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Man-made EM Noise and Electromagnetic Compatibility (EMC)

E1. Electromagnetic Information Security

In electronic information processing and telecommunication services, leakage of information due to unintentional electromagnetic (EM) radiation or emission has a large impact on information security. Tosaka *et al*. investigated a method for determining whether information is contained in EM disturbance radiated from a PC display [Tosaka 2011]. In the IEEE EMC Society, Subcommittee on EM Leakage, under TC-5: High Power Electronics, has been actively studying on the electromagnetic information leakage, and Hayashi *et al*. organized the "Special Section on Electromagnetic Information Security" in IEEE Trans. on Electromagnetic Compatibility [Hayashi 2013-a] and seven papers were published in vol. 55, no. 3 in June 2013. Topics of the papers include theoretical studies on information propagation via EM fields, acquisition, measurement, and analysis techniques for information leakage from information and communication devices via EM fields, modeling and simulation techniques for the evaluation of EM information leakage. Sekiguchi *et al*. discussed maximum receivable distance on EM information leakage [Sekiguchi 2013]. Hayashi *et al*. evaluated and analyzed EM radiation associated with cryptographic devices [Hayashi 2013-b, 2013-c]. Iokibe *et al*. utilized an equivalent circuit model (ICEM and LECCS) developed for pre-estimation of unintentional RF emission from power distribution networks, and developed modeling and simulation technique to evaluate cryptographic devices [Iokibe 2013-a].

The process of obtaining additional information from the internal activity of a physical device through unintentional channels is called "side channel attack". Internal activity of cryptographic devices generates fluctuation on circuits such as power supply network, which is the unintentional channel in this case, and it can be detected in EM observation. The fluctuation can be generated by intentional EM interferences (IEMI) [Sauvage 2013]. Hayashi and others also has published many papers on IEMI and information leakage, countermeasures against attacks, and electrostatic discharge (ESD) threats related to information leakage [Hayashi 2011-a, 2011-b] [Takahashi 2012] [2013-d, 2013-e]. Iokibe *et al*. presented development and improvement of the equivalent circuit model and countermeasure for side-channel attack [Iokibe 2011, 2013-b] [Amano 2012]. Works on evaluation and mapping of leakage sources and suppression were published [Ikematsu 2011] [Shimada 2012] [Hayashi 2012] [Kinugawa 2011, 2013] [Nakasone 2013].

E2. Integrated Circuits and Chip Level EMC

Conventionally the electromagnetic interference (EMI) and EM susceptibility problems of electronic systems were discussed after design and fabrication of electronic units or apparatuses. However, due to miniaturization and high functionality with low power consumption of these apparatuses, sensitivity to EMI has been increasing and requirement for low EMI has become stricter. In this context, consideration for EMI reduction has necessarily been shifted to early design stages in integrated circuits and other semiconductor chip designs. Requirement for EM immunity is also one of the main concerns in chip and circuit design.

Modeling of chip level EMC including emission and immunity is actively discussed recently. Standardization of EMC models for emission and immunity is ongoing in the International Electrotechnical Commission (IEC); the macro-model for conducted emission simulation ICEM-CE, IEC 62433-2, has been published, and radiated emission model ICEM-RE, ICE 62433-3, and recently the conducted immunity model ICIM-CI, IEC 62433-4, have been proposed. Works related to the models and evaluation methods have been published. Wada *et al.* reported an extension of their conducted emission model, LECCS, in time-domain, and discussed program dependency of emission from micro-controllers [Wada 2011]. Nagata *et al.* prepared a test CMOS chip embedding a high precision on-chip waveform monitor, and demonstrated the relation of AC power noise components with the parallel resonance seen from on-chip digital circuits in simulation with their capacitor charging model of digital circuits [Yoshikawa 2011]. They also performed immunity evaluation of SRAM core using the direct RF power injection (DPI) method, IEC 62132-4, with on-chip voltage waveform monitor and diagnosis structures of memory built-in self test (MBIST) [Sawada 2011]. Muroga *et al*. applied the on-chip monitor technique to evaluate in-band spurious attenuation in LTE-class RFIC chip, and proposed a noise suppression technique using a soft magnetic thin film [Muroga 2013]. Paoletti *et al*. proposed a new concept to extract a noise model of LSI power supply above 1 GHz with a new equipment, the printed reverberation board [Paoletti 2012]. Nakayama *et al*. proposed a new current measurement technique for each pin of a BGA package [Nakayama, T. 2012].

Power supply noise reduction is one of the main issues to control EMC and power and signal integrity (PI/SI). Sudo *et al*. discussed power supply noise reduction by on-chip capacitances [Fujii 2011], on-chip power integrity evaluation system for power supply noise dependent on on-chip and off-chip capacitances [Nabeshima 2011], the simultaneous switching noise (SSN) and jitter of FPGA [Fijita 2012]. They also discussed the effects of critically damping of total PDN impedance in chip-package-board co-design [Kobayashi 2012], EMI peak frequency simulation depending on power supply transfer impedance [Hatogai 2012], co-analysis of signal and power integrity of 3D stacked package [Ikemiya 2012], and anti-resonance peak in power supply network [Yamaguchi, T. 2013] [Kiyoshige 2013]. Sasaki *et al*. discussed the noise coupling in mixed-signal system-in-packages (SiPs), which is a chip-on-chip stack of a Class-D speaker amplifier LSI with a DC-DC converter and a sound source LSI with PLL [Sasaki 2011].

In high frequency region, parasitic coupling between a chip, a package and a board can cause parasitic resonances, and it can cause serious power and signal integrity (PI/SI) problems. Matsushima *et al.* discussed a new type of resonance which they call “package-common-mode resonance”, and they demonstrated degradation of PI/SI [Matsushima 2011] [Nishimoto 2012].

E3. Printed Circuit Board (PCB) EMC, Transmission Lines and Cables

E3-1. EMC design of PCB and its enclosure

He *et al.* discussed suppression of the cavity mode resonance with a PCB mounted to a metal chassis. A resistance is added in series to the conducting mounting posts and they derived a closed-form expression for determining an optimal series resistance to damp these cavity resonances [He 2011]. Yamaguchi *et al.* evaluated source bus line current in LCD panel in measurement and simulation [Yamaguchi M. 2011].

E3-2. Power distribution network (PDN) design method

PDN noise has large impact on EMC, and suppression and/or decoupling of the PDN noise is an important topic in EMC design of printed circuit boards and IC/LSI. In high frequency region, electromagnetic band gap (EBG) structure is one promising PDN noise decoupling scheme in a PCB. Kawase *et al*. investigated EMI suppression of a 10 Gbit/s optical transceiver by EBG [Kawase 2011]. Toyota *et al.* proposed a lossy resonator filter consisting of an open stub covered with magnetic thin film to suppress power-bus resonances [Toyota 2013].

E3-3. Signal lines and cables: Common-mode control

Common mode is one of the major sources of unintentional radiated emission, and controlling it in PCBs and cables attached to them is a basic requirement. Kayano *et al.* proposed models to predict EM radiation caused by common-mode current on a cable attached to a PCB and differential-pair lines on a PCB [Kayano 2011, 2012, 2013]. Common-mode suppression with common-mode chokes and noise filters were discussed [Saito 2011] [Oka 2011] [Nakamoto 2012].

