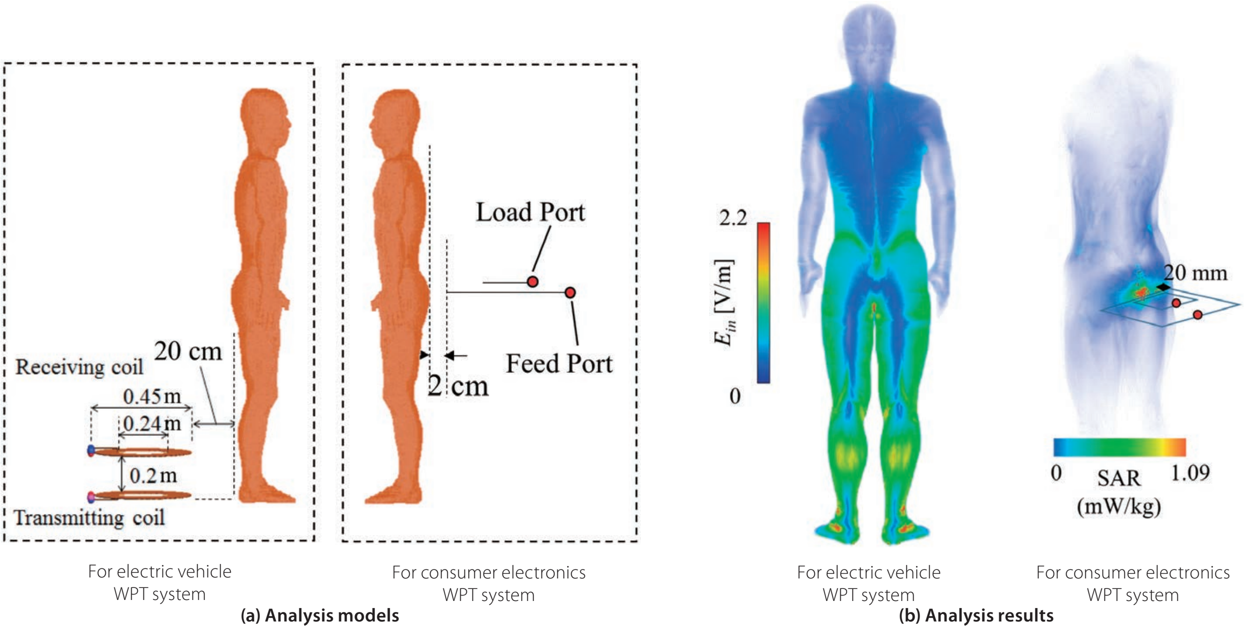

Figure 2 Analysis model and results of wireless power transfer system for electric vehicles and consumer electronics

Numerical analyses of induced quantities in the human body close to a WPT system

In this research, we used the impedance method and a newly proposed, accelerated and improved, finite-difference time-domain method [1][2] for analyses at low frequencies. We placed WPT systems for EVs and for consumer electronics near a numerical model of a Japanese adult developed at NICT, as shown in Figure 2(a). The analysis results for E_{in} and SAR are shown in Figure 2(b). Figure 2(b) shows that for the EV WPT system, E_{in} is high at the lower part of the body (below the waist), and for the consumer electronics WPT system, the SAR value was only high close to the system.

We also developed a new exposure evaluation technique, which uses the measured electromagnetic near-field near the WPT system, enabling us to evaluate exposure from actual WPT products that are difficult to model numerically.

