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Anthropogenic EM Noise and EMC

E1 2009 International Symposium on EMC, Kyoto

EMC'09/Kyoto was organized by L. R. Koga, Okayama University, and was held in Kyoto at Kyoto International Conference Center, from June 20th to 24th, 2009. This was the sixth EMC Symposium in Japan, because they have been held every five years since 1984. Number of attendee was 409 from 21 countries, though the number was less than had been expected due to the Lehman Shock which prohibited financial support of attendees by their farms. Still many traveled with their own expense and enthusiastic discussions were held. Next conference is scheduled on 2014, so far, though the serious earthquake in North East district of Japan associated enormous Tsunami and Nuclear Power Reactor destruction makes its situation ambiguous mainly from the harmful rumour or misinformation in foreign countries.

E2 EMC measurement technology

The studies of EMI antenna and electromagnetic field probe calibration method, near field measurement techniques using electro-optical or magneto-optical crystal, etc, have been performed in this period. Detail descriptions are presented below.

E2-1. Electromagnetic field probes and near field

A high frequency carrier type magnetic field probe, which employs the principle of giant magneto-impedance (GMI) developed by the group of Akita Research and Development Center, was improved in the probe design, including a balanced circuit for increased signal to noise ratio and an on-probe magnetic-field bias circuit suitable for the measurement of time-domain transient current waveform [Zhou, *et al*., 2010a, 2010b].

New measurement technique on the radiated electric field using the principle of the modulated scattering technique (MST) has been developed with a small dielectric material probe. [Komakine, *et al*., 2009, 2010a]. The scattered electric field by the dielectric sphere was theoretically estimated to confirm the measurement factors which relate the sensitivity of the MST system.

To evaluate the permittivity of the material in high electromagnetic frequency range, several practical measurement systems were developed [Komakine, *et al*., 2010b]. Moreover, a frequency

domain analytical method has a possibility to detect the phase shift of the scattered wave caused by the dielectric loss.

A near field Poynting vector visualization system has been developed and applied to the measurement of energy flows caused by crosstalk on a coupled line and by radiation from a patch antenna as a demonstration. This is the first visualization of Poynting vectors that are evaluated with only experimental data in near-field regions [Suzuki, *et al*., 2008]. An optical scanning electromagnetic field probe system consisting of an optic crystal substrate and a galvano scanner has been developed for high speed, low-invasive measurement of electromagnetic near field distribution. Magnetic field distribution measurements above a microstrip line were demonstrated using several magnetic garnet crystal substrates and the probe system [Ota, *et al*., 2008], [Adachi, *et al*., 2008, 2009, 2010], [Takahashi, M., *et al*., 2009, 2010], [Ikenaga, *et al*., 2009, 2010].

E2-2 Antenna factor of EMI measuring antennas

Radio disturbances emitted from electronic equipment have been measured with an EMI antenna, where the disturbance level is expressed in terms of the electrical field strength. In practical measurements, it is given by multiplying the received voltage by the antenna factor of a measuring antenna used. Since the antenna factor can be derived from the actual gain of the antenna under calibration, calibration methods of the actual gain have been developed in the frequency range above 1 GHz in order to improve the accuracy of EMI measurements:

(1) The gain of pyramidal horn and double-ridged guide horn antennas is determined using the three-antenna method by considering the phase center, and the uncertainty of measurement is estimated. The results show that by considering the phase center, accurate gain measurement can be performed at a reduced distance [Harima 2008a, 2009a, 2009b, 2010a, 2010b]. (2) A novel calibration technique in random electric fields was developed [Harima 2008b]. (3) Application of the in-phase synthetic method has been investigated to reduce a reflected wave from the ground plane and objects around the calibration test site for a double-ridged guided antenna [Fujii, *et al*., 2010].

E2-3 Calibration of electromagnetic probe

Electric field probes with three orthogonal elements are calibrated from 1 to 6 GHz by the standard field method in an anechoic chamber [Wu, *et al*., 2009a]. To improve calibration quality and determine the factors affecting calibration, uncertainty in the calibration factors is also investigated. The electric field probes are then calibrated in a GTEM cell from1 to 6 GHz using the reference antenna method [Wu, *et al*., 2009b]. The GTEM cell is as effective as the anechoic chamber for calibrating electric field probes with the same type of probe. When calibrating electric field probes with different type and size, it is important to place the probe in an area with good uniformity or maintain the uniformity of the electric field in the GTEM cell [Wu, *et al*., 2010].

E3 Printed circuit board (PCB) and chip level EMC

Many studies on radiated and conducted emissions related to PCB and integrated circuits

(ICs) , simulation of undesired electromagnetic couplings on PCB, EMI simulation, EMC design, EMC modeling, immunity modeling, design tools, etc, have been performed in this period. Detail descriptions are presented below.

E3-1 Coupling and crosstalk modeling on PCB

Simplified interference coupling model was proposed to evaluate crosstalk between transmission lines on a PCB [Araki, *et al*. 2008]. The main part of the circuit model is evaluation of the distribution of mutual capacitance, and lumped mutual capacitance was expressed using an error function. Coupling between microstrip lines on adjacent layers in a multi-layer printed circuit board was also expressed with a circuit-concept approach based on modified telegrapher's equations [Park, *et al*. 2009]. This approach was extended for the time-domain analysis by using the inverse Laplace transform (ILT), and applied to the evaluation of distortions in the output waveforms of meander delay lines due to the crosstalk [Xiao, *et al*. 2009]. Not the Fourier-transform, but the ILT leads to an analytical expression, so that the calculation efficiency is good.

E3-2 EM radiation from cables and transmission lines on PCB

To evaluate the influence of contact degradation of a connector to radiated emission (RE), a connector model for a coaxial cable was investigated and near-field around a cable was evaluated [Hayashi, *et al*. 2009]. EM emission from UTP cable was calculated by the Moment Method from 0.3 GHz to 2 GHz and compared with the results by the 4-port network method [Kuwabara, *et al*. 2009].

Evaluation method of RE above 1 GHz was proposed for a PCB driven by a connected feed cable [Kayano, *et al*. 2009d]. The results show that far-electric field due to common-mode (CM) dominates the total radiation at lower frequencies, and differential-mode (DM) is the dominant component above 3 GHz. The same authors investigated experimentally and numerically basic left hand mode transmission line (LH mode TL) characteristics made on PCB with a folded-stepped impedance resonator (F-SIR) [Yanagisawa, *et al*. 2010b]. Some backward propagation characteristic and negative group delay was observed.

E3-3 Simulation of undesired noise from PCB

A new switching converter model was proposed for analyzing the generation mechanism of ringing ground leakage (GL) current[Intachot, *et al*. 2010]. An unbalanced converter (half-bridge converter) and a balanced converter (full-bridge converter) for bidirectional D.C. motor drive were used as examples, and good agreement was obtained with the numerical analysis results in terms of the minimum or maximum peak currents and the ringing frequency.

Current distribution on a 2-layer PCB with lumped circuits was estimated by measuring the near electric field [Kato, *et al*. 2008]. Current estimation model was made without considering the electrical parameters of lumped circuits, and experimental and numerical results confirmed the

validity of the method.

Information leakage due to RE from IT devices such as personal computers and smart cards has been investigated. By some experimental results of Tempest, example estimations of amount of information leakage were shown [Tanaka, 2008]. Using the value of channel capacity, the amount of information per pixel in the reconstructed image was calculated, and the effectiveness of Tempest fonts generated by Gaussian method and its threshold of security were evaluated.

E3-4 Common-mode radiation from PCB

Common-mode (CM) radiation is one of the major sources of RE from a PCB and cables. Effective method for evaluation of CM generation was proposed, which is the imbalance difference model (IDM), and some applications and extensions were published. To reduce the CM radiation, guard traces (GT) placed near signal lines are effective, but evaluation of design was a problem. The imbalance difference model (IDM) was applied to evaluate the suppression of CM radiation by a guard trace on a PCB[Matsushima, *et al*. 2009a]. The current division factor (CDF), which represents the degree of imbalance of a transmission line, is the key parameter in the IDM. Experimental results showed that the maximum reduction in common-mode radiation was about 14 dB achieved by placing guard traces on both sides of a signal line. Possibility of CM reduction of about 25 dB was also shown.

Guard traces are usually connected to a ground plane by via-holes. When interval of the ground connection is not short enough, a guard trace can resonate and it may cause increase of CM generation. The authors show the increase of CM radiation adopting the IDM, and additionally they proposed the effective via location of the guard trace to reduce the number of vias [Matsushima, *et al*. 2009b]. Another technique to suppress the CM increase due to GT resonance was proposed [Watabnabe, *et al*. 2010]. By matching the impedance at both ends of a GT, the resonance is suppressed. Particularly, it was shown that "matched termination at the far end of the guard trace" is effective, and at least two vias at both ends of a guard trace and only one matching resistor at the far end suppress the guard-trace resonance.

The IDM was extended to apply to differential transmission lines [Matsushima, *et al*. 2010], which evaluate asymmetric property of differential transmission lines such as ones placed close to an edge of a ground plane. The authors defined a primary common mode and a secondary common mode, and showed that the secondary common mode is dominant in radiation.

E3-5 EMC design of power distribution network on PCB

Controlling the property of power distribution network (PDN) on a PCB is an issue of power integrity (PI) in one sense. In recent years, it has been well recognized that degradation of PI, which means unstable power and ground voltages, causes signal integrity (SI) problems and also EMC problems.

On EMC control in automotive application, power distribution circuit model was improved to

simulate common-mode noise reduction for in-vehicle digital electronic equipment in an actual instrument design [Uno, *et al*. 2010]. Using an EMC macro-model, LECCS, of an LSI, noise reduction technique for common-mode on a wire harness was investigated, and an optimization algorithm for designing PDN was proposed. To optimize PDN on a PCB of an electronic control unit (ECU) for automotive, parallel processing for reducing electromagnetic interference (EMI) was proposed [Okazaki, *et al*. 2010]. Simulated annealing (SA), genetic algorithm (GA) and taboo search (TS) were applied to seek optimal solutions, and a SPICE-like circuit simulator to analyze common-mode current.

Another issue on PDN noise control is the ferrite cores. Evaluation method of noise reduction effect of ferrite cores was proposed for the frequency range of 30 to 100 MHz [Urabe, *et al*. 2008]. Measurement method was proposed and its theoretical expression was induced. For noise reduction design in PDN for an LSI in quad flat package (QFP), a pi-type decoupling circuit consisting of two capacitors and a power trace was proposed and improved design with reduced number of capacitors was discussed [Sasaki, *et al*. 2009].

A novel approach to suppress noise propagation in PDN is the electromagnetic band-gap (EBG) structures. A new EBG structure adopting open stubs into the shunt circuits was proposed [Toyao, *et al*. 2010], and highly suppression of noise propagation over the frequency range of 1.9-3.6 GHz including the 2.4-GHz wireless-LAN band was experimentally demonstrated with a unit cell size of 2.1 mm. Similar idea was tried by Matsumoto, K. *et al.* forming a band-eliminating filters along a transmission line on PCB.

E3-6 Modeling of EMC characteristics of digital IC/LSI

To simulate EMC characteristics of digital ICs and LSIs, macro-models such as ICEM-CE and LECCS models have been proposed. In recent years, these models have been improved to express high-frequency characteristics including internal and external parasitics.

For signal integrity (SI) simulation, the most common macro model is the input/output buffer information specification (IBIS). However, it does not include enough information of PDN and can not handle well the power supply voltage/current simulation. On the other hand, the LECCS model does not express I/O characteristics. In this context, a new modeling technique was proposed [Oka, *et al*. 2009][Oka, *et al*. 2010], which combined the LECCS and IBIS models, and achieved accurate simulation.

The LECCS model itself has been improved to express noise characteristics of LSI having multiple power-supply pins[Iokibe, *et al*. 2010]. The internal parasitic coupling between blocks in an LSI was also evaluated and modeled [Saito , *et al*. 2010]. Those models were applied to practical circuit boards such as automotive ECUs [Mabuchi, *et al*. 2010].