Mechanism of common-mode generation has been widely discussed to control radiated emission. Particularly, it has been well known recently that mode conversion from the differential mode, or the normal mode, to the common-mode is relating to the imbalance of transmission lines and “imbalance difference” is a major mechanism of common-mode generation. Sejima *et al.* explained model validation of the mode-conversion sources with introducing a modal equivalent circuit [Sejima 2012]. Matsushima *et al.* applied the imbalance difference model to differential transmission lines and proposed techniques to suppress common mode generation [Matsushima 2012, 2013]. Ideguchi *et al*. applied a resistive film sheet to suppress radiated emission [Ideguchi 2013]. Maeda *et al*. proposed an estimation method for n-port S parameters with n-1 port measurements [Maeda 2013].

E4. Automotive EMC

With increase of electronic appliances in a vehicle, automotive EMC has been a very hot topic. In addition to it, wireless communication application is increasing in car systems. There have been some intensive works on electromagnetic environment in a car. Maeda *et al.* proposed a method to provide probability distribution of electric field strength in automotive cabin [Maeda 2011]. To implement a local area network (LAN) on an automobile, they also proposed a modeling for an automotive LAN to optimize the wire lengths in the network to secure the signal integrity at every communication node [Mori 2011]. To maintain signal integrity on the Controller Area Network (CAN), they investigated the ringing phenomenon in a linear passive star CAN with connected EUCs, and proposed a ringing suppression circuit [Mori 2012]. They also proposed a receiver circuit to achieve higher data rates in the linear passive star CAN [Mori 2013]. In the automotive environment, the immunity characteristics are really critical for safety. Oguri and Ichikawa proposed a simulation technique to predict malfunction frequencies in the immunity test [Oguri 2012].

E5. Power Electronics EMC

In accordance with development of high-performance switching devices, the noise frequency range of power electronics devices have been expanding from kHz range to MHz and several hundred MHz range. It may cause serious EMI problems. Ibuchi and Funaki discussed EMI noise source modeling with current sources for a power conversion circuit [Ibuchi 2012], and air-core inductor copper loss model for high-frequency power conversion applications [Ibuchi 2013]. Kamikura *et al.* discussed the mode conversion between common-mode and differential-mode noises in EMI filters for power electronics circuits [Kamiura 2013]. Yamada *et al.* presented simulation results of electromagnetic (EM) noise generated by fast switching circuits with gallium nitride (GaN)-based power devices. They analyzed conducted and radiated noise up to several hundred MHz [Yamada 2013].

E6. EMC Problems Related to Telecommunication System

Due to the shift from analog to the digital broadcasting and digital wireless communication, situation of the EMC related to the telecommunication systems has been greatly changed. Kuwabara *et al.* evaluated the effect of disturbances from electrical equipment on a digital TV signal. They evaluated the disturbance using the quasi-peak (QP) value, amplitude probability distribution (APD), average power, and the received images were evaluated using mean opinion score (MOS) and bit error rate (BER) [Kuwabara 2011]. Higashiyama and Tarusawa proposed a method for evaluating the distribution of an electric field to assess the RF human exposure compliance of indoor radio base stations employing a built-in antenna that radiates broadband RF signals such as an Orthogonal Frequency Division Multiplexing (OFDM) signal [Higashiyama 2011].

Matsumoto *et al.* of EMC Group in the National Institute of Information & Communication Technology (NICT) have been continuing intensive investigation on EMC issues related to digital broadcasting and communication systems. Ishigami *et al.* of NICT received the Richard B. Schulz Transactions Prize Paper Award for the paper titled, “A New Method of Interference Evaluation between an Ultrawideband System and a Wireless LAN Using a Gigahertz Transverse Electromagnetic Cell.” at the 2011 IEEE International Symposium on EMC [Ishigami 2010]. It is a method of evaluating the interference to a wireless LAN with a built-in antenna using a gigahertz transverse electromagnetic (GTEM) cell. The strength of the interfering electromagnetic field to be applied to the victim can be directly calculated from a given equivalent isotropically radiated power and propagation distance of the interfering signal in free space. As an example of use of the method, they conducted an evaluation of interference between an IEEE 802.11a wireless LAN and a direct-sequence spread-spectrum UWB.

From their group, there were some papers presented in symposiums. Matsumoto *et al*. discussed the accuracy of Gaussian approximation applied to impulsive interference in OFDM reception [Matsumoto 2011]. Gotoh, *et al*. reported evaluation of EM disturbance using pulse duration distribution [Gotoh 2012]. In another study, they performed interference experiments to evaluate degradation of satellite broadcasting interfered by microwave ovens emission [Gotoh 2013]. Regarding the emission limits mainly applied for microwave ovens emission above 1 GHz in CISPR 11, it has been proposed in CISPR B to delete the peak limits and only to use the weighted (a kind of average) limits for a compliance test.

The spread spectrum clock (SSC) is known to have the ability to reduce the quasi-peak level of clock harmonics noise. However, SSC may also have an adverse effect on wireless systems. Ohmae *et al.* developed a SSC with optimized parameters that has a beneficial effect on one-segment broadcasting, which is based on orthogonal frequency division multiplexing (OFDM) and is used for mobile TV [Ohmae 2012]. Honda *et al*. introduced a new surveillance system named as OCTPASS (Optically Connected Passive Surveillance System) which is under development at Sendai airport by research institute `Electronic Navigation Research Institute (ENRI)'. The OCTPASS using the RoF (Radio over Fiber) has better interference immunity in multipath environment in comparison with the conventional system [Honda 2013]. They simulated propagation characteristics on the airport surface. Numerical simulations showed received powers computed by the ray tracing method.

E7. Numerical Techniques for EMC Simulation

With the increase of circuit complexity and its density, the scale of numerical simulation has become huge, and new numerical techniques are required. Asai *et al.* introduced some new techniques to large scale circuit simulation with EM coupling in high frequency. Sekine *et al.* extended the latency insertion method (LIM) to include complex EM coupling and proposed the block-latency insertion method (block-LIM) [Sekine 2011-a, 2011-b, 2011-c]. They also applied an extended finite-difference time-domain (FDTD) method, a hybrid implicit-explicit (HIE)-finite-difference time-domain (FDTD) method, on graphics processing unit (GPU) for massively parallel electromagnetic field simulation and described its implementation and estimation [Unno 2012].

Another field of large scale simulation is EM field distribution evaluation. Nakayama *et al*. introduced a new equation for calculating the electric field strength in the boundary region between near and far fields, and they applied the method to electric field strength in close vicinity of half-wavelength dipole antennas [Nakayama, M. 2012, 2013]. Hikage *et al.* performed large-scale numerical simulations of the electromagnetic fields inside an aircraft excited by 800 MHz cellular radio. They employed the parallel FDTD technique to estimate field distributions throughout the cabin, and estimated the effect of absorption by the passengers' bodies inside the cabin [Hikage 2011]. Nagaoka *et al*. evaluated the specific absorption rate (SAR) in a human body by the finite-difference time domain (FDTD) method with anatomically realistic computational human models. To improve the method's calculation speed and realize large-scale computing with the computational human model, they adapt three-dimensional FDTD code to a multiple graphics processing unit (multi-GPU) cluster environment with Compute Unified Device Architecture (CUDA) and Message Passing Interface [Nagaoka 2013].