Evaluating compliance using a coupling factor (CF)

It is, in practice, difficult to do numerical analysis when evaluating compliance for actual WPT products. It is easier to use incident magnetic field for safety evaluation. However, regulations for the incident magnetic field were determined by assuming uniform exposure of the human body, so they are too strict to be used for nonuniform exposure as with WPT systems, when compared with evaluation based on quantities induced in the body. Therefore, we proposed a new technique that can be used to evaluate equivalent induced quantities in the human body by measuring only incident magnetic field [3]. This was done by precomputing coupling factors (CF) that relate the incident magnetic field to induced quantities in the human body. The CFs, one for thermal effect and the other for stimulus effect, can be expressed with the following equations.

$$a_{c1} = \left(\frac{\sqrt{\mathrm{SAR}_{max}^{10g}}}{H_{max}}\right) \Bigg/ \left(\frac{\sqrt{\mathrm{SAR}_{limit}^{10g}}}{H_{limit}}\right)$$

$$a_{c2} = \left(\frac{E_{max}^{in}}{H_{max}}\right) \Bigg/ \left(\frac{E_{limit}^{in}}{H_{limit}}\right)$$

SAR_{max}^{10g} : Spatial peak 10g average SAR
$\mathrm{SAR}_{limit}^{10g}$: Limit level for SAR^{10g}
E_{max}^{in} : Internal electric field intensity
E_{limit}^{in} : Limit level for E^{in}
H_{max} : Maximum magnetic field intensity
H_{limit} : Limit level for magnetic field intensity

CFs computed using the above definitions for EV and consumer electronics WPT systems are 0.050 and 0.0041, respectively. When evaluating compliance, the results obtained by multiplying measured magnetic field strength with the CF can be used to compare with the safety levels. Since evaluation using the CFs is equivalent to using the induced quantities (E_{in} or SAR), the input power can be increased while maintaining safety. For example, with an EV WPT system, using a CF of 0.05, the input power can be increased by a factor of 400.

Future prospects

WTP systems are promising for various applications in the future, from industrial robots to capsule endoscopy. Implementation of beam-type (non-coupled) WPT systems is also being studied. Appropriate safety evaluation methods must be developed for each of these systems as well.

In conclusion, computational results on safety evaluation of WPT systems from this laboratory have been reported to the Information and Communications Council of the MIC in Japan, creating a world-leading technical standard in this area. On the other hand, the International Electrotechnical Commission (IEC) began studying compliance evaluation methods for WPT systems in FY2015, and is planning to issue a technical report (TR). Our laboratory will continue to work vigorously to ensure the safety of WPT systems for the human body through international standardization organizations and to strengthen future social infrastructure, in which WPT systems are expected to play an increasing role.

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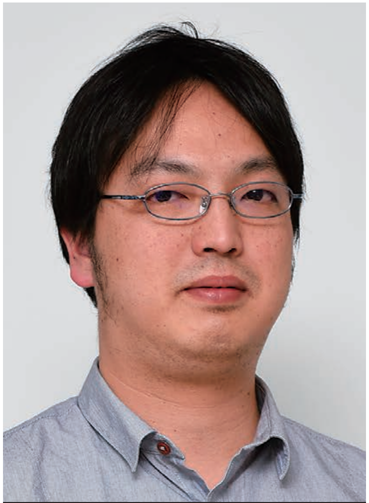
Technology to Assess Safety of Radio Technology in the Increasingly Utilized Quasi-Millimeter Wave and Millimeter Wave Frequency Bands



Kensuke SASAKI
Researcher
Electromagnetic Compatibility Laboratory
Applied Electromagnetic Research Institute

Joined NICT in 2011 after completing graduate school. Engaged in research on measuring dielectric properties of biological tissues and other materials from extremely low frequency to millimeter-wave frequency bands, and assessment of the safety to humans of exposure to electromagnetic fields in the quasi-millimeter-wave and millimeter-wave frequency bands. Ph.D. (Engineering).

Quasi-millimeter wave (10-30 GHz) and millimeter wave (30-300 GHz) frequencies are being studied for use in advanced wireless telecommunication systems. The expansion of these new technologies will increase the public exposure to radio waves; thus, an assessment of the safety of exposure to these electromagnetic waves is a high priority. The Applied Electromagnetic Research Institute conducts research on measurement of the dielectric properties of biological tissue, as it relates to assessing the safety for the human body of new technologies that use radio waves. We are also contributing to setting and revising guidelines for protecting humans from exposure to radio waves, and in standardization to set international regulations for technologies that assess compliance to such guidelines.

