1 Introduction — Special Issue on Calibration and Testing Technologies for Radio Equipment

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As a background of the special issue, calibration and type-approval test services for radio equipment that have been provided by NICT are briefly described. An overview of research activities relating to the test and calibration services at NICT is presented including some future perspectives.

1 Introduction

Type approval test and calibration for radio equipment is a service with a long history behind it[1][2]. The type approval test started in 1935, when the legal system governing type approval testing was put into force (the service was initially provided by the defunct Electrotechnical Laboratory (Ministry of Communications)). Provision of calibration services for the measurement equipment used for wireless devices started in 1950 when the Radio Law was enacted (the service was initially provided by the defunct Radio Regulatory Commission (now included in the Ministry of Internal Affairs and Communications)). Both services were then transferred to the predecessor agencies of NICT — first to Radio Research Laboratory (established in 1952), then to Communication Research Laboratory — before they were placed under the management of NICT. The objective of the type approval test is to test and determine if radio equipment — especially those used for navigation and rescue works controlled by international treaties — satisfies the required functions and performance including resistance to the environment. The purpose of calibration is to determine the deviation of the readings of a measuring instrument from those of a standard instrument. Such a calibration is necessary to guarantee that the measured characteristics (power, frequency, bandwidth, and others) of electromagnetic waves emitted from radio equipment conform accurately to the given technical standard. Although the test and calibration services have been traditionally considered a part of administrative functions under the control of the Radio Law, a tendency toward transfer of these operations to the private sector or sharing of roles with private businesses is growing in step with wider introduction of private-sector initiatives and privatization into administrative domains — by the same token, NICT has become an incorporated administrative agency (a national research and development agency).

Against the backdrop of technology development and diversification, the market for these services is increasing without end: frequencies used for radio communication shift from quasi-millimeter-wave bands to millimeter-wave bands, even to the terahertz region, and the domains of Radio wave usage expand from television and radio to such new areas as mobile phones, wireless LAN, wireless power transfer (WPT) and onboard radar[3]. As the infrastructure technology that supports wider and diversified use of radio waves in future society, research and development on test and calibration technology of wireless applications is gaining importance. Therefore, even higher expectations will be placed on NICT for the research and development of test/calibration technologies that allow future expansion of radio wave applications (new wireless systems and wider frequency usage) as well as the domain of technology development that defies easy access from private enterprises.

Against the above-described backdrop, and at the start of the 4th Medium- to Long-Term Plan, a special issue is projected to cover the research and development of test- and calibration-technologies undertaken by the NICT Electromagnetic Compatibility Laboratory. This report provides an overview of calibration techniques used for measuring instruments and test methods of radio equipment, as well as the technology development related to them.

2 Calibration services and R&D of calibration technology at NICT

Figure 1 shows a conceptual diagram that illustrates how the calibration systems are organized in Japan. In this diagram, three color-coded segments each correspond to

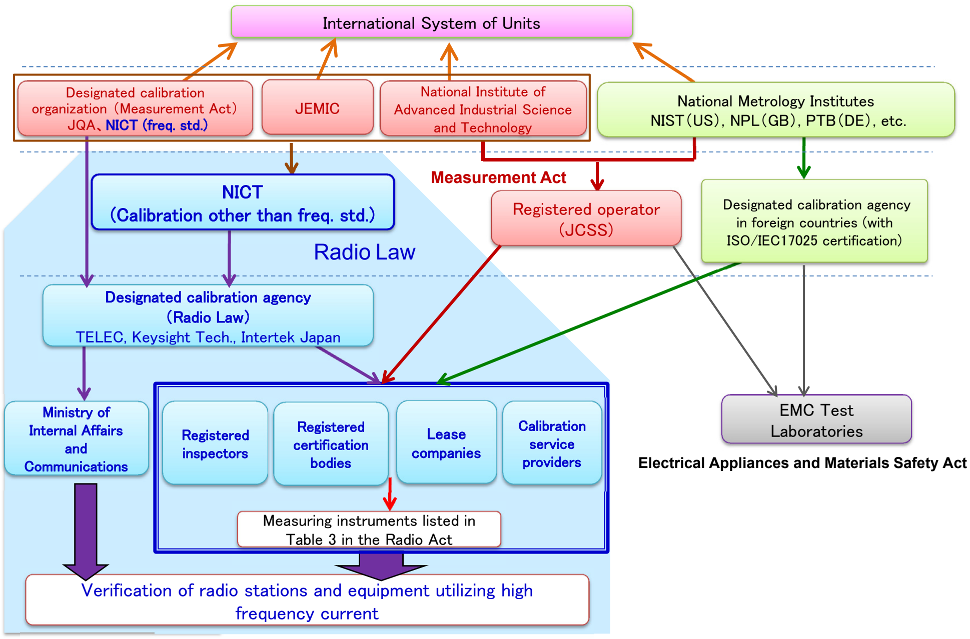

Fig. 1 Calibration systems for measuring instruments specified by Japanese Radio Law

different systems of calibration: the segment in aqua shows calibration based on the Radio Law, the segment in purple based on the Measurement Act, and the segment in lime green based on the traceability to the institutes outside Japan. Legal interpretation of the word "calibration" as defined by the Radio Law differs from that defined by the Measurement Act in some respects: typically, calibration as defined by the Radio Law includes adjustment of the measuring instrument. However, the calibration services now provided by NICT do not include adjustment procedures regardless of the governing laws.

The Radio Law stipulates that businesses that provide inspection of radio equipment (registered inspector) and those that provide technical regulation conformity certification (registered certification body) must use measuring instruments that have been calibrated by one of the accredited bodies (NICT and designated calibration agencies) within one year. The Radio Law also stipulates that the measuring instruments used by designated calibration agencies must be calibrated by NICT at least once a year.