E8. EMC measurement technology & EMC Test Facilities

E8-1. Near field measurement and EM field probes

Near field measurement gives useful information to control undesirable EM noise emission, locating EM emission sources, noise coupling paths, and also field distribution in immunity test. Funato *el al*. proposed a stand-alone electric-field probe to measure electric field inside an enclosure for investigating immunity testing at high electric fields. They evaluated the probe with electric fields of 10 to 100 V/m in the frequency range up to 1 GHz [Funato 2011]. They also investigated a magnetic near-field probes consisting of dual ferrite-core coils [Funato 2012], and an electric field probe with double position signal difference method to independently extract the normal and tangential electric near-field components using two measurements at slightly different heights above the test object [Funato 2013].

Xiao *el al*. proposed a new measurement system for scanning the complex near field on a printed circuit board (PCB) [Xiao 2012]. The measurement is based on the 6-port technique. Yamaguchi *el al*. developed a new Si on-chip planar shielded loop coil with 60 × 60 μm^2 window size for high special resolution magnetic near field measurements. They set the probe on a 3-D scanner with positioning accuracy of 10 μm with yaw, pitch, and roll angles adjustor, and measured magnetic near field distribution on an LTE (Log Term Evolution)-class CMOS RFIC receiver test element group (TEG) chip they developed [Yamaguchi, M. 2013]. Murano *et al.* proposed a new method for suppressing near-magnetic field generated around a printed circuit board (PCB) [Murano 2013]. They implemented some active circuit components such as a varactor diode, and controlled the target frequency of field suppression by externally changing the bias voltage.

E8-2. EM environment

Recently, new types of electric and electronic household appliances have popularly used, which can cause new types of EMC problems. Energy-conservation equipment, such as light-emitting diode

(LED) lamps, operates with high speed switching and it can cause unintentional electromagnetic emissions. IH cookers and power electronic devices also generate unintentional EM fields. Evaluation of EM environment related to these new EM noise sources have been reported.

Mizuno *et al.* reported results of field surveys of low frequency magnetic field in living environments; field characteristics generated by household appliances, and other field characteristics in living environments [Mizuno 2011]. Ishigami *et al.* analyzed electromagnetic-field attenuations of some kind of buildings in very-high frequency (VHF) band numerically by using the finite-integration (FI) method [Ishigami 2012]. They also proposed a measurement method to identify noise from an LED lamp that causes electromagnetic interference. They compared the time domain variation of EM noise and light emission from LEDs which generate product-specific switching patterns. The effectiveness of the proposed method was demonstrated experimentally [Matsumoto 2013]. Komatsu *et al.* evaluated far-field radiation and near-field leakage of self-resonant spiral antennas for coupled-resonant wireless power transfer system [Komatsu 2013]. Sato *et al.* proposed a real-time measuring method of 3D EM field distributions using a built-in infrared camera of a home video game controller [Sato 2013].

E8-3. Antenna calibration

Several groups have reported antenna calibration methods. Ishii *et al.* reported comparison between the three-antenna method and the equivalent capacitance substitution method for calibrating electrically short monopole antenna [Ishii 2011]. Morioka *et al.* proposed a new method to calculate the properly defined antenna factor (AF) of a dipole antenna including environmental and terminal conditions. The AF obtained by the proposed method is free from the mutual coupling effects and the imperfect applied plane wave due to the finite separation from the transmitting antenna [Morioka 2011-a]. Morioka also proposed a simple calibration method for E-field probes using dipole antenna factors (AF) and uncertainty associated with this method was overviewed [Morioka 2011-b]. They also discussed error on AF of a shortened dipole antenna by the reference antenna method at a finite separation [Morioka 2013]. Fijii, Sugiura *et al.* discussed the uncertainty for the three antenna method and the standard antenna method [Fujii 2012], and the equivalent capacitance substitution method for monopole antenna calibration [Sugiura 2012-a].

A folded rhombic antenna as a broadband antenna for measuring a radiated electromagnetic emission was numerically analyzed using the finite integration method in frequencies from 100 MHz to 6 GHz. In the analysis, radiation patterns, absolute gains, front-to-back ratios (F/B), and antenna impedances were calculated for three types of antenna dimensions. As a result, the antenna is applicable to the emission measurement in frequencies from 110 MHz to 2 GHz as a broadband antenna that has larger F/B than that of a biconical antenna and more compact size than that of a log-periodic dipole array antenna [Ishigami 2011].

E8-4. Radiated emission measurement

The frequency range of standardized radiated emission measurement has been extended upward above 1 GHz, and is now being extended downward below 30 MHz. However, there exist problems to solve relating to evaluation of test sites, equipment, and measurement methods. Ameya *et al*. proposed a new site evaluation technique for anechoic chambers above 1 GHz. The proposed method using plane-wave spectral decomposition and fish-eye lens camera enables to obtain the intensity and the angle of arrival of reflection waves from walls, ground and ceiling [Ameya 2011]. Maeda *et al*. proposed another method to evaluate radiated emission test sites above 1 GHz as free-space by means of wave propagation measurements using a conical dipole antenna [Maeda 2012]. To ensure the site-to-site measurement reproducibility of radiated and conducted measurement, Voluntary EMC Laboratory Accreditation Center (VLAC) has organized Proficiency Testing (PT) program of EMI measurement. Osabe *et al*. reported results of the PT program; standards compliance uncertainty for radiated emission measurement, data evaluation criteria for radiated emission test, and evaluation method of proficiency test results on EMI measurement [Osabe 2011, 2012, 2013].

To ensure reproducibility in the radiated emission measurement, VCCI Technical Sub-committee has investigated the dispersion of radiated emission measurement results, and it was confirmed that one of the main cause of the dispersion of radiated emission measurement results was the difference of the power line-to-ground impedance of the power supply for the equipment under test (EUT). To control the line impedance, including the common-mode impedance of a mains cable, they proposed VHF LISN (Very High Frequency Line Impedance Stabilization Network), and reported the results of a round-robin test on the effectiveness of the VHF LISN [Miyazaki, C. 2011]. At present, radiated emission measurement standards do not specify the common mode impedance for the outlet terminal of mains network to the equipment under test (EUT) in the test site. Okuyama *et al*. evaluated the effect of the VHF LISN and the common mode absorbing device (CMAD) specified in CISPR 16-1-4. Though the results showed effectiveness of both, the VHF-LISN is superior to the CMAD; the VHF-LISN can fix both the differential-mode and common-mode impedances independently while the CMAD only control the total common mode [Okuyama 2013].

Some of the information technology equipment (ITE) such as a personal computer is constructed by combining modules such as a hard disc drive and memory boards. To control the undesirable emission generated by each module, module level emission measurement was proposed and used in Japan. Abe *et al*. applied this method in the frequency range from 1 GHz to 6 GHz, and evaluate the power supply current noise and decoupling characteristics with capacitors on the DC supply line of a hard disc drive [Abe 2012]. The measurement method is an extension of the magnetic probe (MP) method, IEC 61967-6. Tohya *et al*. reported test results of the module level test comparing with CISPR 22 [Tohya 2012].