Assessment of safety for next-generation wireless communications technologies

Continuous growth of wireless data traffic is expected with the development of high-speed wireless communication technologies. Wireless Gigabit (WiGig) systems using the 60 GHz band are now practical, and the International Telecommunications Union (ITU) is studying use of quasi-millimeter wave (10-30 GHz) and millimeter wave (30-300 GHz) frequency bands in next generation (5G) mobile wireless terminals and base stations. The Applied Electromagnetic Research Institute is investigating safe use of radio waves and is developing technologies to maintain safety as these new telecommunications technologies spread.

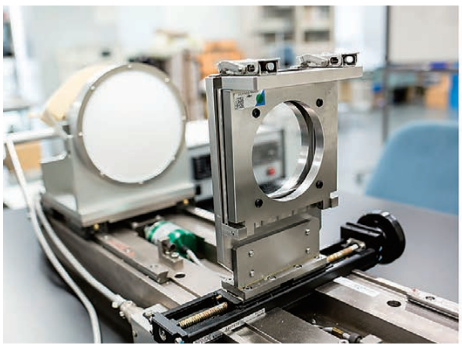
Technologies to measure dielectric properties of biological tissue, which determines responses to EM exposure in the human body

In order to assess amounts of transmission and absorption in the human body when exposed to radio waves, it is necessary to understand correctly electrical physical constants (dielectric properties) such as permittivity and conductivity of the various tissues that comprise the human body. The dielectric properties of tissue vary on the composition of the tissue and the frequency, so they must be measured for each type of tissue and at both quasi-millimeter wave and millimeter wave frequency bands.

To do so, the Applied Electromagnetic Research Institute has developed equipment to accurately measure the dielectric properties of biological tissues (Figure 1). Then, to promote safety assessment research, the dielectric properties of tissues* obtained from pigs and other animals were measured and analyzed (Figure 2). There has been a small amount of research reported on measurement of dielectric properties, particularly in the millimeter wave frequency bands. Thus, most of the results obtained here are novel data, and have made possible accurate assessments of safety (i.e. assessments of energy absorption in the body upon exposure to radio waves).

Beyond human safety assessment, these dielectric properties of biological tissue can also be used for R&D in areas such as medical applications, so it is fundamental information with extremely high utility. Because of this, we intend to continue R&D in the future to measure and analyze in detail, the dielectric properties of a large range of biological tissues that comprise, for example, the brain, and to build the largest-scale database in the world in terms of number of tissues and frequency ranges.

* Mainly livestock byproducts were used (byproducts derived from production of meat from domestic animals)



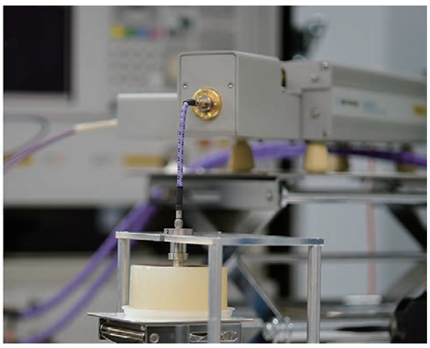


Figure 1 (left) Equipment for measuring dielectric properties in the quasi-millimeter and millimeter wave frequency bands. The equipment is suitable for measuring materials of approximately 100 mm in diameter. (right) Sensor equipment of approximately 10 mm in diameter. It is suitable for taking measurements with only a small amount of tissue.