As a related field of research, more precise noise modeling methods have been developed. A fast calculation tool for state-dependent capacitance of power distribution network (PDN) was proposed [Hagiwara, *et al*. 2010]. The method achieves linear time-complexity, which can be more

than four orders magnitude faster than a conventional SPICE-based capacitance calculation. With its calculation efficiency, the proposed modeling tool facilitates to build an accurate macro model of an LSI. In time-domain, clock skew and jitter were evaluated with a new timing verification method that takes into consideration delay variation inside a clock network due to both manufacturing variability and dynamic power supply noise [Enami, *et al*. 2010]. The proposed method is applied to industrial designs in 90 nm process, and it shows good estimation of dynamic delay.

Electromagnetic immunity in LSI circuit operation was also evaluated with a macro-model [Ichikawa, *et al*. 2010]. EM power injection to a power-supply system leads to malfunction, where the power is translated into voltage bounces, affecting power supply and ground, as well as signal nodes in a die, seen from on-chip waveform measurements. Based on measurement, a lumped power-supply impedance model was derived and the minimum amplitude of voltage bounce induced by EM power for malfunction was evaluated. The formulated EM interference model is helpful in the PCB design toward high immunity.

E3-7 Co-design and co-simulation of IC/LSI and PCB

In high-speed and high-frequency application, parasitic coupling between a package of IC/LSI and PCB degrades noise characteristics. Simultaneous Switching Noise (SSN) for the combined system of the package with the 4-layer Printed Circuit Board (PCB) was evaluated [Takahashi, N., 2009], including coupling between the package and the board.

Power and ground planes on multilayer PCBs can effectively radiate electromagnetic fields excited by the IC simultaneous switching noise. Usually the attention is focused only on the differential-mode current of the package pins, but it was shown that parasitic capacitance between a package and PCB forms a common-mode current path and it excites the power bus noise [Paoletti, *et al*. 2009]. With the proposed equivalent circuit, it was shown that the effectiveness of decoupling inductors is strongly dependent on their location.

E3-8 EM disturbance to digital wireless communication

EM disturbance to digital communication systems is essentially different from that to analog systems. Bit error rate (BER) or packet error rates (PER) is not directly related to the conventional EM noise spectrum, but related to statistical parameters in time-domain. PER in wireless-LAN mounted on a printed circuit board was evaluated and a mechanism of electromagnetic noise coupling affecting the PER was discussed [Iwanami, *et al*. 2010]. The authors utilized the amplitude probability distribution (APD) to investigate the noise coupling channel. With measurement of the magnetic near-field distribution, they confirmed that noise radiates from a power supply system of a digital circuit and its coupling to a receiving antenna causes an increase of the PER.

To estimate the impact of electromagnetic disturbances on multi-carrier wireless systems, a method for converting an amplitude probability distribution (APD) of disturbance measured at a frequency to be valid for another frequency was presented [Matsumoto , *et al*. 2008]. The conversion

uses two parameters, the receiver noise power of the APD measuring equipment and a scale factor that can be estimated from a measured disturbance spectrum. The validity of the proposed method is examined by measurements of actual disturbances.

An equivalent circuit model for predicting EM radiation from a PCB was proposed and demonstrated [Kayano, *et al*., 2009a 2009b, 2009c, 2010a, 2010b]. The equivalent circuit model is based on consideration of the concept of Common Mode (CM) antenna impedance and distributed constant circuit to the mechanisms of current- and voltage-driven.

The frequency responses of the EM radiation from a PCB driven by Low Voltage Differential Signaling (LVDS) were identified by using three EMI-antenna models [Kayano, *et al*., 2008c, 2009d, 2010d]. EM radiation is modeled and analyzed as three kind of EMI antennas, a loop type due to the signal current flowing on the paired lines, the ground plane and cable for a dipole type antenna due to a common-mode current flowing along the PCB with cable, and the trace on the ground plane for the loop-type antenna due to the signal current.

To clarify the electromagnetic compatibility (EMC) problems that related to the interconnection in the IC chip, transmission characteristics and electromagnetic coupling between wirings in the specially designed model transmission lines in IC chip were investigated by experiment and simulation [Kayano, *et al*., 2008a, 2009e]. Model transmission lines, implemented in the bear chip, were designed as model parallel transmission lines. The decrease of transmission coefficient and the significantly large far-end cross-talk are thought to be enough to cause serious errors arise at gigahertz frequency band.

Basic left hand mode transmission line (LH mode TL) characteristics made on PCB and the possibility of a LH mode TL characteristic made by a folded-stepped impedance resonator (F-SIR) type are investigated experimentally and numerically [Yanagisawa, *et al*., 2009, 2010a, 2010b; Kayano, *et al*., 2010]. Some backward propagation characteristic and negative group delay can be made by F-SIR structure.

E4 EMC problem related telecommunication system

E4-1 APD measurement

Measuring the amplitude probability distribution (APD) of a disturbance has been shown to be a promising method of defining emission limits for protecting digital wireless services. It was demonstrated that degradation in sensitivity of digital TV tuner due to intrasystem interference was successfully estimated by means of multichannel APD measurement [Gotoh, *et al*., 2008]. Moreover, an APD measuring system has been developed by using FFT to realize a simultaneous measurement in 8192 channels [Gotoh. *et al*., 2010a]. For establishing APD based emission requirements, an expression for estimating the BEP from a disturbance APD for multilevel digital modulation schemes was theoretically developed with the conditions for applying it [Matsumoto, 2008a]. The expression was extended for a BPSK system with error correction coding interfered with a class A noise [Matsumoto, *et al*., 2008a,

2009a, 2010a]. A method and its applying conditions were developed and demonstrated for converting a disturbance APD measured at one frequency to be valid for another frequency [Matsumoto, *et al*., 2009, 2010b].

E4-2 UWB (Ultra wide-Band) systems

A new method has been proposed and demonstrated for evaluating the interference between the UWB and the wireless LAN by using the GTEM cell that can test the receiver with the antenna built-in type in a case where the UWB signal is multiband orthogonal frequency-division multiplexing (MB-OFDM) [Kamiya, *et al*., 2008]. In addition, the separation distances in regulation limits of FCC and Japan are evaluated using the method. The measurement results for the amplitude probability distribution (APD) of the interfering UWB signal were also discussed. [Ishigami, *et al*., 2008]. The results of the evaluation of the interference between a direct-sequence spread-spectrum UWB (DSUWB) system and an IEEE 802.11a wireless LAN by a GTEM cell using the proposed method are reported. Furthermore, the APD of the DS-UWB signal was measured at each subcarrier frequency of the victim IEEE 802.11a signal. The measured APDs were used to calculate the throughput of the IEEE 802.11a wireless LAN. These results were compared with the throughputs measured by the proposed method [Ishigami, *et al*., 2010].

E4-3 Interference from PCs employing spread spectrum clock systems

Recent electronic appliances, such as PCs (personal Computers) peripheral devices, game devices, etc., usually employ SSC (Spread Spectrum Clocking) by the frequency modulation of clock signals to reduce the peak spectral amplitude of their radiating clock harmonics measured in the compliance tests. However, this technique does not actually reduce the total radiating noise power. The effects of SSC on an OFDM UWB system was analyzed [Matsumoto, *et al*., 2010c], and it was found that SSC had no interference mitigation effects on the transmission performance of the system even though it apparently reduces the spectral amplitude of radiating noise.

E4-4 EMC problem related PLC (Power Line Communication) system

The attenuation effect of a reinforced concrete wall of a building on the electromagnetic (EM) field generated by an indoor power line communication (PLC) system is numerically investigated at a distance of 10 m from the single, finite-sized wall [Wu, *et al*., 2009]. The attenuation of the EM field asymptotically approaches a constant value when the wall is over 15 m long. The relation between the attenuation effect of the single-wall model and that of the house model is also investigated. It is found that the attenuation effect of the house model is almost the same as that of the 15-m-wall model. This suggests that evaluation of the attenuation of the EM field using a single wall model instead of a house model is effective.

E 5 EMC test facilities

The studies of test methods using rotating electromagnetic fields, correlation between GTEM cells and anechoic chambers, evaluation methods of reverberation chamber, etc, have been performed in this period. Detail descriptions are presented below.

E5-1 Immunity/susceptibility test method

To obtain the radiated RF immunity/susceptibility characteristics of electronic equipment in detail, a new test method using a modulated electromagnetic field with low-speed rotation (modulated rotating-EM field) was proposed by Prof. Kami's group. It became possible to find the immunity/susceptibility-weak points of the equipment by using the RF-pulsed rotating-EM field. Moreover, it was clarified that complex EM fields, such as the EM noise generated by Spread-Spectrum Clocking (SSC), can be experimentally simulated by using the rotating FM-EM field [Murano, *et al*., 2008, 2010].

E5-2 GTEM Cell

A GTEM (gigahertz transverse electromagnetic) cell is used for immunity and emission tests. A calibration method of an electric-field probe using a GTEM cell with a monopole antenna, of which method is not a gain transfer method that is conventionally reported in a case of a GTEM cell, is proposed [Ishigami, *et al*., 2009]. The basic standard of a TEM waveguide including GTEM cell for the immunity and emission tests was improved and released in 2010. A description of the new calibration method is added in the standard.

E5-3 Reverberation chamber

A new application for determining antenna gain with a reverberation chamber was developed. This method exploits the statistical characteristics of complex electric fields in multipath environments, i.e. averaging the complex received value eliminates the reflected waves with random phases [Harima 2008b].

E6 EM Wave Absorbing and Shielding Materials' Design

EM-wave absorbers, shielding sheets and gaskets have been widely used to block undesired interferences. Recently, the absorbing/shielding materials have been developed based on new ideas.

For the automotive radar (around 75GHz), absorbers produced by the traditional smoking roof-tile sintering process have been proposed [Hatakeyama *et al*. 2008a,b, Nakamura andYamamoto *et al*. 2010]. This type of absorbers placed along roads can absorb emission from radars mounted on cars to eliminate the false echo in the radar receiver. Since they are manufactured by the "roof-tile process", the absorbers possess a very good durability for the out-door use.

By using artificially designed dielectrics such as wire-array sheets, wire-grid planes, new methods have been proposed in an absorbing/shielding materials' design. Thin-flat absorbers

showing a wide absorption frequency range have been developed by using a resonance in permittivity of a wire-array sheets [Hatakeyama *et al*. 2010]. Frequency selective shielding screens and reflection-transmission control screens, which show total reflection at particular frequency while at another frequency total input energy can transmit through the screens. These devices are developed by combining several artificial dielectric layers having different resonant frequencies, or by piling a dielectric sheet up on an artificial dielectrics having negative permittivity [Tsutaoka *et al*. 2010, Iwai *et al*. 2010, Kasagi *et al*. 2010].

In order to suppress the undesired electromagnetic radiation from a PCB, new PCB structure and shielding technique, Noise Suppression Sheet (NSS), and some effect of on EM radiation from a PCB driven by a connected feed cable are investigated with FDTD modeling and experimental studies [Kayano, *et al*., 2008d], [Kasuga, *et al*., 2009]. At lower frequency, CM current and near field in the "with NSS" case are larger than that of "without NSS (PCB only)" case. In addition, increment of EMI due to the NSS in the Surface-MSL structure case is larger than that of Embedded-MSL structure case.

EM radiation through aperture of metallic enclosure with a PCB inside was investigated by experiment and calculation [Miyata, *et al*., 2008]. It was demonstrated that PCB placement influences directivity, strength and resonance of EM radiation from aperture of the enclosure.

For the improvement of the analytical method on the very narrow to wide space, FDTD-Multi Analysis Space (FDTD-MAS) calculation method was expanded. Good agreement in the engineering accuracy is obtained for the electromagnetic analysis to use surrounding large objects [Kasuga, *et al*., 2009].