E8-5. Conducted emission measurement

In conjunction with the progress of power electronics as well as digital communication, conventional techniques of conducted emission measurement still need extension and improvement. One of the important applications is the broadband power line telecommunication (PLT) or power line communication (PLC) systems. Sugiura and Kami theoretically discussed generation and propagation of the common-mode currents in a balanced two-conductor line utilizing a newly developed equivalent circuit, and show the validity in comparison with numerical results [Sugiura 2012-b].

Evaluation of RF noise generation by power electronics equipment is a critical issue particularly in extension of frequency range and development of the measurement equipment with new standards. Coupling and decoupling networks for emission (CDNEs) are used in an alternative method for measuring radiated emission from lighting equipment, such as LED lamps, in the frequency range of 30 to 300 MHz. Hirasawa *et al*. evaluate the correlations between radiated emission measurements and conducted disturbance measurement using the CDNE method, and the results showed the correlations are weak. They also showed the effects of longitudinal conversion loss (LCL), and LCL requirements are necessary when measuring the disturbances of which differential-mode components are dominant [Hirasawa 2012].

E8-6. Immunity test facilities

The electromagnetic field immunity test requires uniformity of electric field. Uchida *et al*. applied the array antenna technology to generate high uniformity of electric field and high power electric field near the antenna, in wideband, by beam forming technology. Their system is constructed by a 128-element array antenna with low price and low power amplifiers [Uchida 2013].

E9. EM Wave Absorbing and Shielding Materials' Design

E9-1. EM wave absorber

There have been many works on new types of EM absorbers, designs and applications. Yamamoto and Hatakeyama proposed EM-wave absorber composed of straight metal wire array sheet and a ferrite-powder/rubber mixture plate, and discussed its characteristics and design including two resonant frequencies [Yamamoto 2011, 2012-a, 2012-b, 2013]. Hashimoto *et al*. proposed two-layered wave absorber using short carbon fibers [Kato, 2011], a thin wave absorber using an admittance sheet composed of closely placed conductive and resistive films [Tsuda 2011-a,2011-b], absorbers using foamed polyimide containing carbon black [Takano 2011], etc. They also discussed multi-layered translucent wave absorber using carbon fibers and its application to portable anechoic chamber [Yasuzumi 2012-a], and evaluation of absorber placed on ceiling of ETC gate [Yasuzumi 2012-b].

Electromagnetic band-gap (EBG) structures were applied to absorbers. Yagitani *et al.* discussed absorption characteristics of a tunable thin EBG absorber consisting of an array of mushroom unit cells and lumped resistors, and applied it to capture the 2-d image of radio-frequency (RF) power distribution [Yagitani 2011]. Shinohara *et al*. also proposed a thin wave absorber composed of mushroom structures [Shinohara 2012].

E9-2. EM material characterization

Many types of materials for EMC applications have been reported in wide ranges of frequencies above GHz and millimeter waves.

Yamada *et al.* reported high-performance laminated thin-film shield with conductors and magnetic material multilayer in UHF band [Yamada 2011]. Kik and Nishikata proposed a new calibration algorithm for the waveguide-penetration method to evaluate the complex permittivity and permeability in the S-band [Kik 2011]. Tsutaoka *et al.* reported characterization of ferrite materials including metamaterials; metal granular composite materials, spinel ferrite composites, negative permeability spectra of YIG composite materials [Tsutaoka 2011, 2012, 2013-a, 2013-b]. Wakatsuchi discussed reproducible measurements of complex permittivity to crystalline lens from 500 MHz to 50 GHz [Wakatsuchi 2012].

E10. Electrostatic Discharge (ESD) Measurement and Simulation

Kuriyama *et al.* proposed a silicon micro-mirror array to measure EM field distribution at ESD events [Kuriyama 2012]. Asai and his group discussed simulation of ESD with circuit and electromagnetic hybrid modeling [Sekine 2012, 2013] [Takada 2012]. Mori *et al.* also discussed a simulation to calculate discharge currents for air discharges of ESD-guns [Mori 2011]. Xiao *et al.* proposed a model of secondary ESD for a portable electronic product [Xiao 2012]. Masugi *et al.* performed analysis of ESD and discussed the effect of discharge gap shape [Masugi 2012-a, 2012-b].

Natural EM Noise

E11. Electromagnetic Phenomena Associated with Earthquakes

The disastrous Japan earthquake (EQ) in March 2011 reminds us of the importance of EQ prediction, particularly "short-term EQ prediction". The short-term EQ prediction means that we predict an EQ with the timescale of a few days to a few weeks before an EQ with the information on the possible epicenter and magnitude. This prediction has been carried for many years on the basis of conventional mechanical methods (such as the measurement of crustal movements with seismometers), but it is recently confirmed that this method is not suitable for short-term EQ prediction. On the other hand, there has appeared a new wave based on electromagnetic effects and there has been a lot of progress of seismo-electromagnetic effects during the last few decades, with a hope of possible EQ prediction.

Before the earthquake, Hayakawa *et al*. reported a statistical study on the correlation between lower ionospheric perturbations as seen by subionospheric VLF/LF propagation and earthquakes [Hayakawa 2010]. An extensive period of data over 7 years from January 2001 to December 2007 and a combination of different propagation paths in and around Japan were used to examine the statistical correlation between the VLF/LF propagation anomaly (average nighttime amplitude, dispersion, and nighttime fluctuation) and earthquakes with magnitude >6.0. They found that the propagation anomaly exceeding the 2σ (standard deviation) criterion indicating the presence of ionospheric perturbation is significantly correlated with earthquakes with shallow depth (<40 km). They also discussed the mechanism of seismoionospheric perturbations. Hobara *et al.* introduced various ground-based radio physical measurements to study seismo-electromagnetic signals [Hobara 2011-a], and reported statistical analysis of the ULF magnetic field data during earthquake swarm around Izu Island [Hobara 2011-b].

After the Japan earthquake, Hayakawa *et al*. published a "Special Issue on Earthquake Precursors" in Annals of Geophysics, Vol 55, No 1 in 2012, and it included 22 papers presenting some of the recent results obtained from around the world. Three of them were from groups including Japanese members. Hayakawa *et al*. presented a possible precursor to the March 11, 2011, Japan earthquake: ionospheric perturbations as seen by subionospheric very low frequency/low frequency propagation [Hayakawa 2012-a]. Kopytenko *et al*. reported the anomaly disturbances of the magnetic fields before the earthquake [Kopytenko 2012]. Ono *et al*. reported ionospheric perturbations associated with two huge earthquakes in Japan [Ono 2012].

The Open Street Map Project (OSM) is creating a world geographic database that can be edited by anyone. Its activities have high social significance. Hayakawa *et al*. reported the relevance of the information quality of OSM. They compared the data of other regions and before the Great East Japan Earthquake to the Japanese data to analyze community activities, and analyzed the transitions

[Hayakawa 2012-b] [Imi 2012].