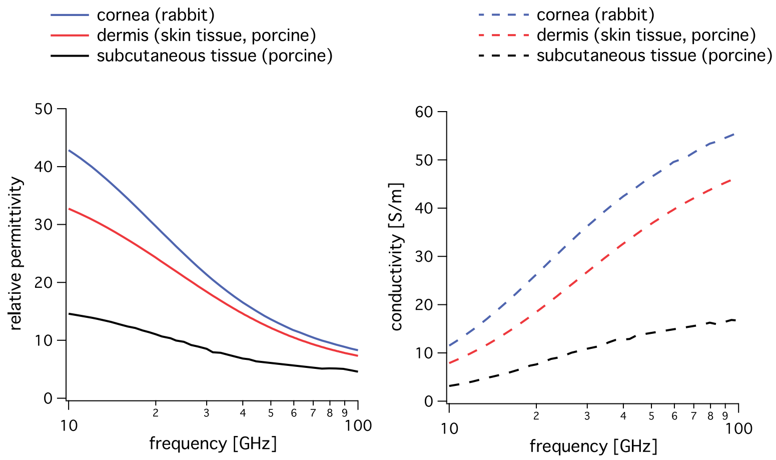


Figure 2 Measured dielectric properties of tissues (solid line: permittivity, dotted line: conductivity) Blue: cornea (rabbit), Red: dermis (porcine), Black: subcutaneous tissue (porcine)

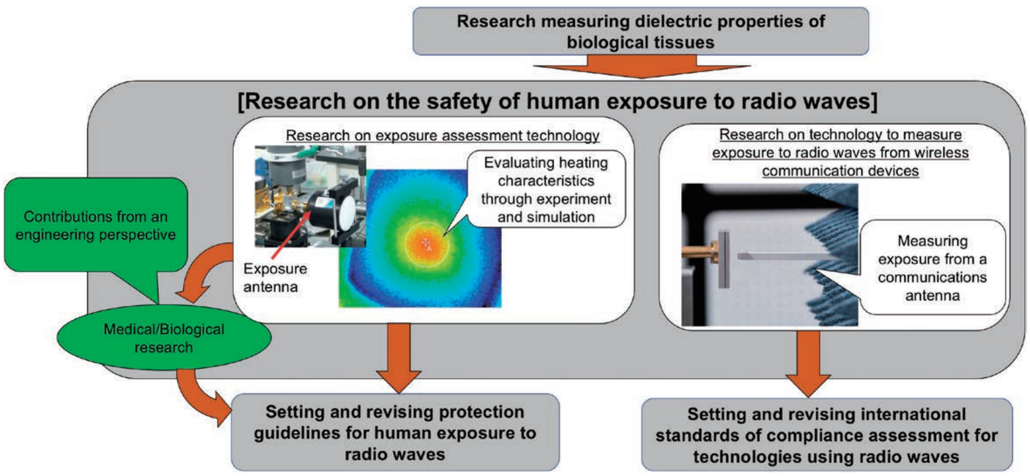


Figure 3 Applied Electromagnetic Research Institute initiatives in radio wave safety assessment research

Research on exposure assessment technology

Exposure assessment refers to the assessment of power density of the electromagnetic field incident on the human body, or the amount of effect induced in the body such as the amount of power absorption or the amount of heating caused. Almost of all energy is absorbed over the surface of the body at frequencies ranging from quasi-millimeter and millimeter frequencies, so heating caused by absorption of electromagnetic power by tissue is known to be a primary cause of biological effect. The Applied Electromagnetic Research Institute is promoting investigation and research on exposure assessment using a computational approach simulating energy absorption and heating characteristics inside the human body, and using experimental techniques that use human-equivalent phantoms to imitate the electrical characteristics of the human body (Figure 3).