E7 Electrostatic Noise(ESD) and Gap discharge

E7-1 ESD measurements and ESD phenomena

A Method for estimating wideband transients of ESDs waveform using transmission loss of high performance semi-rigid coaxial cable was proposed by experimental and theoretical study [Kawamata, *et al*., 2009]. (2) Spark-resistance formula for electromagnetic fields due to spark between charged metal bars with ferrite core attachment was examined using the FDTD simulation method [Fujiwara, *et al*., 2009]. (3) Estimation and validation of electrical breakdown field due to approach of hand held metal from charged human body was investigated by experimental and theoretical study [Taka, *et al*., 2010]. (4) One of a relationship between radiated electromagnetic field intensity and electrode condition due to micro gap discharge was examined experimental study [Kawamata, *et al.*, 2010b]. (5) The potential gradient was estimated using from discharge current through hand held metal piece from charged human body. The corresponding potential gradients

were estimated, which were validated in comparison with the Paschen's law and other researcher's experimental results [Taka, *et al*., 2010]

For the improvement of the analytical method on the very narrow to wide space, FDTD-Multi Analysis Space (FDTD-MAS) calculation method was expanded. Good agreement in the engineering accuracy is obtained for the electromagnetic analysis to use surrounding large objects [Kasuga, *et al*., 2009].

E7-2 ESD immunity test concerned with the IEC test method

One of a method for immunity prediction technique due to conducted ESD current proposed to the early design on PCB (printed circuit boards). Validity of this method was confirmed in experimental study [Shiraki, 2010]. (2) A method for immunity testing less dependent on arrangements of equipment under test in contact discharge of ESD Gun onto vertical coupling plane was proposed as a new method [Yamamoto, *et al*., 2010]. (3) One of a severity evaluation of the IEC immunity test against ESD was discussed based on wideband measurement of discharge current waveform [Mori, *et al*., 2010]

Special session of "ESD and Transients" was organized by Prof. Pommerenke, Prof. Fujiwara and Prof. Kawamata in the 2010 Asia-pacific International Symposium on Electromagnetic Compatibility. In the Special session, (1) the influence of the electrode surface condition upon electromagnetic field radiation due to micro-gap discharge was examined by experimental study [Kawamata, *et al*., 2010a]. (2) ESD phenomena of magnetic head impressed 1 ns pulse ESD was posed a problem [Ohtsu, *et al*., 2010]. (3) Effect of Shapes of metal electrodes on ESD Current and radiation noise was arranged by experimental and theoretical study [Yoshida, T. *et al*.].

Oral session of "Lightning and discharge in EMC" was organized by Prof. Qie and Prof. Kawamata in the 2010 Asia-pacific Radio Science Conference. In the session, five lightning papers and one ESD paper were presented. (1) Measurement result of radiated electromagnetic field intensity due to micro gap discharge was examined using wide band experimental system and spherical electrode. The amplitude properties of radiated electromagnetic field intensity were discussed by experimental study. [Kawamata, *et al*., 2010c].

E7-3 EM radiation from an Electric Contacts

To clarify the mechanism of the generation of electromagnetic noise, current and radiation noise up to the GHz band originated by slowly breaking silver-compound contacts were investigated experimentally with and without external direct current (DC) magnetic field [Inoue, *et al*., 2008, 2010; Kayano, *et al*., 2008b, 2010e].

The experimental results on $AgSnO_2$ material newly revealed that although applying external DC magnetic field is effective in reduction of duration of gaseous phase in arc discharge,

higher variation of contact voltage in the gaseous phase which results in high frequency noise is caused. There are two kinds of rapid changes, which cause high-frequency EMC problem, in the voltage waveform. One is at extinction of arc discharge. Others phenomena is short-duration arc (short-arc) before the ignition of the continuous metallic arc.

Natural EM Noise

E.8 Lightning

The followings are carried out by Z. Kawasaki's group. Akita *et al*. [in press] conducted observation campaign in Australia and found that the Cloud to Ground (CG) and intracloud (IC) flashes were initiated from the outer and the inner parts of the upper side of the graupel regions, respectively. In the cases of CG flashes, the negative leaders traveled first about ten kilometers horizontally through positive charge regions and then began to bend toward the ground when they reached the end edge of the positive charge regions where there were no graupel region underneath. In contrast, in the cases of the IC flashes the negatively charged graupel regions block the downward developments of negative leaders.

In Yoshikawa *et al*. [2010a], the raindrop size distribution DSD in the lower atmospheric boundary layer (ABL) is retrieved using Ku-band broadband radar (BBR) having an observational range of 50 m to 15 km, and a high range resolution of several meters and a 3dB beam width of 3 degree. While the DSD reveals no significant change in the stratiform event, the growth process increases about 2 times in the number of raindrops larger than 0.5 mm in diameter in the convective event.

In Yoshida, S., *et al*. [2010], upward positive leaders (UPLs) in two artificially-initiated lightning flashes were imaged in three dimensions using VHF broadband digital interferometers and a high-speed video camera with time synchronized channel base current measurements. Locatable VHF sources of the two UPLs began at 1.1 km and 1.5 km, a few milliseconds after the UPL inception, and ascended to 2.4 km and 3.7 km, respectively, with average 3D speeds on the order of 106 ms1.

In Akita *et al*. [2010a], as a result of the VHF observations during the 2006–2007 monsoon season in Darwin, Australia, cloud flashes accompanied by K processes are clearly imaged in three dimensions with high time resolution. In the late stage of the cloud flashes, negative recoil streamers accompanied by K changes propagate along the same channels as that of preceding negative breakdowns in the early stage. The speeds of the negative recoil streamers are 2 orders of magnitude faster than the preceding negative breakdown.

Akita *et al*. [2010b] conducted observation campaign in the coastal area of the Japan Sea using VHF broadband digital interferometers during winter, and observed a bipolar flash that transferred both positive and negative charge inside thunderclouds. In the flash, a subsequent negative leader was initiated from the proximities of the initiation points of the preceding negative stepped leaders. The bipolar lightning flashes observed in this campaign transferred positive charge after lowering the negative charge to the ground.

In Yoshikawa *et al*. [2010b], a new high-resolution Doppler radar, called Ku-band broadband radar (BBR), with fast scanning capability for meteorological application has been developed. Due to the new system design, the BBR can accurately measure the radar reflectivity factor with a range resolution of several meters and a time resolution of 55 s per volume scan from the nearest range of 50 m to 15 km for 10W power using pulse compression. In this paper, the basic concepts, configuration, and signal processing of the BBR are described.

In Yoshida, S., *et al*. [2009a], coincident data from the precipitation radar and the lightning imaging sensor aboard the Tropical Rainfall Measuring Mission satellite are used to examine the correlation between the number of lightning flashes per second per convective cloud (NFSC) and the cold-cloud depth. The cold-cloud depth is defined as the height from the melting level, which is the altitude at 0 degree, to the storm height. It is found that the NFSC is approximately proportional to the fifth power of the cold-cloud depth. In addition, it should be noticed that the relationship does not have regional dependencies.

Nakamura and Yoshikawa *et al*. [2009] proposed a high-resolution precipitation and lightning monitoring for meteorological application with a Ku-band broadband radar (BBR) and a VHF broadband digital interferometer (DITF). The BBR measurer radar reflectivity factor and mean Doppler velocities with 5 m resolution over a rave from 40 m to several kilometers.

Lightning channels are imaged in 3D with a use of two or more DITFs. The initial observations for severe storms involving lightning during both summer and wither thunderstorm seasons indicate that we estimated precipitation distribution in detail and detected active convective cells with lightning discharges.

Nakano *et al*. [2009] examined the equivalent potential temperature (EPT) at lightning locations in typhoons in order to determine whether a storm in typhoon produces lightning, and found that the lightning producing thunderstorms in typhoons typically have two instability layers at upper level (250hPa-300hPa) and lower levels (600hPa-700hPa). The difference between the 250hPa EPT and 300hPa EPT in the upper-level convective instability is used to create an instability index for the forecast of lightning flashes particularly in typhoon. Nakano *et al*. [2009] found that in cases of the 250hPa EPT of 367K or more, and 300hPa EPT of 390K or less, a Critical Success Index shows the highest score of 0.49.

In Yoshida, S., *et al*. [2009b], six initial continuing current (ICC) pulses contained in upward negative lightning were studied. Yoshida *et al*. [2009] classified these ICC pulses into two types according to current pulse shapes. The type 1 ICC pulses had a short geometric mean (GM) of

10-90% risetimes of 8.9 μs, while the type 2 ICC pulses had a long GM of 10-90% risetimes of 55 μs. Yoshida *et al*. [2009] found that the type 1 ICC pulses had preceding negative leaders which were connected to the channel of the existing ICC. These negative leaders caused the current increases of the ICC pulses by creating the conducting channels.

Yoshikawa *et al*. [2009] proposed a new approach of the real-time estimation of Doppler spectral moments for precipitation in the presence of ground clutter overlap. The proposed method is a frequency domain approach that uses a Gaussian model both to remove clutter spectrum and to estimate weather spectrum. The performance of this method was evaluated based on simulation data and the observation data acquired by the Ku-band broadband radar.

Yoshida, S., *et al*. [2008] conducted a field campaign during the Japanese winter thunderstorm season to observe radiation bursts associated with lightning discharges using a NaI scintillator and a thin plastic scintillator (PS), which primarily detects high energy electrons. Yoshida *et al*. [2008] successfully recorded the bursts of high energy electrons with energies in excess of 100 keV from lightning discharges, and speculate that these high energy electrons were produced by high energy photon interactions near the PS.

E.9 Lightning and spherics

This subject is carried by the group of M. Hayakawa. ELF (extremely low frequency) wave propagation in the Earth-ionosphere waveguide (or cavity) has been investigated in order to study the global lightning activity and the lower ionosphere. There are known two types of ELF sferics; one is the stationary background noise known as Schumann resonance, and the other is non-stationary strong ELF sferics (sometimes called ELF transients or Q bursts). As for the 1st topic, Sekiguchi *et al*. [2008] have studied the diurnal and seasonal variations of the Schumann resonance parameters (such as resonance frequency, intensity and Q value) observed at Moshiri, Japan. Then Nickolaenko and Hayakawa [2008] have tried to separate the UT [universal time] and LT [local time) effects in the Schumann resonance data observed at Moshiri, in which the UT dependence is expected to indicate the most important global lightning activity of our interest. The importance of positive lightning in the excitation of Schumann resonances has been pointed out by Surkov and Hayakawa [2010]. An important contribution of the use of Schumann resonance data in mapping the global lightning activity has been done by Shvets *et al*. [2009, 2010]. These authors have developed an inversion problem to the Schumann resonance data observed simultaneously at several stations in the world to estimate the snapshot global distribution of background lightning activity. A few days real data are used in Shvets *et al*. [2009], but Shvets *et al*. [2010] have used the long-enough one-year data and succeeded in finding the seasonal change in the global lightning activity.

As for the 2nd class of ELF sferics, Yamashita *et al*. [2009] have deduced the global mapping of ELF huge transients observed at Moshiri, Japan, for one year, who have found significant

differences in the characteristics and global distributions between negative and positive lightning discharges. Nakamura and Sekiguchi *et al*. [2010] have compared different direction finding methods to locate ELF transients by using the ELF sferics from huge lightning discharges whose positions are known, who have finally recommended the use of Lissajous method (in time domain), together with the wavelet analysis.

Those ELF transients are recognized to be very useful for the study of lightning-induced mesospheric transient luminous events (optical emissions such as sprites, elves etc.). Nickolaenko and Hayakawa [2010] and Nickolaenko *et al*. [2008] have compared the observed waveforms of Q burst with the corresponding theoretical computations. Matsudo *et al*. [2009] have estimated the time delay of sprites behind their causative lightning, who have suggested significant differences of this time delay depending on the morphology of sprites (larger time delays for carrots and small delays for columns). Williams et *al*.(2010) have compared the mesospheric optical emissions (sprites) with their parent lightning flashes over Africa, and they have found a good correlation between the two.

The generation of those mesospheric luminous events has been studied theoretically by means of EM computer code [Asano *et al*. 2008, 2009], and especially Asano *et al*. [2009a] have indicated the importance of high-frequency components (like M components) in the continuing current of a lightning discharge in on the triggering of sprites in addition to the quasi-electrostatic electric field. Asano *et al*. [2009b] have studied the 3D simulation on sprite initiation above a horizontal lightning discharge. Similar computations have been performed by Kudintseva *et al*. [2010], who have considered only the EMP radiation for a gamma-shape lightning. Myokei *et al*. [2009] have studied the morphology of winter sprites in the Hokuriku area of Japan in relation to the cloud charge height.