E12. Lightning

Lightning on power distribution lines can damage home electric appliances. Miyazaki *et al*. reported the patterns of intrusion of lightning surges into residences, data on 18 lightning strokes between 2003 and 2006, observed by the Tokyo Electric Power Company using lightning surge waveform detectors installed at ordinary residences [Miyazaki, T. 2010]. They also reported analysis of distribution-line faults caused by lightning based on the 284 datasets including data on 62 direct flashes to lines [Miyazaki, T. 2011]. Toyonaga *et al.* reported lightning damage to underground cables [Toyonaga 2011]. Sekioka *et al.* proposed an analytical formula based on the Return-Stroke Model for calculating lightning-induced voltages on an infinitely long overhead line generated by a lightning stroke [Sekioka 2011].

The operating voltages of low-voltage control circuits in power stations and substations have become lower with the installation of digital control equipment. This significantly increases the risk of faults and malfunctions of the circuits resulting from overvoltages in the control circuits due to lightning and switching surges. Tatematsu *et al.* reported experimental study of lightning and switching surges-induced overvoltages in low-voltage control circuits a gas-insulated switchgear (GIS) model with two instrumental transformers, and digital-type protection-relay equipment [Tatematsu 2013]. Lightning has caused considerable damage to telecommunications equipment that has multiple ports, such as home gateways. As a protection device, Masuda and Hiroshima reported a new compact multi-electrode gas discharge tube (GDT) and showed its characteristics [Masuda 2013]. Yutthagowith performed calculations of lightning transient potential rises in grounding systems. In the paper they applied the partial element equivalent circuit (PEEC) method, adopting a modified image method. The effect of retardation in the PEEC method is also investigated [Yutthagowith 2011]. Yuda applied the transmission-line modeling (TLM) method to analyzing transient responses of grounding electrodes and lightning-induced voltages on an overhead wire [Yuda 2013].

References

Abe, Y., N. Kuwabara, H. Muramatsu, T. Shimasaki [2012], “Method of measuring disturbances from modular devices by magnetic probe method above 1 GHz,” 2012 International Symposium on Electromagnetic Compatibility (EMC EUROPE), A:8:5, pp.1-6, 17-21 Sept. 2012.

Akiyama, Y., Y. Aotani, K. Okada, H. Muramatsu [2013], “Comparison of conducted disturbance voltages at telecommunication ports measured using different reference ground planes in accordance with CISPR 32,” 2013 IEEE International Symposium on Electromagnetic Compatibility (EMC), pp.611-615, 5-9 Aug. 2013.

Amano, T., K. Iokibe, Y. Toyota [2012], “Equivalent current source of side-channel signal for countermeasure design with analog circuit simulator,” 2012 IEEE International Symposium on Electromagnetic Compatibility (EMC), pp.806-811, 6-10 Aug. 2012.

Ameya, M., S. Kurokawa, I. Watanabe, M. Yamaguchi, R. Hasumi [2011], “Evaluation technique for EMI anechoic chamber over 1 GHz by plane-wave spectral decomposition and fish-eye lens camera,” 2011 International Symposium on Electromagnetic Compatibility (EMC EUROPE 2011 York), pp.186-191, 26-30 Sept. 2011.

Fujii, H., Y. Kobayashi, T. Sudo [2011], “Evaluation of power supply noise reduction by implementing on-chip capacitance,” 8th Workshop on Electromagnetic Compatibility of Integrated Circuits (EMC Compo), pp.219-223, 6-9 Nov. 2011.

Fujii, K., M. Alexander, A. Sugiura [2012], “Uncertainty analysis for three antenna method and standard antenna method,” 2012 IEEE International Symposium on Electromagnetic Compatibility (EMC), pp.702-707, 6-10 Aug. 2012.

Fujita, H., Y. Iijima, T. Sudo [2012], “Measurement and analysis of SSN and Jitter of FPGA,” 2012 International Symposium on Electromagnetic Compatibility (EMC EUROPE), P2-2:12, pp.1-6, 17-21 Sept. 2012.

Funato, H., T. Suga [2011], “Stand-alone electric-field probe for measurements within enclosures,” 2011 IEEE International Symposium on Electromagnetic Compatibility (EMC), pp.11-15, 14-19 Aug. 2011.

Funato, H., T. Suga, M. Suhara [2012], “Measurement-based modeling of dual loop magnetic near-field probe,” 2012 IEEE International Symposium on Electromagnetic Compatibility (EMC), pp.714-719, 6-10 Aug. 2012.

Funato, H., T. Suga, M. Suhara [2013], “Double position-signal-difference method for electric near-field measurements,” 2013 IEEE International Symposium on Electromagnetic Compatibility (EMC), pp.621-625, 5-9 Aug. 2013.

Gotoh, K., T. Shinozuka, S. Ishigami, Y. Matsumoto [2012], “Electromagnetic disturbance evaluation using pulse duration distribution,” 2012 International Symposium on Electromagnetic Compatibility (EMC EUROPE), P3-3:8, pp.1-5, 17-21 Sept. 2012.

Gotoh, K., S. Ishigami, T. Shinozuka Y. Matsumoto [2013], "Interference study of microwave ovens emission with satellite broadcasting according to the emission limits in CISPR 11," 2013 International Symposium on Electromagnetic Compatibility (EMC EUROPE), pp.717-720, 2-6 Sept. 2013.

Hatogai, Y., H. Sasaki, T. Sudo [2012], "EMI peak frequency forecast by power supply transfer impedance with on-chip property," 2012 International Symposium on Electromagnetic Compatibility (EMC EUROPE), P2-2, pp.1-4, 17-21 Sept. 2012.

Hayakawa, M., Y. Kasahara, T. Nakamura, F. Muto, T. Horie, S. Maekawa, Y. Hobara, A. Rozhnoi, M. Solivieva, 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.

Hayakawa, M., Y. Hobara, Y. Yasuda, H. Yamaguchi, K. Ohta, J. Izutsu, T. Nakamura [2012-a], "Possible precursor to the March 11, 2011, Japan earthquake: ionospheric perturbations as seen by subionospheric very low frequency/low frequency propagation," Annals of Geophysics, Vol 55, No 1, pp. 95-99.

Hayakawa, T., Y. Imi, T. Ito [2012-b], "Analysis of Quality of Data in Open Street Map," 2012 IEEE 14th International Conference on Commerce and Enterprise Computing (CEC), pp. 131-134.

Hayashi, Y., N. Homma, T. Sugawara, T. Mizuki, T. Aoki, H. Sone [2011-a], "Non-invasive EMI-based fault injection attack against cryptographic modules," 2011 IEEE International Symposium on Electromagnetic Compatibility (EMC), pp.763-767, 14-19 Aug. 2011.

Hayashi, Y., S. Gomisawa, Y. Li, N. Homma, K. Sakiyama, T. Aoki, K. Ohta [2011-b], "Intentional electromagnetic interference for fault analysis on AES block cipher IC," 2011 8th Workshop on Electromagnetic Compatibility of Integrated Circuits (EMC Compo), pp. 235-240, 6-9 Nov. 2011.