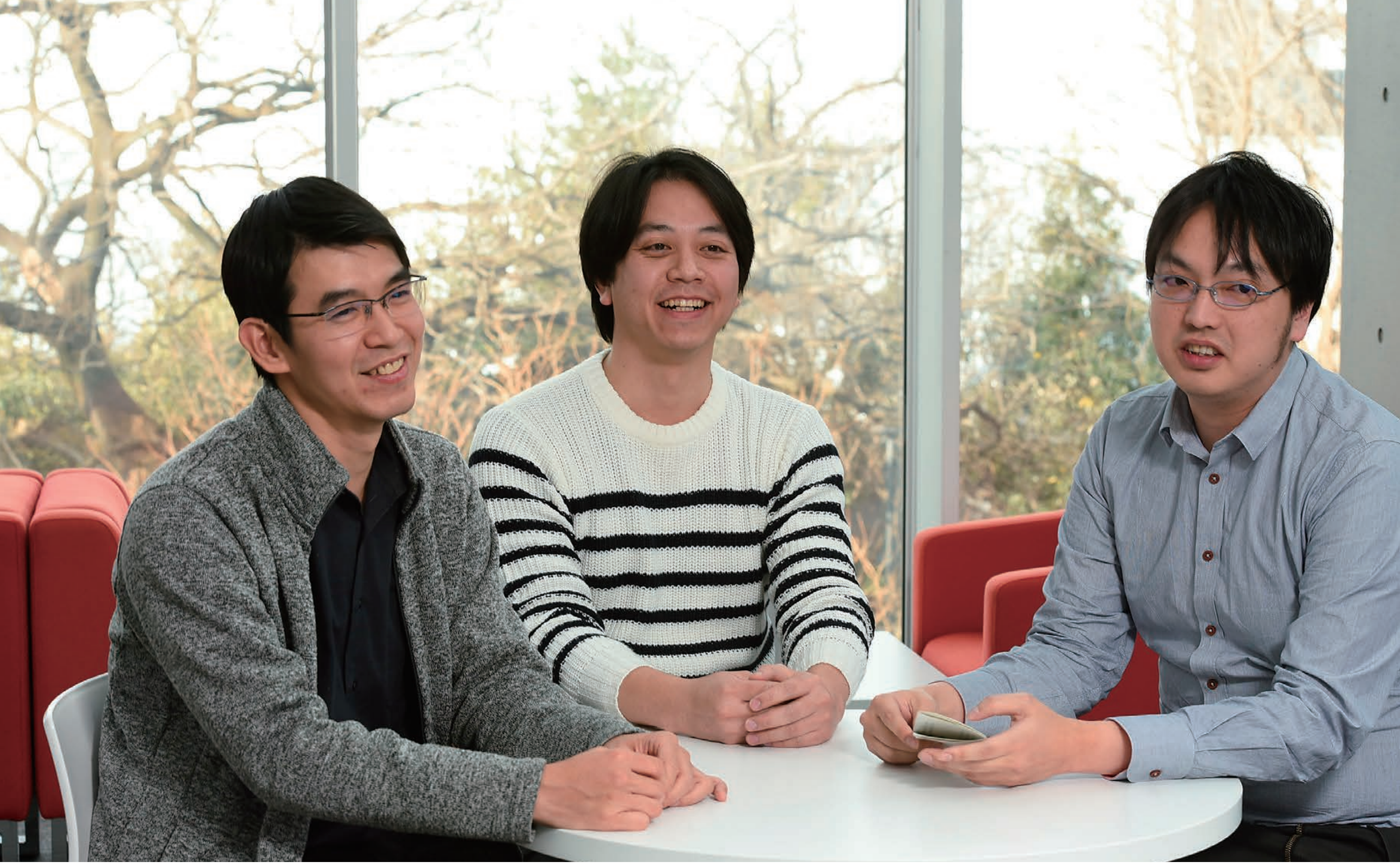
Medical and biological knowledge is also essential when assessing the biological effects of exposure to radio waves. The Applied Electromagnetic Research Institute conducts R&D in collaboration with medical universities and biological research institutes to research any medical or biological effects due to exposure to radio waves, such as inflammation from tissue heating due to exposure, or whether there are any biological effects caused by aspects other than heating. Within this collaborative research we contribute to promoting the research from an engineering perspective by developing equipment that enables highly reproducible testing and by conducting exposure assessment using that equipment.

There is still not enough scientific knowledge regarding the safety to humans of exposure to quasi-millimeter wave and millimeter wave frequency bands, and continued investigation and research is needed. Discussion is in progress to revise guidelines regarding these frequency bands at the International Commission of Non-Ionizing Radiation Protection (ICNIRP) and the Institute of Electrical and Electronics Engineers International Committee on Electromagnetic Safety (IEEE ICES), which are the organizations that develop these protection guidelines regarding exposure of humans. The Applied Electromagnetic Research Institute is contributing to creation and revision of guidelines for the safe and secure use of radio waves by contributing to international risk management activity with the results from investigation and research as described above.