Hayakawa *et al*. [2008] have modeled the VHF/UHF radiation from the preliminary breakdown stage of lightning, in terms of the fractal concept, and a comparison with the observation indicates that both are in good agreement.

E10 Electromagnetic phenomena associated with earthquakes

This subject is also carried by the group of M. Hayakawa. Electromagnetic phenomena are known to take place in association with earthquakes (EQs), and these seismo-electromagnetic effects are expected to be of extreme significance in short-term EQ prediction. The first phenomenon is ULF (ultra-low-frequency, f<10Hz) electromagnetic emissions. Ida *et al*. [2008] have improved the former polarization analysis and applied it to the Chinese ULF data, who have succeeded in finding out significant precursors of Chinese EQs. Mezentsev *et al*. [2009] have studied the fractal properties of geomagnetic ULF data, and they have tried to distinguish between the geomagnetic and seismogenic effects.

The subionospheric VLF/LF propagation has been extensively utilized in order to investigate

the ionospheric perturbations associated with EQs. Some statistical studies on the correlation of the presence of ionospheric perturbations and EQs with magnitude M larger than 6.0 and with shallow depth [Kasahara *et al*., 2008; Muto *et al*., 2008; Biagi *et al*., 2009; Hayakawa *et al*.,2009; Kasahara *et al*., 2010a,b;. Hayakawa *et al*., 2010a, b, c; Hayakawa, 2010; Hayakawa and Hobara, 2010]. Additional case studies have also been performed for different huge EQs (Biagi *et al*.[2008] for an Italian EQ, Hayakawa *et al*. [2008c] for the 2007 Niigata-Chuetsu-oki EQ, Muto *et al*. [2009a] for the 2005 Miyagi-oki EQ, Rozhnoi *et al*. [2009a] for the 2009 Abrusso EQ in Italy). The generation mechanism of those seismo-ionospheric perturbations has been investigated in terms of the atmospheric gravity wave (AGW) mechanism. A lot of indirect evidences on the important role of AGWs have been obtained in terms of amplitude fluctuations, fractal analysis etc. [Korepanov *et al*., 2009; Blaunstein and Hayakawa, 2009; Muto *et al*., 2009a,b; Rapoport *et al*., 2009; Imamura *et al*., 2010; Kasahara *et al*., 2010]. Furthermore, the satellite observations have also been succeeded in finding the lower ionospheric perturbation associated with EQs by means of the detection of such whistler-mode VLF/LF transmitter signals [Rozhnoi *et al*., 2008, 2009, 2010; Muto *et al*., 2009].

Anomalous effects in Schumann resonance phenomena have been observed in Japan (Moshiri) by Hayakawa *et al*. [2008], who have found abnormal behaviors in Schumann resonance (enhancement of third or fourth harmonic) in possible association with an EQ in Taiwan and who have interpreted those anomalies in terms of the interference between the direct wave from the lightning source in South America and the wave reflected from the seismo-ionospheric perturbation above Taiwan. Izutsu *et al*. [2009] and Ohta *et al*. [2009] have found further anomalous effects such as the excitation of Schumann-resonance-like line emissions in possible association with the EQs in Japan, and Hayakawa *et al*. [2010] have interpreted these line emissions in terms of the gyrotropic waves excited by the ELF waves from below in association with EQs. The effects of a large-scale gamma-ray burst (SGRJ 1550-5418) on the ELF Schumann resonance has been studied theoretically by Nickolaenko and Hayakawa [2010], who have predicted a severe decrease of all parameters (intensity, resonance frequency, etc.) of Schumann resonance modes.

Yasuda *et al*. [2009] have developed an interferometric direction finding for over-horizon VHF transmitter signals and natural VHF emissions possibly associated with EQs, in which the direction information is found to be extremely useful in sorting out the natural emission and VHF transmitter signal and to be useful to find one-to-one correspondence between the anomaly and an EQ. Nagamoto *et al*. [2008] have studied the disturbances in VHF/UHF telemetry links as a possible effect of a particular EQ in Hokkaido. Hayakawa [2009] has reviewed different kinds of direction finding systems for sferics in VLF and ELF bands, and he has discussed advantages and disadvantages of each direction finding system.

A few reviews on these seismogenic effects have been published. Hayakawa [2009] has edited a monograph composed of ten chapters, whose authors are qualified scientists working on this topic, including ULF emissions, geochemical effects, laboratory experiments, atmospheric disturbances, ionospheric disturbances and the lithosphere-atmosphere-ionosphere coupling. Hayakawa and

Hobara [2010] have reviewed the whole view of seismo-electromagnetics, but paying more attentions to ULF emissions and ionospheric perturbations which are regarded as being most prospective for EQ prediction.

References

Araki, K., F. Xiao, Y. Kami, [2008], Simplified Interference Coupling Model for Two Orthogonal Striplines on Adjacent Layers, IEICE Trans. on Communications, Vol.E91-B, No.12, pp.3983-3989, 2008.

Adachi, N., D. Uematsu, T. Ota, K. Kawasaki, M. Takahashi, H.Ota, K. Arai, S. Fujisawa, S. Okubo, H. Ota[2008], Magnetic Garnet Film for the Probe Sensor of The High Frequency Electromagnetic Field, The 3rd International Workshop on Advanced Ceramics, 2008, Limoges France.

Adachi N., K. Isarai, T.O ta, K. Ishiyama, H. Ota, and K. I. Arai [2009], Magnetic and Magneto-Optical properties of Bismuth Iron Garnet prepared by MOD method, International Conference on Magnetism 2009, Karlsruhe Germany.

Adachi, N. D. Uematsu, T. Ota, M. Takahashi, K.Ishiyama, K. Kawasaki, H. Ota, K. I. Arai, S. Fujisawa, S. Okubo, and H. Ohta[2010], Far-infrared Ferromagnetic Resonance of Magnetic Garnet for High Frequency Electromagnetic Sensor, IEEE Trans. on Magnetics, vol. 46, no. 6, pp. 1986-1989, 2010.

Adalev, A. S., M. Hayakawa, N. V. Korovkin, D. I. Iudin, V. Yu. Trakhtengerts[2007], Simulation of surface discharge dynamics by means of cellular automata, J. Applied Physics, vol. 101, 083302, 2007.

Adalev, S. A., N. V. Korovkin, and M. Hayakawa[2008], Using linear relations between experimental characteristics in stiff identification problems of linear circuit theory, IEEE Trans. on Circuits and Systems, vol. 55, No. 5, 1237-1247, 2008.

Akita, M., Y. Nakamura, S. Yoshida, T. Morimoto, T. Ushio, Z. Kawasaki, and D. Wang[2010a], What Occurs in K-process of Cloud Flashes?, J. Geophs. Res., 115, D07106, doi:10.1029/2009JD012016, 2010.

Akita, M., S. Yoshida, Y. Nakamura, T. Morimoto, T. Ushio, Z-I.Kawasaki, and D. Wang[2010b], Lightning Channels of Cloud-to-ground Flashes Neutralizing Multiple Charge Regions inside Winter Thunderclouds, IEEJ Trans. on FM., 130, 5, 467-472, 2010.

Akita, M., Y. Nakamura, S. Yoshida, T. Morimoto, T. Ushio, Z. Kawasaki, and D. Wang, Effects of Charge Distribution in Thunderstorm on Lightning Propagation Paths in Darwin, Australia, J. Atmos. Sci.,（in press）

Asai, S., S. Yamamoto, Y. Kasahara, Y. Hobara, T. Inaba, and M. Hayakawa, Measurement of Doppler shifts of short-distance subionospheric LF transmitter signals and seismic effects, J. Geophys. Res.,

doi:10.1029/2010JA016055, 2010.

Asano, T., M. Hayakawa, M. Cho, and T. Suzuki[2008], Computer simulations on the initiation and morphological difference of Japan winter and summer sprites, J. Geophys. Res., vol. 113, A02308, doi:10.1029/2007JA012528, 2008.

Asano, T., T. Suzuki, M. Hayakawa, and M. G. Cho[2009a], Three-dimensional EM computer simulation on sprite initiation above a horizontal lightning discharge, J. Atmos. Solar-terr. Phys., vol. 71, 983-990, 2009.

Asano, T., T. Suzuki, Y. Hiraki, E. Mareev, M. G. Cho, and M. Hayakawa[2009b], Computer simulations on sprite initiation for realistic lightning models with higher-frequency surges, J. Geophys. Res., vol. 114, A02310, doi: 10.1029/2008JA013651, 2009.

Biagi, P. F., L. Castellana, T. Maggipinto, D. Loiacono, V. Augelli, L. Schiavulli, A. Ermini, V. Capozzi, M. S. Solovieva, A. A. Rozhnoi, O. A. Molchanov, and M. Hayakawa[2008], Disturbances in a VLF radio signal prior the M=4.7 offshore Anzio (central Italy) earthquake on 22 August 2005, Natural Hazards Earth System Sci., vol. 8, 1041-1048, 2008.

Biagi, P. F., L. Castellana, T. Maggipinto, G. Maggipinto, A. Minafra, A. Ermini, O. Molchanov, A. Rozhnoi, M. Solovieva, and M. Hayakawa[2009], Anomalies in VLF radio signals related to the seismicity during November-December 2004: A comparison of ground and satellite results, Physics and Chemistry of the Earth, Parts A/B/C, vol. 34, Issues 6-7, Special issue, Electromagnetic Phenomena Associated with Earthquakes and Volcanoes, Edited by M. Hayakawa, J. Y. Liu, K. Hattori, and L. Telesca, 456-463, 2009.

Blaunstein, N., and M. Hayakawa, Short-term ionospheric precursors of earthquakes using vertical and oblique ionosondes, Physics and Chemistry of the Earth, Parts A/B/C, vol. 34, Issues 6-7, Special issue, Electromagnetic Phenomena Associated with Earthquakes and Volcanoes, Edited by M. Hayakawa, J. Y. Liu, K. Hattori, and L. Telesca, 496-507, 2009.

Enami, T., S. Ninomiya, K. Shinkai, S. Abe, M. Hashimoto, Statistical Timing Analysis Considering Clock Jitter and Skew due to Power Supply Noise and Process Variation, IEICE Trans. on Fundamentals, Vol.E93-A No.12,pp.2399-2408, 2010.

Fujii, K., Y. Yamanaka, K. Koike, and A. Sugiura[2010], Antenna Calibration Using the 3-Antenna Method with In-Phase Synthetic Method, IEICE Trans. on Communications, vol. E93-B, No.8 pp.2158-2164, 2010.

Gotoh, K., Y.Matsumoto, H.Tsutagaya, and S.Kazama, [2008], Evaluation of sensitivity of digital TV receiver subjected to intrasystem interference, EMC Europe 2008, pp. 727-730, Hamburg, 2008.

Gotoh K., and M. Matsumoto [2010], A multi-channel FFT-based, amplitude probability distribution measuring instrument, EMC Europe 2010, Wroclaw.

Hagiwara, S., K. Yamanaga, R. Takahashi, K. Masu, T. Sato, Linear Time Calculation of On-Chip Power Distribution Network Capacitance Considering State-Dependence, IEICE Trans. on Fundamentals, Vol.E93-A No.12, pp.2409-2416, 2010.

Harima, K, M. Sakasai, and K. Fujii, [2008a], Determination of Gain for Pyramidal-Horn Antenna on

Basis of Phase Center Location, 2008 IEEE EMC Symposium, Detroit.

Harima, K. [2008b], Technique for Antenna Calibration in Random Electric Fields, IEICE Trans. on Communications, vol. E91-B, no. 6, pp. 1838-1841.

Harima, K. [2009a], Calibration of Double-Ridged Guide Horn Antenna Using Phase Center, 2009 IEEE EMC Symposium, pp. 287-291, Austin.

Harima, K. [2009b], Calibration of Broadband Double-Ridged Guide Horn Antenna by Considering Phase Center, The 39th European Microwave Conference, pp.1610-1613, Roma, 2009.

Harima, K. [2010a], Effect of Measurement Distance on Gain Calibration of Pyramidal Horn Antenna, IEICE Trans. on Communications, vol. E93-B, no. 7, pp. 1847-1850, 2010.