Hayashi, Y., N. Homma, T. Ikematsu, T. Mizuki, T. Aoki, H. Sone, J.-L Danger [2012], "An efficient method for estimating the area of information propagation through electromagnetic radiation," 2012 IEEE International Symposium on Electromagnetic Compatibility (EMC), pp.800-805, 6-10 Aug. 2012.

Hayashi, Y.-I., N. Homma, T. Watanabe, W. O. Price, W. A. Radasky [2013-a], "Introduction to the Special Section on Electromagnetic Information Security," IEEE Trans. on Electromagnetic Compatibility, vol. 55, no. 3, pp. 539-546.

Hayashi, Y.-I., N. Homma, T. Mizuki, H. Shimada, T. Aoki, H. Sone, L. Sauvage, J.-L. Danger

[2013-b], “Efficient Evaluation of EM Radiation Associated with Information Leakage from Cryptographic Devices,” IEEE Trans. on Electromagnetic Compatibility, vol. 55, no. 3, pp. 555-563.

Hayashi, Y.-I., N. Homma, T. Mizuki, T. Aoki, H. Sone, L. Sauvage, J.-L. Danger [2013-c], “Analysis of Electromagnetic Information Leakage From Cryptographic Devices With Different Physical Structures,” IEEE Trans. on Electromagnetic Compatibility, vol. 55, no. 3, pp. 571-580.

Hayashi, Y., N. Homma, T. Mizuki, T. Aoki, H. Sone [2013-d], “Transient IEMI Threats for Cryptographic Devices,” IEEE Trans. on Electromagnetic Compatibility, vol. 55, no. 1, pp. 140- 148.

Hayashi, Y.-I., N. Homma, T. Mizuki, T. Aoki, H. Sone [2013-e], “Map-based analysis of IEMI fault injection into cryptographic devices,” 2013 IEEE International Symposium on Electromagnetic Compatibility (EMC), pp.829-833, 5-9 Aug. 2013.

He, X., T. Hubing, H. Ke, N. Kobayashi, K. Morishita, T. Harada [2011], “Calculation of Optimal Ground Post Resistance for Reducing Emissions from Chassis-Mounted Printed Circuit Boards,” IEEE Trans. on Electromagnetic Compatibility, vol. 53, no. 2, pp. 475-481.

Higashiyama, J., Y. Tarusawa [2011], “RF exposure compliance assessment for radio base station with built-in antenna,” 2011 International Symposium on Electromagnetic Compatibility (EMC EUROPE 2011 York), pp. 90-93, 26-30 Sept. 2011.

Hikage, T., S. Hiraiwa, T. Nojima, S. Futatsumori, A. Kohmura, N. Yonemoto [2011], “Numerical estimation of the electric field distributions due to mobile radio in an aircraft cabin based on large scale FDTD analysis,” 2011 International Symposium on Electromagnetic Compatibility (EMC EUROPE 2011 York), pp.523-526, 26-30 Sept. 2011.

Hirasawa, N., S. Kanno, Y. Akiyama [2012], “Issues on the method of conducted disturbances measurement by using coupling and decoupling networks for emission,” 2012 International Symposium on Electromagnetic Compatibility (EMC EUROPE), P1-1:8, pp.1-5, 17-21 Sept. 2012.

Hobara, Y., M. Hayakawa [2011-a], “Ground-based measurement of the seismo-electromagnetic signals,” 2011 XXXth URSI General Assembly and Scientific Symposium.

Hobara, Y., T. Kamoi, M. Hayakawa [2011-b], “Statistical analysis of the ULF magnetic field data during earthquake swarm,” 2011 XXXth URSI General Assembly and Scientific Symposium.

Honda, J., Y. Kakubari, T. Koga, H. Shimada, H. Miyazaki, S. Nihei [2013], “Analysis of propagation characteristics on airport surface,” 2013 International Symposium on Electromagnetic Compatibility

(EMC EUROPE), pp.727-732, 2-6 Sept. 2013.

Ibuchi, T., T. Funaki [2012], "A study on EMI noise source modeling with current source for power conversion circuit," 2012 International Symposium on Electromagnetic Compatibility (EMC EUROPE), C1:4, pp.1-6, 17-21 Sept. 2012.

Ibuchi, T., T. Funaki [2013], "Validation of the air-core inductor copper loss model for high-frequency power conversion applications," 2013 International Symposium on Electromagnetic Compatibility (EMC EUROPE), pp.561-566, 2-6 Sept. 2013.

Ideguchi, T., T. Uehara [2013], "Method of reducing electromagnetic interference from transmission lines using a resistive film sheet," 2013 International Symposium on Electromagnetic Compatibility (EMC EUROPE), pp.1062-1067, 2-6 Sept. 2013.

Ikematsu, T., Y. Hayashi, T. Mizuki, N. Homma, T. Aoki, H. Sone [2011], "Suppression of information leakage from electronic devices based on SNR," 2011 IEEE International Symposium on Electromagnetic Compatibility (EMC), pp.920-924, 14-19 Aug. 2011.

Ikemiya, K., M. Kanazawa, T. Sudo, S. Masuda, Y. Hirakawa, K. Wada [2012], "Co-analysis of signal and power integrity of 3D stacked package using flexible printed circuits," 2012 International Symposium on Electromagnetic Compatibility (EMC EUROPE), P2-2:8, pp.1-4, 17-21 Sept. 2012.

Imi, Y. T. Hayakawa, T. Ito [2012], "Analyzing the Effect of Open Street Map During Crises: The Great East Japan Earthquake," 2012 IEEE 14th International Conference on Commerce and Enterprise Computing (CEC), pp. 126-130.

Iokibe, K., T. Amano, Y. Toyota [2011], "On-board decoupling of cryptographic FPGA to improve tolerance to side-channel attacks," 2011 IEEE International Symposium on Electromagnetic Compatibility (EMC), pp.925-930, 14-19 Aug. 2011.

Iokibe, K., T. Amano, K. Okamoto, Y. Toyota [2013-a], "Equivalent Circuit Modeling of Cryptographic Integrated Circuit for Information Security Design," IEEE Trans. on Electromagnetic Compatibility, vol. 55, no. 3, pp. 581-588.

Iokibe, K., T. Amano, K. Okamoto, Y. Toyota, T. Watanabe [2013-b], "Improvement of linear equivalent circuit model to identify simultaneous switching noise current in cryptographic integrated circuits," 2013 IEEE International Symposium on Electromagnetic Compatibility (EMC), pp.834-839, 5-9 Aug. 2013.

Ishigami, S., W. Ifong, K. Gotoh [2011], "Numerical analysis of folded rhombic antenna for EMI measurements using FI method," 2011 International Symposium on Electromagnetic Compatibility (EMC EUROPE 2011 York), pp.722-727, 26-30 Sept. 2011.

Ishigami, S., W. Ifong, K. Gotoh, Y. Matsumoto [2012], "Numerical analysis on effect of building materials on electromagnetic fields in VHF band," 2012 International Symposium on Electromagnetic Compatibility (EMC EUROPE), P1-3:8, pp.1-6, 17-21 Sept. 2012.

Ishii, M., S. Kurokawa, Y. Shimada [2011], "Comparison between three-antenna method and equivalent capacitance substitution method for calibrating electrically short monopole antenna," 2011 IEEE International Symposium on Electromagnetic Compatibility (EMC), pp.101-106, 14-19 Aug. 2011.