Research activity ensuring the safety of new wireless communication technologies

When implementing new telecommunications technologies, exposure to radio waves from the actual wireless terminals and other devices must be measured accurately and assessed for compliance with policies.

Currently, discussion toward development of international standards for measurement of exposure to telecommunications devices using quasi-millimeter wave and millimeter wave frequency bands, including 5G systems, is in progress at the International Electrotechnical Commission, Technical committee 106 (IEC TC106). 5G system services are scheduled to begin in 2020 in Japan, so development of these international regulations is an urgent matter. NICT is participating in these standardization activities with IEC TC106 as an international expert partner, to establish international standards for the safe and secure use of new technologies using radio waves (Figure 3).



Special Interview: Views of Our Next-Generation Researchers

Allure of research that can only be done at NICT

What sort of activities are conducted at the Applied Electromagnetic Research Institute? What are your goals and aspirations for the future? We have three young researchers with us today who will help us understand the research activities discussed earlier on pages 4-9: Dr. Chakarothai JERDVISANOP (left), Dr. Ifong WU (center), and Dr. Kensuke SASAKI (right).

NICT's EMC technology: neutral leading-edge research

—How did you get involved in EMC research and what appealed about working at NICT?

SASAKI: At university, I studied electromagnetic field computation technology, then became interested in research on protecting human health risk by radio wave exposure. NICT is the only national research institute in Japan that has a division specializing in electromagnetic compatibility (EMC). I was particularly impressed by NICT's neutrality and its commitment to pursue state-of-the-art work in this field.

Basically, we approach research on human health risk by exposure from an engineering standpoint, but progress can be anticipated eventually by collaborating with other organizations in medicine and biology. This opportunity for collaborative research with other research institutes is a strong motivator and excites my interest.

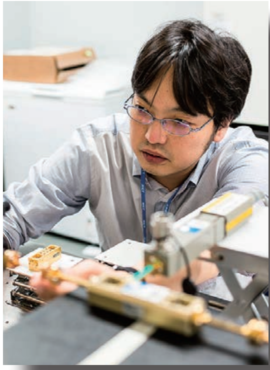
JERDVISANOP: After graduating from high school in Thailand, I began studying electrical engineering at a technical college in Japan in 1999, and then pursued wireless technology in a serious way at university and graduate school. I jumped at the opportunity when NICT was looking for engineers in wireless power transmission technology, and now I work here as a researcher.

Practical applications exploiting wireless power transmission might allow you to charge your electric vehicle while you are out driving around, or enable you to recharge your notebook PC without using a cable. At the same time, assessing and securing safety is also extremely important. I find this work very rewarding, but of course it also involves responsibility.

WU: There are many opinions on EMC fields that are low-key and have not been fully investigated, yet are extremely important. I took the job knowing that NICT would give me an opportunity to drill down and elucidate issues related to EMC. Here is a place where I could deal with the essential core of the matter and

Q: What are your outside interests? What do you do on your days off?

I like to play basketball on holiday (WU).



I'm the indoor type. I like nothing better than to work on workbooks for college exam takers (SASAKI).

Since coming to Japan, I've become an ***onsen*** fan. We take lots of family trips that mostly end up at an ***onsen*** or hot-spring resorts (JERDVISANOP).

satisfy my desire to pursue in-depth research. I also found it very appealing that the technology and knowledge of actual EMC obtained through research could benefit a range of other fields besides the area of EMC.

Forge ahead even in the face of adversity

—What attitude should the researcher bring to bear on research?

SASAKI: Never forget your early learning. That includes everything you learned in university, and all the diverse lessons learned when you first started at NICT. This is a perfect environment to sustain the growth of a young researcher, and the potential for the truly motivated researcher is practically unlimited. I think it is really important to take up and pursue this challenge with all one's heart.