In the Applied Electromagnetic Research Institute (AERI) of NICT, the Space-Time Standards Laboratory provides calibration of frequency standards, and the Electromagnetic Compatibility Laboratory provides calibration of other instruments/devices including frequency meters, high-frequency power meters, high-frequency attenuators, signal generators, spectrum analyzers, voltammeters, field intensity meters, antennas, and SAR (specific absorption rate) probes.

High-frequency power meters are further divided into sub-classes depending on the power and input impedance. Antennas need different calibration sites and methods depending on the frequency and bandwidth.

To cope with the large variety of calibration items as described above, NICT makes it the basic policy to promote transferring calibration items to private sector laboratories as far as technically feasible, and focuses its resources on two areas: calibration that is technically beyond the reach of private sector laboratories, and R&D of novel calibration technology based on the projected radio wave utilization into the future. The objectives of R&D efforts include, for example, the technology for antenna and power calibration in millimeter-wave bands: this technology is strongly needed because unwanted emission measurement up to 300 GHz will become compulsory (scheduled to start in 2022). Other examples include antenna calibration technology in the range below 30 MHz, which is assumed to be in high demand with wider dissemination of WPT systems, and uncertainty evaluation techniques used in various modes of calibration. Especially in millimeter-wave bands, as the size of the waveguide is reduced nearly to its lower limit, the effect of mechanical accuracy within and at the junction area becomes problematic from the viewpoint of measurement results. To establish the power standard in millimeter-wave bands, which is traceable to national standards, NICT is working now in research and development in cooperation with the National Institute of Advanced Industrial Science and Technology (the agency in charge of physical standards).

3 Type approval test service and research and development of testing technology for radio equipment

International treaties — administered by such organizations as International Maritime Organization (IMO) and International Civil Aviation Organization (ICAO) — stipulate that the radio equipment used in distress coping systems for securing human lives must have the capacity to maintain its rated function and performance even in harsh critical environments. This class of radio equipment must go through the type approval test assigned by the supervisory authority of each country. In Japan, the Ministry of Internal Affairs and Communications (MIC) is in charge of executing the type test to verify if the radio equipment satisfactorily meets the required technical standard as showin Fig. 2.

Precursor bodies to NICT (Radio Research Laboratory, followed by Communication Research Laboratory, until the current independent administrative agency NICT is established) were national institutes as a part of MIC in charge of executing the type approval test. After the reorganization into the current incorporated administrative agency in April 2001, the type test was assigned to NICT or other businesses certified by the Minister of MIC. Thus, until FY2015, NICT undertook the type test under the service contract with MIC. In FY2016, type test services are provided by a private sector company (Labotech International Co., Ltd).

In parallel with the above-described type approval test services, NICT is also conducting research and development toward improved measurement techniques. An example is unwanted emission measurement of radar systems. This process is determined to be performed complying with ITU-R recommendations[4][5]: spurious radiation actually emitted from an antenna is measured at the given frequencies — from 30 MHz up to 5th order harmonics for an S-band radar, and within the range of 30 MHz-26 GHz for an X-band radar (in the case of a waveguide-based system, the lowest frequency is set to the value 0.7 times the waveguide's cut-off frequency).

The spurious radiation measurement must be performed in the far field of the radar antenna (shipboard radar, a target of type approval testing, typically requires a distance from 100 to 400 m), necessitating an outdoor test site wide enough for securing the measurement distance easily, and with little fear of interference from background radio waves. As the features surrounding the test site may have an effect on radio propagation, the propagation characteristics of the test site must be evaluated in advance. In addition, the direction of maximum spurious radiation may not coincide with that of the antenna's main lobe at the fundamental frequency of the radar signal. Therefore, to measure a wide frequency range while rotating the radar antenna, the sequence of successive measurement is used as a basic procedure. In view of the length of time this measurement requires (shipboard radar will typically requires 20 hours or longer), our objective of technical development will be to accelerate spectrum measurement through the application of digital signal processing, while, at the same time, maintaining measurement accuracy and dynamic range.

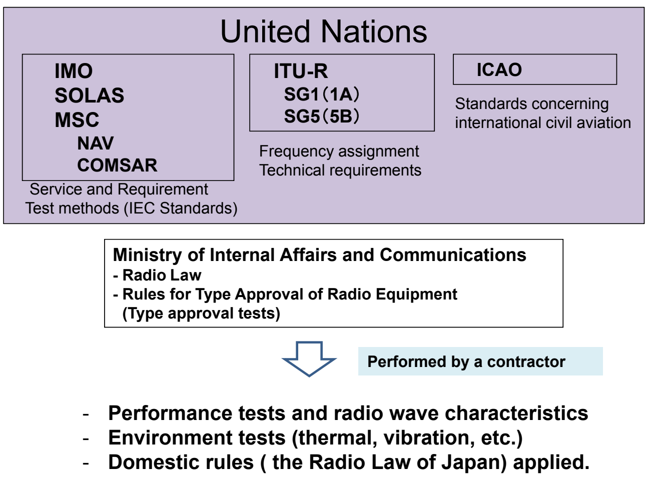

Fig. 2 Type approval test system in Japan

4 Summary

This special issue contains, in addition to the themes directly involved in technical development, many valuable materials whose detailed descriptions are often difficult in standard journals due to page-length limitations — e.g. the system overview of ISO/IEC17025, and the method to evaluate uncertainty. The author hopes that these materials will provide useful information in the future research and development efforts at NICT, as well as in the provision of test/calibration services and transfer of research results to the private sector.

References

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