Harima, K. [2010b], Determination of gain of double-ridged guide horn antenna by considering phase center, IEICE Electron. Express, vol. 7, no. 2, pp.86-91, 2010.

Hatakeyama K, T. Nakamura, S. Yoshiuchi, M. Hirose,[2008a], High-power Characteristics of Pyramidal Absorber by Roof Tile Smoking Process, IEEJ Trans. FM, Vol.128, No.7, pp.497-498, 2008 (in Japanese).

Hatakeyama K, T. Nakamura, M. Hirose, S. Yoshiuchi[2008b], EM Wave Absorption Characteristics of Pyramids Produced by Smoked Roof Tile Production Process, IEICE Trans. B, Vol.J91-B, No.8, pp.870-872, 2008 (in Japanese).

Hatakeyama K, T. Tsutaoka[2010a], Development of Artificially-designed Materials Including LHM and Their Application for the Transmission-reflection Control in EMC, Journal of the IEICE, Vol.23, No.6, pp.457-462, 2010.

Hayakawa, M., and Y. Ida[2008a], Fractal (mono- and multi-) analysis for the ULF data during the 1993 Guam earthquake for the study of prefracture criticality, Current Development in Theory and Applications of Wavelets, vol. 2(2), 159-174, 2008.

Hayakawa, M., D. I. Iudin, and V. Y. Trakhtengerts[2008b], Modeling of thundercloud VHF/UHF radiation on the lightning preliminary breakdown stage, J. Atmos. Solar-terr. Phys., vol. 70, 1660-1668, 2008.

Hayakawa, M., T. Horie, M. Yoshida, Y. Kasahara, F. Muto, K. Ohta, and T. Nakamura[2008c], On the ionospheric perturbation associated with the 2007 Niigata Chuetsu-oki earthquake, as seen from subionospheric VLF/LF network observations, Natural Hazards Earth System Sci., vol. 8, 573-576, 2008.

Hayakawa. M., A. P. Nickolaenko, M. Sekiguchi, K. Yamashita, Y. Ida, and M. Yano[2008d], Anomalous ELF phenomena in the Schumann resonance band as observed at Moshiri (Japan) in possible association with an earthquake in Taiwan, Natural Hazards Earth System Sci., vol. 8, 1309-1316, 2008.

Hayakawa, M.[2009a], Seismogenic pertubation in the atmosphere, “Electromagnetic Phenomena Associated with Earthquakes” Ed. by M. Hayakawa, Transworld Research Network, Trivandrum(India), chapter 5(119-136), 2009.

Hayakawa, M.[2009b], Lower ionospheric pertubations associated with earthquakes, as detected by subionospheric VLF/LF radio waves, “Electromagnetic Phenomena Associated with Earthquakes” Ed. by M. Hayakawa, Transworld Research Network, Trivandrum(India), chapter 6(137-185), 2009.

Hayakawa, M. [2009c], A review on direction finding methods for VLF/ELF sferics, J. Atmos. Electr., vol. 29, No. 1, 35-52, 2009(in Japanese).

Hayakawa, M.[2010a], The use of subionospheric VLF/LF propagation for the study of lower ionospheric perturbations associated with earthquakes, “Propagation effects of Very Low Frequency Radio Waves”, Ed. by S. K. Chakrabarti, American Inst. Physics, AIP conference Proceedings, Vol. 1286, 223-269, 2010.

Hayakawa, M., and Y. Hobara.[2010b], Current status of seismo-electromagnetics for short-term earthquake prediction, Geomatics, Natural Hazards and Risk, vol. 1, no. 2, 115-155, 2010.

Hayakawa, M., K. Ohta, V. M. Sorokin, A. K. Yaschenko, J. Izutsu, Y. Hobara, and A. P. Nickolaenko[2010c], Interpretation in terms of gyrotropic waves of Schumann-resonance-like line emissions observed at Nakatsugawa in possible association with nearby Japanese earthquakes, J. Atmos. Solar-terr. Phys., vol. 72, 1292-1298, 2010.

Hayakawa, M., T. Horie, F. Muto. Y., Kasahara, K. Ohta, J. Y. Liu, and Y. Hobara[2010d], Subionospheric VLF/LF Probing of Ionospheric Perturbations Associated with Earthquakes: A Pssibility of Earthquake Prediction, SICE J. Control, Measurement, and System Integration (SICE JCMSI), vol. 3, No. 1, 10-14, 2010.

Hayakawa, M., Y. Kasahara, T. Nakamura, F. Muto, T. Horie, S. Maekawa, Y. Hobara, A. Rozhnoi, M. Solivieva, and O. A. Molchanov[2010e], A statistical study on the correlation between lower ionospheric perturbations as seen by subionospheric VLF/LF propagation and earthquakes, J. Geophys. Res., vol. 115, A09305, doi:10. 1029/2009JA015143, 2010.

Hayakawa, M., Y. Kasahara, T. Nakamura, Y. Hobara, A. Rozhnoi, M. Solovieva, O. A. Molchanov[2010f], On the correlation between ionospheric perturbations as detected by subionospheric VLF/LF signals and earthquakes as characterized by seismoc intensity, J. Atmos. Solar-terr. Phys., vol. 72, 982-987, 2010.

Hayakawa.M.[2011], On the fluctuation spectra of seismo-electromagnetic phenomena, Natural Hazards and Earth System Sci., vol. 11, 301-308, 2011.

Hayashi, Y., H. Sone, The Effect of Position of a Connector Contact Failure on Electromagnetic Near-Field around a Coaxial Cable, IEICE Trans. on Communications, Vol.E92-B No.6, pp.1969-1973, 2009.

Hobara, Y., M. Hayakawa, H. Fuji, and K. Ohta, VLF subionospheric disturbances and ELF transients associated with TLEs; Observations and modeling, “Propagation effects of Very Low Frequency Radio Waves”, Ed. by S. K. Chakrabarti, American Inst. Physics, AIP conference Proceedings, Vol. 1286, 158-176, 2010.

Ichikawa, K., Y.Takahashi, Y. Sakurai, T. Tsuda, I. Iwase, M. Nagata, Measurement-Based Analysis of Electromagnetic Immunity in LSI Circuit Operation, IEICE Trans. on Electronics, Vol.E91-C No.6,

pp.936-944, 2008.

Ida, Y., D. Yang, Q. Li, H. Sun, and M. Hayakawa, Detection of ULF electromagnetic emissions as a precursor to an earthquake in China with an improved polarization analysis, Natural Hazards Earth System Sci., vol. 8, 775-777, 2008.

Ikenaga T., H. Ohba, H. Ota, and K. I. Arai [2009], Simulated Characteristics of Optical Magnetic Field Probe, 2009 International Symposium on Electromagnetic Compatibility, EMC'09/Kyoto, Kyoto, Japan.

Ikenaga, T., H. Ota, and K. I. Arai [2010], Simulated Characteristics of Optical Electric Field Probe, 2010 IEEE International Symposium on Electromagnetic Compatibility, Fort Lauderdale, Florida USA.

Imamura, T., Y. Ida, Y. Kasahara, T. Nakamura, Y. Hobara, and M. Hayakawa, Fractal analysis of subionospheric LF propagation data and consideration of the lithosphere-atmosphere-ionosphere coupling, Natural Hazards Earth System Sci., vol. 10, 901-906, 2010.

Inoue, H., H. Miura, Y. Kayano and K. Miyanaga[2008], Current Noise up to GHz Band Generated by Slowly Breaking Silver-Compound Contacts with External DC Magnetic Field, in Proc. International Conference on Electrical Contacts, pp.329-334, SAINT-MALO, France, Jun. 2008.

Inoue, H., H. Miura, Y. Kayano and K. Miyanaga[2010], Current Noise up to GHz Band Generated by Slowly Breaking Silver-Compound Contacts with External DC Magnetic Field, European Physical Journal Applied Physics, vol.49, 22098, Feb. 2010.

Intachot, T., N. Chuladaycha, Y. Prempraneerach, S. Nitta, A Current Mode Analysis on Ground Leakage Current Noise Generation in Unbalanced and Balanced Switching Converters, IEICE Trans. on Communications, Vol.E93-B No.8, pp.2142-2157, 2010.

Iokibe, K., R. Higashi, T. Tsuda, K. Ichikawa, K. Nakamura, Y. Toyota, R. Koga, [2010a], Validation of Multiple Power-Supply-Pin LECCS-core Model for Conducted RF Power Current Simulation, IEICE Trans. on Electronics, Vol. J93-C, No. 11, pp. 516-520, 2010 (in Japanese).

Ishigami, S., M.Yamada, K.Gotoh, Y.Matsumoto, and M.Tokuda, [2008], A new method of interference evaluation between UWB system and wireless LAN using a GTEM Cell, EURO EM, European Electromagnetic 2008, pp. 59-59, Lausanne.

Ishigami, S. and M. Hirata,[2009], A New Calibration Method for an Electric-field Probe using TEM Waveguides, 20th International Zurich Symposium on Electromagnetic Compatibility, ImTe-3, 2009, pp. 425-428, Zurich.

Ishigami, S., M. Yamada, H. Kamiya, K. Gotoh, Y. Matsumoto, and M.Tokuda, [2010], A new method of interference evaluation between an ultra wide band system and a wireless local-area network using a gigahertz electromagnetic cell, IEEE Transactions on. electromagnetic compatibility, vol.52, no.3, pp.737-744, 2010.

Iwai T, T. Kanemoto, S. Yamamoto, K. Hatakeyama[2010], Shielding Effectiveness of Wire Mesh in the Near Field, 2010 Asia-Pacific Radio Science Confrence, EP-7, 2010.

Iwanami, M., H. Fukuda, M. Kusumoto, T. Harada, ,Study of Electromagnetic Noise Coupling in Wireless-LAN Communication System, IEICE Trans. on Communications, Vol.E93-B No.7, pp.1776-1780.

Izutsu, J., K. Ohta, and M. Hayakawa, The direction finding of ULF emissions observed before the 2007 Noto Hantou and the 2008 Iwate-Miyagi Nairiku earthquakes, Inst. Electr. Engrs. Japan, Trans. Fundamentals and Materials, Special Issue on Electromagnetic technologies for forcasting and monitoring natural hazards, vol. 129, No. 12, 865-869, 2009.

Kamiya, H., M. Yamada, M. Tokuda, S. Ishigami, K. Gotoh, and Y. Matsumoto, [2008], A new method for measuring interference between UWB and wireless LAN systems, 2008 IEEE International Wireless Communications and Mobile Computing Conference (IWCMC), 03-11-02, Crete, Greece, 2008.

Kasagi T, K. Umezu, T. Tsutaoka, K. Hatakeyama[2010], Electromagnetic Properties of Ferromagnetic Metal Granular Composite Materials and the Application to EM-absorber, 2010 Asia-Pacific Radio Science Confrence, E4-2, 2010.

Kasahara, Y., F. Muto, T. Horie, M. Yoshida, M. Hayakawa, K. Ohta, A. Rozhnoi, M. Solovieva, and O. A. Molchanov[2008], On the statistical correlation between the ionospheric perturbations as detected by subionospheric VLF/LF propagation anomalies and earthquakes, Natural Hazards Earth System Sci., vol. 8, 653-656, 2008.

Kasahara, Y., F. Muto, Y. Hobara, and M. Hayakawa[2010a], The ionospheric perturbations associated with Asian earthquakes as seen from the subionospheric propagtion from NWC to Japanese stations, Natural Hazards Earth System Sci., vol. 10, 581-588, 2010.

Kasahara, Y., T. Nakamura, Y. Hobara, M. Hayakawa, A. Rozhnoi, M. Solovieva, and O. A., Molchanov[2010b], A statistical study on the AGW modulation in subionospheric VLF/LF propagation data and consideration of the generation mechanism of seismo-ionospheric perturbations, J. Atmos. Electr., vol.30, No.2, 103-112, 2010.

Kasuga, T., Y. Matsumoto, A. Nakajiri and H. Nakayama[2009], Study on Invasiveness and Suppression Effect for Near Electromagnetic Field above PCB by Suppression Material", in Proc. International Conference on Electronics Packaging, 21Q2-5, pp.105-108, Kyoto, Japan, Jun. 2009.