WU: I took a lot of classes at university, but at the time I could not imagine how all these subjects could possibly help me in the years ahead. But then when I started doing research at NICT, it suddenly became clear that these diverse subjects were inextricably linked together. In my current job I am now taking full advantage of all the technical knowhow and expertise I learned at university to help me untangle thorny problems associated with EMC of IoT. It dawned on me that all those courses I took that seemed so superfluous at the time were not wasted after all.

JERDVISANOP: In the field of safety evaluation, change has come so quickly and there are still so many questions to be resolved that ongoing research is critically important. This requires tenacity and concentration.

As I continue to move forward with my own work, sometimes things do not go smoothly. When I run into one of these rough patches, I have to remind myself of never giving up in the face of adversity. Building on your efforts and accumulating knowledge will always stand you in good stead in the future.

Sasaki-san observed earlier that it will be beneficial to collaborate with other researchers in medical care and other fields, so it's extremely important that we accumulate as much information as possible so we have something to share and to exchange with others.

Vision of global growth and expansion

—What were you hoping to accomplish before you joined NICT? And what do you hope to achieve in the years ahead?

SASAKI: When I was a student, I remember being asked what I hoped to accomplish after I graduated, and now I would say I have largely achieved the goals that I set for myself in my student days during approximately the first three years after I joined NICT. I believe that I have been very fortunate in choosing an excellent career path for me personally.

WU: In order to overcome international competition and maintain top level research amid the progress of globalization, it is important to connect with human resources from an international perspective. I think that I could be very useful in helping forge stronger partnerships with researchers around the world, and in promoting more robust international competitiveness. In my current capacity as a researcher, I would like to challenge the unknown world as a specialist in this field, and conduct research that impresses and influences people around the world.

JERDVISANOP: After graduating from a university in Japan, I had options to work at various places around the country, but I chose NICT. Considering the rapid evolution of information and communication technology and the beneficial impact this is having on society, this was clearly the right choice for me.

Rather than designing and manufacturing products, my dream was to pursue more basic research on technology that would support these activities. Looking ahead, I think that I am finally getting a glimpse of how my path will continue to unfold in the years ahead.

Method, program, and system for generating computational human model having individual internal tissue structure

—Free deformation of the shape of voxel structure models—

NICT has developed a series of computational human models with anatomical features based on standard Japanese body types for assessing human exposure to radio-frequency electromagnetic fields (RF-EMFs) . The models are depicted in a standing position, but postures can be modified quickly and easily while keeping the internal structures of the figures. This permits simulations to be conducted easily for various postures and situations.

■Overview of the technology and application areas

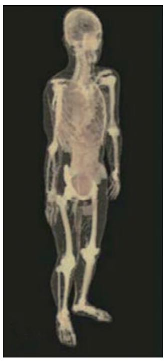
There is a variety of different human models ranging from computer-graphics (CG) animation to mannequins used for various scientific purposes, but relatively few models accurately representing the internal structure (skeletons, organs, etc.) of people. When using the human models to evaluate effects under different circumstances, we often need to assess the impact for different postures.

NICT developed computational human models with internal structure based on the standard Japanese physique, but the internal tissue and structure would get totally scrambled by merely changing the angle of the joints. To avert this potential problem, we came up with a technique to alter the stance or posture of the model by first extracting just the body surface data from the original voxel model (i.e., consisting of 2-mm-cube blocks). Next, we change the posture of the body surface data and convert it back to a voxel model. We are then able to alter the posture of the model including internal tissue and structure by filling out the changed surface data with the internal structure and adjusting the position of organs while checking against the original data.

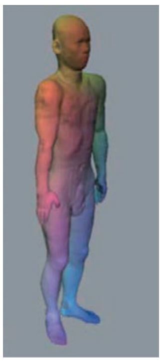
■Quest for uses, applications, and partners

The computational human model was developed to simulate and assess the safety of human exposure to RF-EMFs, however the model has enormous potential in combination with other technologies. For example, the model could be used to assess the impact of car crashes on passengers by setting elastic modulus at soft tissue sites, or it could be used to simulate radiotherapy for cancer or other disease patients by setting the absorbed dose. And the human model is not just confined to radio waves. It could just as easily be adapted for wireless technologies such as IoT that is now on the threshold of widespread deployment. Nor is the technique confined to human models, for it could be readily used to alter the stance or posture of a wide variety of animals as well. It is very likely that this technique will find many useful applications across a broad range of disciplines in the years ahead.