Kamikura, M., Y. Murata, A. Nishizawa [2013], "Investigation on the mode conversion between common-mode and differential-mode noises in EMI filters for power electronics circuits," 2013 International Symposium on Electromagnetic Compatibility (EMC EUROPE), pp.557-560, 2-6 Sept. 2013.

Kato, S., T. Yasuzumi, O. Hashimoto, T. Tanaka [2011], "Two-layered wave absorber using short carbon fibers having broadband characteristics," 2011 Asia-Pacific Microwave Conference Proceedings (APMC), pp. 1786-1789.

Kawase, D., H. Oomori, M. Shiozaki, H. Kurashima [2011], "EMI suppression of 10Gbit/s optical transceiver by using EBG structure," 2011 IEEE International Symposium on Electromagnetic Compatibility (EMC), pp.33-38, 14-19 Aug. 2011.

Kayano, Y., H. Inoue [2011], "Electromagnetic radiation resulting from strip line structure driven by a feed cable," 2011 IEEE International Symposium on Electromagnetic Compatibility (EMC), pp.161-166, 14-19 Aug. 2011.

Kayano, Y., Y. Tsuda, H. Inoue [2012], "Identifying EM radiation from asymmetrical differential-paired lines with equi-distance routing," 2012 IEEE International Symposium on Electromagnetic Compatibility (EMC), pp.311-316, 6-10 Aug. 2012.

Kayano, Y., H. Inoue [2013], "Imbalance component and EM radiation from differential-paired lines with serpentine equi-distance routing," 2013 IEEE International Symposium on Electromagnetic Compatibility (EMC), pp. 359-364, 5-9 Aug. 2013.

Kik, A., A. Nishikata [2011], "A New Calibration Algorithm Using Reference Materials for the

Waveguide-Penetration Method,” IEICE Trans. on Communication, E94-B, No.9, pp.2549-2557.

Kinugawa, M., Y. Hayashi, T. Mizuki, H. Sone [2011], “Information leakage from the unintentional emissions of an integrated RC oscillator,” 2011 8th Workshop on Electromagnetic Compatibility of Integrated Circuits (EMC Compo), pp.24-28, 6-9 Nov. 2011.

Kinugawa, M., Y. Hayashi, T. Mizuki, H. Sone [2013], “Study on Information Leakage of Input Key due to Frequency Fluctuation of RC Oscillator in Keyboard,” IEICE Trans. on Communication, E96-B, No.10, pp.2633-2638.

Kiyoshige, S., W. Ichimura, M. Terasaki, R. Kobayashi, G. Kubo, H. Otsuka, T. Sudo [2013], “Measurement and analysis of anti-resonance peak in total PDN impedance,” 2013 International Symposium on Electromagnetic Compatibility (EMC EUROPE), pp.931-936, 2-6 Sept. 2013.

Kobayashi, R., G. Kubo, H. Otsuka, T. Mido, Y. Kobayashi, H. Fujii, T. Sudo [2012], “Effects of critically damped total PDN impedance in chip-package-board co-design,” 2012 IEEE International Symposium on Electromagnetic Compatibility (EMC), pp.538-543, 6-10 Aug. 2012.

Komatsu, K., H. Hirayama, N. Kikuma, K. Sakakibara [2013], “Far-field radiation and near-field leakage of self-resonant spiral antennas for coupled-resonant wireless power transfer,” 2013 International Symposium on Electromagnetic Compatibility (EMC EUROPE), pp.883-886, 2-6 Sept. 2013.

Kopytenko, Y. A., V. S. Ismaguilov, K. Hattori, M. Hayakawa [2012], “Anomaly disturbances of the magnetic fields before the strong earthquake in Japan on March 11, 2011,” Annals of Geophysics, Vol 55, No 1, pp. 101-107.

Kuriyama, T., T. Aoi, W. Takatsuji, H. Maeda, T. Itoh, Y. Ueno, T. Nakaie, J. Matsui, Y. Miyamoto [2012], “Electrostatic field distribution measurement using silicon micro-mirror array,” 2012 IEEE International Symposium on Electromagnetic Compatibility (EMC), pp.351-356, 6-10 Aug. 2012.

Kuwabara, N., S. Yanagi, H. Miyake [2011], “Effect on digital TV of disturbances from electrical equipment evaluated using an actual broadcasting signal,” 2011 IEEE International Symposium on Electromagnetic Compatibility (EMC), pp.964-969, 14-19 Aug. 2011.

Maeda, A., H. Muramatsu, S. Kobayashi [2012], “A proposal for new method to evaluate radiated emission test sites above 1 GHz,” 2012 International Symposium on Electromagnetic Compatibility (EMC EUROPE), A2:1, pp.1-4, 17-21 Sept. 2012.

Maeda, N., S. Fukui, N. Ishihara, T. Naito [2011], "Empirical estimation of probability distribution for electric field strength in automotive cabin," 2011 IEEE International Symposium on Electromagnetic Compatibility (EMC), pp.970-975, 14-19 Aug. 2011.

Maeda, N., S. Fukui, K. Ichikawa, Y. Sakurai, T. Sekine, Y. Takahashi [2013], "An estimation method for the n port S parameters with n-1 port measurements," 2013 International Symposium on Electromagnetic Compatibility (EMC EUROPE), pp.348-353, 2-6 Sept. 2013.

Masuda, T., Y. Hiroshima [2013], "Fundamental characteristics of multi-electrode gas discharge tube small enough to be mounted close to the local area network port of equipment," 2013 International Symposium on Electromagnetic Compatibility (EMC EUROPE), pp.799-804, 2-6 Sept. 2013.

Masugi, M., N. Hirasawa, Y. AKkiyama K. Murakawa [2012-a], "Analysis of Electrostatic Discharge in Terms of Electromagnetic Interference Assessment: Assessing High Oscillations in ESD Events," IEICE Trans. on Communication, E95-B, No.11, pp.3601-3604.

Masugi, M., N. Hirasawa, Y. Akiyama, K. Murakawa [2012-b], "Effect of Discharge Gap Shape on High-Speed Electrostatic Discharge Events," IEICE Trans. on Communication, E95-B, No.12, pp.3898-3901.

Matsumoto, Y., K. Gotoh [2011], "Accuracy of Gaussian approximation applied to impulsive interference in OFDM reception," 2011 International Symposium on Electromagnetic Compatibility (EMC EUROPE 2011 York), pp.250-253, 26-30 Sept. 2011.

Matsumoto, Y., I. Wu, S. Ishigami [2013], "A method to identify interference noise from LED lamps by comparing EM noise waveform with light intensity in time domain," 2013 International Symposium on Electromagnetic Compatibility (EMC EUROPE), pp.180-184, 2-6 Sept. 2013.

Matsushima, T., N. Hirayama, T. Hisakado, O. Wada [2011], "SI/PI degradation due to package-common-mode resonance caused by parasitic capacitance between package and PCB," 8th Workshop on Electromagnetic Compatibility of Integrated Circuits (EMC Compo), pp.213-218, 6-9 Nov. 2011.