Kato, S., Q. Chen, K. Sawaya, Current Estimation on Multi-Layer Printed Circuit Board with Lumped Circuits by Near-Field Measurement, IEICE Trans. on Communications, Vol.E91-B No.11, pp.3788-3791, 2008.

Kawamata, K., S. Minegishi, Y. Taka, O. Fujiwara[2009], A Method for Estimating Wideband Transients Using Transmission Loss of High Performance Semi-Rigid Coaxial Cable, IEICT Trans. Commun., vol.E92-B, no. 6, pp.1965-1968, 2009.

Kawamata, K., S. Minegishi, O. Fujiwara[2010a], The Relationship between Radiated EM Field Intensity and Electrode Condition due to Micro Gap Discharge, IEEJ Trans. FM, vol.130, no.5, pp.445-450, 2010.

Kawamata, K., S. Minegishi, O. Fujiwara[2010b], Influence of the Surface Condition of EM field Intensity due to Micro Gap discharge., Proc. of the 2010 Asia-pacific International Symposium on

Electromagnetic Compatibility, No. 215, 2010.

Kawamata, K., S. Minegishi, O. Fujiwara[2010c], Wideband Measurement of Radiated Electromagnetic Field Intensity due to Micro Gap using the Spherical Electrode, Proc. of the 2010 Asia-pacific Radio Science Conference, E3, 6, 2010.

Kayano, Y., and H. Inoue[2008a], A Study on Electromagnetic Coupling between Transmission Line on Model Chip, in Proc. IEEE International Symposium on Electromagnetic Compatibility (CD-ROM), THU-AM-2-4, Detroit, Aug. 2008.

Kayano, Y., H. Miura, K. Miyanaga and H. Inoue[2008b], The Relationship between Voltage and Duration of Short-Time Arc Generated by Slowly Breaking Silver Contact, IEICE Transactions on Electronics, vol.E91-C, no.8, pp.1230-1232, Aug. 2008.

Kayano, Y., Y. Ono and H.Inoue[2008c], EM Radiation from a Printed Circuit Board with an Interconnection Cable Driven by Low-Voltage Differential-Signaling, in Proc. International Conference on Electronics Packaging, pp.144-149, Tokyo, Japan, Jun. 2008.

Kayano, Y. and H. Inoue[2008d], A Study on Effect of Noise Suppression Sheet on EM Radiation from a PCB, in Proc. Pan-Pacific EMC Joint Meeting, 15S2-2, pp.11-12, Tokyo, Japan, May 2008.

Kayano, Y., and H. Inoue[2009a], Characteristics of EM Radiation from a PCB Driven by Feed-Cable, in Proc. 2009 Korea-Japan Joint Conference on AP/EMC/EMT, EMC-5-1, Inchon, Korea, May 2009.

Kayano, Y., and H. Inoue[2009b], Prediction of EM Radiation from a PCB Driven by a Connected Feed Cable, IEICE Transactions on Communications, vol.E92-B, no.6, pp.1920-1928, Jun. 2009.

Kayano, Y., and H. Inoue[2009c], EM Radiation from Interconnected Surface-Microstrip Line Structures by a Coaxial Cable, in Proc. IEEE International Symposium on EMC, WE-AM-2-4, pp.51-56, Austin, USA, Aug. 2009.

Kayano, Y. and H. Inoue[2009d], Prediction of EM Radiation from a Printed Circuit Board Driven by Differential-Signaling, in Proc. International Conference on Electronics Packaging, 16B-1-5-4, pp.144-149, Kyoto, Japan, Jun. 2009.

Kayano, Y., and H. Inoue[2009e], Transmission and Coupling Characteristics of Transmission Line in IC Chip, in Proc. International Symposium on EMC, pp.591-594, Kyoto Japan, Jul. 2009.

Kayano, Y., H. Inoue,[2009f], Prediction of EM Radiation from a PCB Driven by a Connected Feed Cable, IEICE Trans. on Communications, Vol.E92-B No.6, pp.1920-1928, 2009.

Kayano, Y., and H. Inoue[2010a], Predicting CM Radiation from Strip Line Structure by Equivalent Circuit Mode, Proc. IEEE International Symposium on EMC, pp.748-758, Fort Lauderdale, FL, USA, Jul. 2010.

Kayano, Y., and H. Inoue[2010b], A Study on Characteristics of EM Radiation from Strip Line Structure, in Proc. Asia-Pacific Radio Science Conference, E2-1, Toyama, Japan, Sep. 2010.

Kayano, Y., R. Yanagisawa and H. Inoue[2010c], Negative Group Delay Circuit fabricated in an Integrated Circuit Chip, in Proc. 2010 Asia-Pacific International Symposium on EMC, pp.1126-1129,

Beijing China, Apr. 2010.

Kayano, Y., R. Hashiya and H. Inoue[2010d], The Correlation between Imbalance Current and EM Radiation from a Printed Circuit Board Driven by Differential-Signaling, in Proc. International Conference on Electronics Packaging, pp.608-613, Hokkaido, Japan, May 2010.

Kayano, Y., K. Miyanaga and H. Inoue[2010e], Voltage Fluctuation of Short-Time Arc at Slowly Breaking Silver-Compound Contacts", in Proc. the Joint Meeting 25th International Conference on Electrical Contacts & 56th IEEE Holm Conference on Electrical Contacts, pp.18-23, Charleston, SC, Oct. 2010.

Kiso, T., T. Iwaki, T. Kasuga and H. Inoue, Modification of FDTD-MAS Method for EMI Estimation with Surrounding Large Objects in Analytical Space", Proceedings of the 2009 International Symposium on EMC, Kyoto, 23P1-1, pp.509-511, 2009.7.23 (Kyoto).

Komakine, T., T. Kurosawa and H. Inoue[2009], A Novel Method of Electric Field Estimation by using Spherical Dielectric Scatterer, in Proc. International Symposium on EMC, pp.173-176, Kyoto Japan, Jul. 2009.

Komakine, T., T. Kurosawa, K. Miyanaga and H. Inoue[2010a], A Novel Measurement Method of Electric Field by using Spherical Dielectric Scatterer, IEEJ Trans. FM, vol.130, no.5, pp.462-466, 2010.

Komakine, T., T. Kurosawa and H. Inoue[2010b], A Novel Measurement Method of Permittivity by using Scattering Wave, in Proc. Asia-Pacific Radio Science Conference, B5a-1, Toyama, Japan, Sep. 2010.

Kondo, K., S. Yoshida, H. Ono, Y. Toyota, Band Elimination Characteristics of EBG Structure Containing High Permeability Ferrite Thin Films, VIII International Symposium on Electromagnetic Compatibility and Electromagnetic Ecology (EMC'2009), pp.151-153, St. Petersburg, Russia, 2009.6.16-19.

Korepanov, V., M. Hayakawa, Y. Yampolski, and G. Lizunov, AGW as a seismo-ionospheric coupling responsible agent, Physics and Chemistry of the Earth, Parts A/B/C, vol. 34, Issues 6-7, Special issue, Electromagnetic Phenomena Associated with Earthquakes and Volcanoes, Edited by M. Hayakawa, J. Y. Liu, K. Hattori, and L. Telesca, 485-495, 2009.

Korovkin, N. V., E. B. Solovyeva, and M. Hayakawa, Synthesis of polynomial compensators for suppression of low-frequency noise in electronic devices, IEEJ Trans. Electronics, Information and Systems, vol. 128, No. 7, 1197-1203, 2008.

Kudintseva, I. G., A. P. Nickolaenko, and M. Hayakawa[2009], Spatial fine structure of model electric pulses in the mesosphere above a Γ-shaped stroke of lightning, J. Atmos. Solar-terr. Phys., vol. 71, 603-608, 2009.

Kudintseva, I. G., A. P., Nickolaenko, M. Hayakawa[2010], Transient electric field in the mesosphere above a Γ-shape lightning stroke, Survey Geophys., vol. 31, 427-448, DOI 10.1007/s10712-0010-9095-x, 2010.

Kuwabara, N., Y. Ishida, M. Kawabata, Calculation of Electromagnetic Field Emitted from UTP

Cable by Moment Method from 0.3 GHz to 2 GHz, IEICE Trans. on Communications, Vol.E92-B No.6, pp.1974-1980, 2009.

Mabuchi, Y., T. Uno, K. Ichikawa, A. Nakamura, O. Wada, Development of an EMI Simulation Technique for Automotive ECUs, IEICE Trans. on Communications, Vol.J93-B No.2, pp.341-350, 2010 (in Japanese).

Matsudo, Y., T. Suzuki, K. Michimoto, K. Myokei, and M.Hayakawa, Comparison of time delays of sprites induced by winter lightning flashes in the Japan Sea with those in the Pacific Ocean, J. Atmos. Solar-terr. Phys., vol. 71, 101-111, 2009.

Matsumoto, K., Y. Toyota, K. Iokibe, R. Koga, Development of Equivalent Circuit Model with Transmission Line Model for Designing Filters Formed on Printed Circuit Boards, IEEE International Symposium on Electromagnetic Compatibility, pp. 289-294, Fort Lauderdale, Florida, USA, 2010.7.28.

Matsumoto, Y.[2007], On the Relation Between the Amplitude Probability Distribution of Noise and Bit Error Probability, IEEE Trans. on Electromagnetic Compatibility, vol. 49, no. 4, pp. 940-941, 2007.

Matsumoto, Y., K. Gotoh, and T. Shinozuka [2008a], A Method for Converting Amplitude Probability Distribution of Disturbance from one Measurement Frequency to Another, IECIE Trans. on Communications, vol. E91-B, no.6, pp. 2010-2019, 2008.

Matsumoto, Y., K. Gotoh, T. Shinozuka [2008b], A Method for Converting Amplitude Probability Distribution of Disturbance from One Measurement Frequency to Another, IEICE Trans. on Communications, Vol.E91-B No.6, pp.2010-2019, 2008.

Matsumoto, Y., K. Gotoh, and K. Wiklundh, [2008b], Band-limitation Effect on Statistical Properties of Class-A Interference, EMC Europe 2008, pp. 715-719.

Matsumoto, Y. and K. Wiklundh [2009a], A simple expression for bit error probability of convolutional codes under class-A interference, 2009 International Symposium on EMC, EMC'09/Kyoto, pp. 430-433.

Matsumoto, Y., K. Gotoh, and K. Wiklundh [2010a], Definition of APD-based Emission Limits for the Protection of Coded Wireless Systems from Impulsive Interference, EMC Europe 2010, pp. 629-634, Kyoto.

Matsumoto, Y. and K. Gotoh [2010b], Comparison of Estimated and Measured Multichannel Amplitude Probability Distributions for Real-time Monitoring of EM Environment, Asia-Pacific Radio Science Conference (AP-RASC) 2010, EP-9, Toyama.

Matsumoto, Y., T. Murakami, K. Fujii, and A. Sugiura, [2010c], Impact of Electromagnetic Noise From PCs on Performance of Multiband-OFDM UWB Systems, IEEE Trans. on Consumer Electronics, vol. 56, no. 2, pp. 348-352, Kyoto.

Matsushima, T., T. Watanabe, Y. Toyota, R. Koga, O. Wada,[2009a], Evaluation of EMI Reduction Effect of Guard Traces Based on Imbalance Difference Model, IEICE Trans. on Communications, Vol.E92-B No.6, pp.2193-2200.

Matsushima, T., T. Watanabe, Y. Toyota, R. Koga, O. Wada,[2010b], Increase of Common-Mode Radiation due to Guard Trace Voltage and Determination of Effective Via-Location, IEICE Trans. on Communications, Vol.E92-B No.6, pp.1929-1936, 2009.

Matsushima, T., T. Watanabe, Y. Toyota, R. Koga, O. Wada [2010a], Calculation of Common-Mode Radiation from Single-Channel Differential Signaling System Using Imbalance Difference Model, IEICE Trans. on Communications, Vol.E93-B No.7, pp.1739-1745, 2010.