For further information about the model or associated technology, please contact our office shown below.



Voxel model
(Includes organs and other internal structures, but only bone and skin are colored)



Polygon mesh
(All internal structures have been deleted, leaving only the skin data)

Posture deformation
(Posture can be changed at will by bending joints)

Voxel model
(Internal structure configuration is adjusted through comparison with original data)

Figure: Example of posture deformation using the technology described

<Patent Information>

Patent No.: 5500683

Name of invention: Method, program, and system for generating computational human model having individual internal tissue structure

<Contact (Inquiries,etc.)>

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Going Global: Promoting Globalization of NICT Activities

Nozomu NISHINAGA, Managing Director, Global Alliance Department

As smartphones and other digital devices have become commonplace commodities, all sorts of ICT services have flowed one country to the next and now have become virtually ubiquitous the world over. Japan finds itself in an awkward situation with shrinking domestic markets as its population continues to decline, and thus cannot achieve robust growth by relying on the domestic market alone. Figuring out a way in which Japan can become a major player and compete on the world stage is thus a matter of the utmost importance.

Seeking to project NICT diverse activities around the globe, the Global Alliance Department is pursuing two key initiatives in Silicon Valley, the tech-centric brain pool and home base of the World's ICT industry.

The first initiative is to deploy NICT's research and development achievements overseas. Silicon Valley is home to many of the world's best-known ICT giants, an immense number of startups, and countless small early-stage emerging venture firms. But regardless of the company's size, Silicon Valley is the perfect setting for us to skillfully integrate our strengths and state-of-the-art technologies to create all new values and true innovation. With the goal of bringing NICT's R&D achievements to the eyes of stakeholders and the Silicon Valley community, we held two major exhibitions of NICT's latest technology in Silicon Valley during FY2016, one in July and the other in September.

The second initiative is to lend support to Japanese startups in establishing operations in global markets. For example, NICT carries out an ICT Venture Business Plan Contest that includes two components—*Entrepreneurs' Koshien* and *Entrepreneurs' Challenge*. Built on NICT's Mentor Platform, the program provides guidance to younger entrepreneurs regarding the fundamentals of business and helping them polish and refine their business plans. In FY2016, we offered demonstration space at the West Coast exhibition to some of the winners at previous *Entrepreneurs' Challenges* for small and medium-sized business owners, and organized a four-day Silicon Valley Boot Camp for students who took part in the last *Entrepreneurs' Koshien* (February 20-23, 2017). The boot camp gives students a deeper insight into entrepreneurial thinking and a direct on-site learning experience into how the venture ecosystem works in Silicon Valley. We posted a new column on the NICT ICT Venture Support Center website (http://www.venture.nict.go.jp/) that publishes regularly updated information about West Coast venture businesses.

Japan's ICT success—and that includes technology developed by NICT— will make a significant global contribution, so we remain committed to projecting our technology and operations into global markets. At the same time, this gives all of our stakeholders, everyone associated with NICT, ready access to the most innovative leading-edge information available in the world.

Top photo: Technology developed by Cyber Security Institute on demonstration at Tech Crunch Disrupt SF in September 2016. Bottom photo: Silicon Valley Boot Camp students discuss business chat operations with ChatWork CEO Toshiyuki YAMAMOTO.

Announcement of new President / Announcement of new organizations

New President

We are pleased to announce the inauguration of NICT's President, Hideyuki TOKUDA, on April 1, 2017.

(Professor, Graduate School of Media and Governance, Keio University /
Professor, Faculty of Environment and Information Studies, Keio University)

New Organizations

Two new organizations have been established under the Social Innovation Unit since April 1, 2017:

- National Cyber Training Center
- AI Science Research and Development Promotion Center

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