Mezentsev, A. Yu., M. Hayakawa and K. Hattori, Fractal ULF signatures related to seismic processes, J. Atmos. Electr., vol.29, No.2, 81-93, 2009.

Miyata, S., Y. Kayano and H. Inoue, EM Radiation through Aperture of Metallic Enclosure with a PCB inside, in Proc. 2008 Asia-Pacific Symposium on Electromagnetic Compatibility, pp.670-673, Singapore, May 2008.

Mori, I., O. Fujiwara, Severity Evaluation of the IEC Immunity Test against ESD Based on Wideband Measurement of Discharge Current Waveform, IEEJ Trans. FM, vol.130, no.5, pp.457-461, 2010.

Murano, K., M. Tayarani, F. Xiao, and Y. Kami [2008], New radiated RF immunity/susceptibility test method using RF-pulsed rotating-EM field, 2008 IEEE Int. Symp. Electromagn. Compat., TU-AM-3-6, pp. 79-83, Detroit.

Murano, K., M. Tayarani, F. Xiao, and Y. Kami [2010], New radiated immunity/susceptibility test method using rotating FM-EM field, 2010 IEEE Int. Symp. Electromagn. Compat., TUE-PM-1(6), pp. 189-193, Fort Lauderdale.

Muto, F., M. Yoshida, T. Horie, M. Hayakawa, M. Parrot, and O. A. Molchanov[2008], Detection of ionospheric perturbations associated with Japanese earthquakes on the basis of reception of LF transmitter signals on the satellite DEMETER, Natural Hazards Earth System Sci., vol. 8, 135-141, 2008.

Muto, F., T. Horie, M. Yoshida, M. Hayakawa, A. Rozhnoi, M. Solovieva, and O. A. Molchanov[2009a], Ionospheric perturbations related to the Miyagi-oki earthquake on 16 August 2005, as seen from Japanese VLF/LF subionospheric propagation network, Physics and Chemistry of the Earth, Parts A/B/C, vol. 34, Issues 6-7, Special issue, Electromagnetic Phenomena Associated with Earthquakes and Volcanoes, Edited by M. Hayakawa, J. Y. Liu, K. Hattori, and L. Telesca, 449-455, 2009.

Muto, F., Y. Kasahara, Y. Hobara, M. Hayakawa, A. Rozhnoi, M. Solovieva, and O. A. Molchanov[2009b], Further study on the role of atmospheric gravity waves on the seismo-ionospheric perturbations as detected by subionospheric VLF/LF propagation, Natural Hazards Earth System Sci., 9, 1111-1118, 2009.

Myokei, K, Y. Matsudo, T.Asano, T.Suzuki, Y. Hobara, K.Michimoto, and M.Hayakawa[2009a], A study of the morphology of winter sprites in the Hokuriku area of Japan in relation to cloud charge height, J. Atmos. Solar-terr. Phys., vol. 71, 597-602, 2009.

Myokei, K., Y. Matsudo, T. Asano, M. Sekiguchi, T. Suzuki, T. Hobara, and M. Hayakawa[2009b], Morphology of winter sprites in the Hokuriku area on Japan: Monthly variation and dependence on

air temperature, J. Atmos. Electr., vol.29, No.1, 23-34, 2009.

Nagamoto, H., T. Fukushima, Y. Ida, Y. Matsudo, and M. Hayakawa, Disturbances in VHF/UHF telemetry links as a possible effect of the 2003 Hokkaido Tokachi-oki earthquake, Natural Hazards Earth System Sci., vol. 8, 813-817, 2008.

Nakamura, T., S. Yamamoto, S. Yoshiuchi, M. Hirose, K. Hatakeyama [2010], Preparation of EM-Wave Absorber by Smoked Roof-Tile Process and its Performances, 2010 Asia-Pacific Radio Science Conference, EP-8, 2010.

Nakamura, T., M. Sekiguchi, Y. Hobara, M. Hayakawa [2010], A comparison of different source location methods for ELF transients by using the parent lightning discharges with known positions, J. Geophys. Res., vol. 115, A00E39, doi:10. 1029/2009JA014992, 2010.

Nakamura, Y., E. Yoshikawa, M. Akita, T. Morimoto, T. Ushio, Z. Kawasaki, T. Saito, T. Nishida, and N. Sakazume [2009], High-resolution Precipitation and Lightning Monitoring by the Ku-band Broadband Radar and the VHF Broadband Digital Interferometer, IEEJ Trans. on FM.129, 12, pp.845-852, 2009.

Nakano, F., T. Morimoto, T. Ushio, and Z. Kawasaki, An Instability Index for Lightning Prediction in Typhoon, IEEJ Trans. on FM., 129, 12, pp.859-864, 2009.

Nickolaenko, A. P., and M. Hayakawa[2008a], Universal and local time components in Schumann resonance intensity, Ann. Geophysicae, vol. 26, 813-822, 2008.

Nickolaenko, A. P., M. Hayakawa, T. Ogawa, and M. Komatsu[2008b], Q-bursts: A comparison of experimental and computed ELF waveforms, Radio Science, vol. 43, RS4014, doi:10.1029/2008RS003838, 2008.

Nickolaenko, A. P., M. Hayakawa, Y. Hobara[2010], Q-bursts: Natural ELF radio transients, Survey Geophys., vol. 31, 409-425, DOI 10.1007/s10712-0010-9096-9, 2010.

Ohta, K., J. Izutsu, and M. Hayakawa, Anomalous excitation of Schumann resonances and additional anomalous resonances before the 2004 Mid-Niigata prefecture earthquake and the 2007 Noto Hantou Earthquake, Physics and Chemistry of the Earth, Parts A/B/C, vol. 34, Issues 6-7, Special issue, Electromagnetic Phenomena Associated with Earthquakes and Volcanoes, Edited by M. Hayakawa, J. Y. Liu, K. Hattori, and L. Telesca, 441-448, 2009.

Ohtsu, T., K. Kataoka, Study on ESD phenomena of Magnetic Head by 1 ns Pulse ESD, Proc. of the 2010 Asia-pacific International Symposium on Electromagnetic Compatibility, No. 119, 2010.

Oka, N., K. Iokibe, Y. Toyota, R. Koga, [2009], EMI Macro Modeling of Driver Circuits Using Static Characteristics of Transistors, IEICE Trans. on Communications, Vol.J92-B No.1, pp.287-295, 2009 (in Japanese).

Oka, N., K. Iokibe, Y. Toyota, R. Koga, [2010], EMI Macro Modeling of Driver Circuits Using Static Characteristics of Transistors, IEICE Trans. on Electronics, Vol. J93-C, No. 11, pp. 433-444, 2009 (in Japanese).

Okazaki, Y., T. Uno, H. Asai, An Optimization System with Parallel Processing for Reducing

Common-Mode Current on Electronic Control Unit, IEICE Trans. on Electronics, Vol.E93-C, No.6, pp.827-834, 2010.

Ota, H., M. Takahashi, K. Ishiyama, and K. I. Arai[2008], Electromagnetic Field Distribution Measurements using Electro-optic and Magneto-optic Crystals, International Workshop on Nano-structured Materials & Magnetics, Okinawa, Japan, 2008.

Paoletti, U., T. Hisakado, O. Wada, Importance and Limitations of Modeling Parasitic Capacitance between Package and PCB for Power Bus Noise and Radiation, IEICE Trans. on Communications, Vol.E92-B No.6, pp.1937-1944.

Park, S. W., F. Xiao, Y. Kami, Crosstalk Analysis for Embedded-Line Structure at PCB Using Circuit-Concept Approach, IEICE Trans. on Communications, Vol.E92-B No.6, pp.1945-1952, 2009.

Rapoport, Yu. G., M. Hayakawa, O. E. Gotynyan, V. N. Ivchenko, A. K. Fedorenko, and Yu. A. Selivanov, Stable and unstable plasma perturbations in the ionospheric F region, caused by spatial packet of atmospheric gravity waves, Physics and Chemistry of the Earth, Parts A/B/C, vol. 34, Issues 6-7, Special issue, Electromagnetic Phenomena Associated with Earthquakes and Volcanoes, Edited by M. Hayakawa, J. Y. Liu, K. Hattori, and L. Telesca, 508-515, 2009.

Rozhnoi, A., M. Solovieva, O. Molchanov, O. Akentieva, J. J. Berthelier, M. Parrot, P. F. Biagi, and M. Hayakawa[2008], Statistical correlation of spectral broadening in VLF transmitter signal and low-frequency ionospheric turbulence from observation on DEMETER satellite, Natural Hazards Earth System Sci., vol. 8, 1105-1111, 2008.

Rozhnoi, A., M. Solovieva, O. Molchanov, K. Schwingenschuh, M. Boudjada, P.F. Biagi, T. Maggipinto, L. Castellana, A. Ermini, and M. Hayakawa[2009], Anomalies in VLF radio signals prior to the Abrusso earthquake(M=6.3) on 6 April 2009, Natural Hazards and Earth System Sci., vol. 9, 1727-1732, 2009.

Rozhnoi, A., M. Solovieva, O. Molchanov, P.F. Biagi, M. Hayakawa, K. Schwingenschuh, M. Boudjada, and M. Parrot [2010], Variations of VLF/LF signals obsered on the ground and satellite during a seimic activity in Japan region in May-June 2008, Natural Hazards and Earth System Sci., vol. 10, 529-534, 2010.

Saito, Y., M. Yasuhara, Y. Funato, U. Paoletti, T. Hisakado, O. Wada, 3-Port LECCS-core Model Including Inter-Block Coupling in an LSI with Multiple Power-Supply Pins, IEICE Trans. on Communications, Vol.J93-B No.2, pp.332-340, 2010 (in Japanese).

Saroso, S., K. Hattori, H. Ishikawa, Y. Ida, R. Shirogane, M. Hayakawa, K. Yumoto, K. Shiokawa, and M. Nishihashi, ULF geomagnetic anomalous changes possibly associated with 2004-2005 Sumatra earthquakes, Physics and Chemistry of the Earth, Parts A/B/C, vol. 34, Issues 6-7, Special issue, Electromagnetic Phenomena Associated with Earthquakes and Volcanoes, Edited by M. Hayakawa, J. Y. Liu, K. Hattori, and L. Telesca, 343-349, 2009.

Sasaki, H., T. Harada, T. Kuriyama, T. Sato, K. Masu, Application of the EMI Decoupling Circuit Consisting of Two Capacitors and a Power Trace to Quad Flat Package (QFP) LSI, IEICE Trans. on Communications, Vol.J92-B No.5, pp.883-891 (in Japanese).

Schekotov, A. Y., O. A. Molchanov, M. Hayakawa, E. N. Fedorov, V. N. Chebrov, V. I. Sinitsin, E. E.

Gordeev, S. E. Andreevsky, G. G. Belyaev, N. V. Yagova, V. A. Gladishev, and L. N. Baransky, About possibility to locate an EQ epicenter using parameters of ELF/ULF preseismic emission, Natural Hazards Earth System Sci., vol. 8, 1237-1242, 2008.

Sekiguchi, M., Y. Hobara, and M. Hayakawa, Diurnal and seasonal variations in the Schumann resonance parameters at Moshiri, Japan, J. Atmos. Electr., vol. 28, 1-10, 2008.

Shiraki, Y., Development of Immunity Prediction Technique for Printed Wiring Boards to Electrostatic Discharge Combining Conducted Immunity Measurement of ICs and Circuit Simulation, IEEJ Trans. FM, vol.130, no.5, pp.416-422. 2010.

Shvets, A.V., M. Hayakawa, M. Sekiguchi, and Y. Ando[2009], Reconstruction of the global lightning distribution from ELF electromagnetic background signals, J. Atmos. Solar-terr. Phys., vol. 71, 1405-1412, 2009.

Shvets, A.V., Y. Hobara, and M. Hayakawa[2010], Vatiations of the global lightning distribution revealed from three-station Schumann resonance measurements, J. Geophys. Res., vol. 115, A12316, doi:10. 1029/2010JA015851, 2010.

Sorokin, V. M., and M. Hayakawa, On the generation of narrow-banded ULF/ELF pulsations in the lower ionospheric conducting layer, J. Geophys. Res., vol. 113, A06306, doi:10.1029/2008JA013094, 2008.

Surkov, V. V., and M. Hayakawa [2008], Natural electromagnetic ULF noise due to fluctuations of ionospheric currents, J. Geophys. Res., vol. 113, A11310, doi:10.1029/2008JA013196, 2008.

Surkov, V. V., and M. Hayakawa[2010a], Schumann resonances exciation due to positive and negative cloud-to-ground lightning, J. Geophys. Res., vol. 115, D04101, doi:10. 1029/2009JD012539, 2010.

Surkov, V. V., Y. Matsudo, M. Hayakawa, and S.V. Goncharov[2010b], Estimation of lightning and sprite parameteres based on observation of sprite-producing lightning power spectra, J. Atmos. Solar-terr. Phys., vol. 72, 448-456, 2010.

Suzuki, E., S. Arakawa, M. Takahashi, H. Ota, K. I. Arai, and R. Sato, [2008a], Visualization of Poynting Vectors by Using Electro-Optic Probes for Electromagnetic Fields, IEEE Trans. Instrumentation and Measurement, vol. 57, no. 5, pp. 1014-1022, 2008.

Suzuki, T., K. Kusunoki, K. Hattori, and M. Hayakawa[2008b], Recent developments in portable weather radars and new experiments, Inst. Electr. Engrs. Japan, Trans. Fundamentals and Materials, vol. 128, No. 1, 2-4, 2008.

Taira, S., O, Fujiwara, FDTD Simulation on Spark Resistance Formula for Electromagnetic Fields due to Spark between Charged Metal Bars with Ferrite Core Attachment, IEICT Trans. Commun., vol.E92-B, no. 6, pp.1960-1964, 2009.

Taka, Y., O. Fujiwara, Estimation and Validation of Breakdown Field due to Approach of Hand-Held Metal from Charged Human Body, IEEJ Trans. FM, vol.130, no.5, pp.428-432, 2010.

Takahashi, M., K. Kawasaki, H. Ohba, T. Ikenaga, T. Orikasa, K. Ishiyama, N. Adachi, H.O ta, and K. I. Arai[2009], Electromagnetic near field distribution measurements using optically scanning system,

International Symposium on Electromagnetic Compatibility EMC Europe 2009, Athens, Greece.

Takahashi, M., K. Kawasaki, H. Ohba, T. Ikenaga, H. Ota, T. Orikasa, N. Adachi, K. Ishiyama, and K. I. Arai [2010], Electromagnetic near field measurements by using magnet garnet crystal, Journal of Applied Physics, vol. 107, no. 9, pp. 09E711-09E711-3, 2010.

Takahashi, N., K. Kagawa, Y. Honda, Y. Takahashi [2009],Simultaneous Switching Noise Analysis for High-Speed Interface, IEICE Trans. on Electronics, Vol.E92-C No.4, pp.460-467, 2009.

Tanaka, H., Evaluation of Information Leakage via Electromagnetic Emanation and Effectiveness of Tempest, IEICE Trans. on Information and Systems Vol.E91-D No.5, pp.1439-1446, 2008.

Toyao, H., N. Ando, T. Harada, Electromagnetic Bandgap (EBG) Structures Using Open Stubs to Suppress Power Plane Noise, IEICE Trans. on Communications, Vol.E93-B No.7, pp.1754-1759, 2010.

Tsutaoka T, K. Hatakeyama[2010], An EM Absorber and Frequency Selective Shielding by Use of Metal Fiber Array Composite, IEICE Trans. on Comm. Vol. E93-B, No.7, pp.1858-1861, 2010.

Uno, T., K. Ichikawa, Y. Mmabuchi, A. Nakamura, Y. Okazaki, H. Asai, An Approach for Practical Use of Common-Mode Noise Reduction Technique for In-Vehicle Electronic Equipment, IEICE Trans. on Communications, Vol.E93-B No.7, pp.1788-1796, 2010.

Watanabe, T., T. Matsushima, Y. Toyota, O. Wada, R. Koga, Suppression of Guard-Trace Resonance by Matched Termination for Reducing Common-Mode Radiation, IEICE Trans. on Communications, Vol.E93-B No.7, pp.1746-1753, 2010.

Williams, E., W. Lyons, Y. Hobara, V. Mushtak, N. Asencio, R. Boldi, J. Bor, S. Cummer, E. Greenberg, M. Hayakawa, R. Holzworth, V. Kotroni, J. Li, C. Morales, T. Nelson, C. Price, B. Russell, G. Satori, K. Shirahata, Y. Takahashi, K. Yamashita, Ground-Based Detection of Sprites and their Parent Lightning Flashed over Africa during the 2006 AMMA Campaign, Special Issue in the Quarterly Journal of the Royal Meteorological Society, Q. J. R. Meteorol. Soc., 136 (s1), 257-271, DOI: 10.1002/qj.489, 2010.

Wu, I., S. Ishigami, K. Gotoh, and Y. Matsumoto, [2009a], Calibration of Electric Field Probes with Three Orthogonal Elements by Standard Field Method, IEICE Electron. Express, vol.6, no.14, pp.1032-1038.

Wu, I., S. Ishigami, K. Gotoh, and Y. Matsumoto, [2009b], Calibration of Electric Field Probes in GTEM Cell using Reference Antenna Method, IEICE Electron. Express, vol.6, no.?20, pp.1469-1475.

Wu, I., S. Ishigami, K. Gotoh, and Y. Matsumoto[2009c], Dependence of Attenuation of Common Mode Radiation from Indoor Power Line Communication System on Structure of Reinforced Concrete Wall, IEICE Trans. on Communications, vol.E92-B, no.9, pp.2931-2938, 2009.

Wu, I., S. Ishigami, K. Gotoh, and Y. Matsumoto[2010], Probe calibration by using a different type of probe as a reference in GTEM cell above 1GHz, IEICE Electron. Express, vol.7, no.6, pp.460-466.

Xiao, F., K. Murano., Y. Kami, Analytical Solution for Two Parallel Traces on PCB in the Time Domain with Application to Hairpin Delay Lines, IEICE Trans. on Communications, Vol.E92-B No.6,

pp.1953-1959.

Taka, Y., O. Fujiwara, Estimation of Potential Gradient from Discharge Current through Hand-Held Metal Piece from Charged Human Body, IEICE Trans. Commun., vol.E93-B, no.7, pp.1797-1800, 2010.

Yamamoto, N., Y. Taka, O. Fujiwara, A New Method for Immunity Testing Less Dependent on Arrangements of Equipment-under-Test and Contact Discharge of ESD-Gun onto Vertical Coupling Plane, IEEJ Trans. FM, vol.130, no.5, pp.423-427, 2010.

Yamashita, K., T. Otsuyama, Y. Hobara, M. Sekiguchi, Y. Matsudo, M. Hayakawa, and V. Korepanov, Global distribution and characteristics of intense lightning discharges as deduced from ELF transients observed at Moshiri(Japan), J. Atmos. Electr., vol.29, No.2, 71-80, 2009.

Yanagisawa, R., Y. Kayano and H. Inoue[2009], Left-Handed Transmission Line Characteristics Made by F-SIR Structure on PCB, in Proc. International Symposium on EMC, pp.645-648, Kyoto Japan, Jul. 2009.

Yanagisawa, R., Y. Kayano and H. Inoue[2010a], Equivalent Circuit Analysis of F-SIR Structure with Negative Group Time Delay, in Proc. Pan-Pacific EMC Joint Meeting'10, TH-AM2-1, pp.31-34, Sendai, Japan, May 2010.

Yanagisawa R., Y. Kayano and H. Inoue [2010b], Left Hand Mode Transmission Line Characteristics Made by F-SIR on PCB, IEICE Transactions on Communications, vol.E93-B, no.7, pp.1855-1857, Jul. 2010.

Yano, M., Y. Ida, Y. Hobara, M. Hayakawa, and A. P. Nickolaenko, Reception of ELF transmitter signals at Moshiri, Japan, and their propagation characteristcs, Radio Sci., vol. 45, RS1009, doi: 10.1029/2009RS004224, 2010.

Yasuda, Y., Y. Ida, T. Goto, and M. Hayakawa, Interferometric direction finding of over-horizon VHF transmitter signals and natural VHF radio emissions possibly associated with earthquakes, Radio Sci., vol. 44, RS2009, doi:10.1029/2008RS003884, 2009.

Yoshida, S., T. Morimoto, T. Ushio, Z-I. Kawasaki, T. Torii, D. Wang, N. Takagi, and T. Watanabe[2008], High energy photon and electron bursts associated with upward lightning strokes, Geophys. Res. Lett., 35, L10804, doi:10.1029/2007GL032438, 2008.

Yoshida, S., T. Morimoto, T. Ushio, and Z.-I. Kawasaki [2009a], A fifth power relationship for lightning activity from TRMM satellite observations, J. Geophys. Res., 114, D09104, doi:10.1029/2008JD010370, 2009.

Yoshida, S., M. Akita, Y. Nakamura, T. Morimoto, T. Ushio, Z.-I. Kawasaki, D. Wang, and N. Takagi [2009b], Evidence of negative leaders prior to fast rise ICC pulses of upward lightning, J. Atmos. Electr., 29, 1, 13-21, 2009.

Yoshida, S., C. J. Biagi, V. A. Rakov, J. D. Hill, M. V. Stapleton, D. M. Jordan, M. A. Uman, T. Morimoto, T. Uhio, and Z.-I. Kawasaki[2010], Three-dimensional imaging of upward positive leaders in triggered lightning using VHF broadband digital interferometers , Geophys. Res. Lett., 37, L05805, doi:10.1029/2009GL042065, 2010.

Yoshida, T., H. Yoshihara, K. Kawasaki, N. Masui, Effect of the Shapes of Metal Electrodes on ESD Current and Radiation Noise, Proc. of the 2010 Asia-pacific International Symposium on Electromagnetic Compatibility, No. 168, 2010.

Yoshikawa, E, T. Mega, T. Morimoto, T. Ushio, Z. Kawasaki[2009], Real-Time spectral moments estimation and ground clutter suppression, for precipitation radar with high resolution, IEICE Transactions on Communications, E92-B, 2, pp.578-584, 2009.

Yoshikawa, E., S. Kida, S. Yoshida, T. Morimoto, T. Ushio, Z.Kawasak [2010a], Vertical structure of raindrop size distribution in lower atmospheric boundary layer, Geophys. Res. Lett., 37, L20802, doi:10.1029/2010GL045174, 2010.

Yoshikawa, E., T. Ushio, Z. Kawasaki, T. Mega, S. Yoshida, T.Morimoto, K. Imai, and S. Nagayama [2010b], Development and Initial observation of High Resolution Volume Scanning Radar for Meteorological Application, IEEE Trans. on Geoscience and Remote Sensing, 48, 8, pp 3225-3235, 2010.

Yumoto, K., S. Ikemoto, M. G. Cardinal, M. Hayakawa, K. Hattori, J. Y. Liu, S. Saroso, M. Ruhimat, M. Husni, D. Widarto, E. Ramos, D. McNamara, R. E. Otadoy, G. Yumul, R. Ebora, and N. Servando, A new ULF wave analysis for Seismo-Electromagnetics using CPMN/MAGDAS data, Physics and Chemistry of the Earth, Parts A/B/C, vol. 34, Issues 6-7, Special issue, Electromagnetic Phenomena Associated with Earthquakes and Volcanoes, Edited by M. Hayakawa, J. Y. Liu, K. Hattori, and L. Telesca, 360-366, 2009.

Zhou, F., S. Wu, D. Pommerenke, Y. Kayano, H. Inoue, K. Tan and J. Fan[2010a], Improvements in GMI Probe Design for Time-Domain Transient Current Measurements, in Proc. IEEE International Symposium on EMC, pp.340-343, Fort Lauderdale, FL, USA, Jul. 2010.

Zhou, F., S. Wu, D. Pommerenke, Y. Kayano, H. Inoue, K. Tan and J. Fan[2010b], Measuring IC Switching Current Waveforms Using a GMI Probe for Power Integrity Studies, Proc. 2010 Asia-Pacific International Symposium on EMC, pp.321-324, Beijing, China, Apr. 2010.