Matsushima, T., O. Wada, T. Watanabe, Y. Toyota, L.R. Koga [2012], "Verification of common-mode-current prediction method based on imbalance difference model for single-channel differential signaling system," 2012 Asia-Pacific Symposium on Electromagnetic Compatibility (APEMC), pp.409-412.

Matsushima, T., O. Wada [2013], "A method of common-mode reduction based on imbalance difference model for differential transmission line bend,” 2013 International Symposium on Electromagnetic Compatibility (EMC EUROPE), pp.338-341, 2-6 Sept. 2013.

Miyazaki, C., K. Tanakajima, M. Yamaguchi, K. Endo, H. Muramatsu, J. Kawano [2011], “A round-robin test on effectiveness of a VHF LISN for radiated emission measurements,” 2011 IEEE International Symposium on Electromagnetic Compatibility (EMC), pp.405-410, 14-19 Aug. 2011.

Miyazaki, T., T. Ishii, S. Okabe [2010], “A Field Study of Lightning Surges Propagating Into Residences,” IEEE Trans. on Electromagnetic Compatibility, vol. 53, no. 1, pp. 921-928.

Miyazaki, T., S. Okabe [2011], “Field Analysis of the Occurrence of Distribution-Line Faults Caused by Lightning Effects,” IEEE Trans. on Electromagnetic Compatibility, vol. 53, no. 1, pp. 114-121.

Mizuno, Y., K. Tanaka, K. Naito [2011], “Quantification of low frequency magnetic field in living environment,” 2011 International Symposium on Electromagnetic Compatibility (EMC EUROPE 2011 York), pp.811-815, 26-30 Sept. 2011.

Mori, H., N. Maeda, S. Fukui, H. Goto [2011], “Optimization method for signal integrity of automotive LAN,” 2011 International Symposium on Electromagnetic Compatibility (EMC EUROPE 2011 York), pp.762-767, 26-30 Sept. 2011.

Mori, H., Y. Suzuki, N. Maeda, H. Obata, T. Kishigami [2012], “Novel ringing suppression circuit to increase the number of connectable ECUs in a linear passive star CAN,” 2012 International Symposium on Electromagnetic Compatibility (EMC EUROPE), P2-2:3, pp.1-6, 17-21 Sept. 2012.

Mori, H., N. Maeda, Y. Kaku, T. Kishigami [2013], “Novel receiver circuit to achieve higher data rates in a linear passive star CAN,” 2013 International Symposium on Electromagnetic Compatibility (EMC EUROPE), pp.910-915, 2-6 Sept. 2013.

Mori, I., O. Fujiwara, H. Garbe [2011], “Equivalent circuit modeling to calculate discharge currents for air discharges of ESD-Guns,” 2011 International Symposium on Electromagnetic Compatibility (EMC EUROPE 2011 York), pp.449-452, 26-30 Sept. 2011.

Morioka, T., K. Hirasawa [2011-a], “MoM Calculation of the Properly Defined Dipole Antenna Factor With Measured Balun Characteristics,” IEEE Trans. on Electromagnetic Compatibility, vol. 53, no. 1, pp. 233-236.

Morioka, T. [2011-b], “Tracing E-field probe responses to the dipole antenna factor,” 2011 IEEE International Symposium on Electromagnetic Compatibility (EMC), pp.1-5, 14-19 Aug. 2011.

Morioka, T., M. Yamanaka, K. Hirasawa [2013], “Shortened dipole antenna factors by the reference antenna method at a finite separation,” 2013 IEEE International Symposium on Electromagnetic Compatibility (EMC), pp.439-444, 5-9 Aug. 2013.

Murano, K., Y, Kotsuka [2013], “New controllable noise suppression methods for near-magnetic field radiations on PCB using small active component circuits,” 2013 IEEE International Symposium on Electromagnetic Compatibility (EMC), pp.124-127, 5-9 Aug. 2013.

Muroga, S., Y. Endo, T. Ito, S. Tanaka, M. Murakami, K. Hori, S. Takahashi, A. Naoya, T. Makita, S. Imai, M. Nagata, M. Yamaguchi [2013], “In-band spurious attenuation in LTE-class RFIC chip using a soft magnetic thin film,” 2013 IEEE International Symposium on Electromagnetic Compatibility (EMC), pp.657-661, 5-9 Aug. 2013.

Nabeshima, Y., Y. Oizono, T. Okumura, T. Sudo [2011], “On-chip power integrity evaluation system,” 8th Workshop on Electromagnetic Compatibility of Integrated Circuits (EMC Compo), pp.165-169, 6-9 Nov. 2011.

Nagaoka, T., S. Watanabe [2013], “Large-scale calculation of the specific absorption rate in a human body exposed to RF-EMFs by GPU cluster system,” 2013 International Symposium on Electromagnetic Compatibility (EMC EUROPE), pp.891-895, 2-6 Sept. 2013.

Nakamoto, F., T. Uchida, C. Miyazaki, N. Oka, K. Misu [2012], “A simplified model of a common mode choke coil for 3D field simulators,” 2012 IEEE International Symposium on Electromagnetic Compatibility (EMC), pp.617-622, 6-10 Aug. 2012.

Nakasone, T., Y. Li, K. Ohta, K. Sakiyama [2013], “Exploration of the CC-EMA attack towards efficient evaluation of EM information leakage,” 2013 International Symposium on Electromagnetic Compatibility (EMC EUROPE), pp.411-414, 2-6 Sept. 2013.

Nakayama, M., T. Kobayashi [2012], “Electric field strength estimation in boundary region between near and far fields,” 2012 International Symposium on Electromagnetic Compatibility (EMC EUROPE), P3-4:4, pp.1-6, 17-21 Sept. 2012.

Nakayama, M., T. Kobayashi [2013], “New computation method of electric field strength in close vicinity of half-wavelength dipole antennas,” 2013 IEEE International Symposium on Electromagnetic Compatibility (EMC), pp.428-433, 5-9 Aug. 2013.

Nakayama, T., D. Kitagawa, M. Ishii, Y. Saito [2012], “Proposal of a current measurement technique for each pin of a BGA package," 2012 International Symposium on Electromagnetic Compatibility (EMC EUROPE), B7:1, pp.1-6, 17-21 Sept. 2012.

Nishimoto, T., R. Asai, T. Matsushima, T. Hisakado, O. Wada [2012], "Experimental verification of signal integrity deterioration due to package-common-mode resonance," 2012 International Symposium on Electromagnetic Compatibility (EMC EUROPE), P2-2:11, pp.1-4, 17-21 Sept. 2012.

Oguri, Y., K. Ichikawa [2012], "Simulation method for automotive electronic equipment immunity testing," 2012 International Symposium on Electromagnetic Compatibility (EMC EUROPE), B3:4, pp.1-6, 17-21 Sept. 2012.

Ohmae, A., W. Li, T. Suga, H. Osaka, M. Toyama, A. Nakamura [2012], "Reduction technique for spread spectrum clock interference with wireless system," 2012 International Symposium on Electromagnetic Compatibility (EMC EUROPE), D2:5, pp.1-4, 17-21 Sept. 2012.

Oka, N., K. Misu, S. Yoneda, S. Saito, S. Nitta [2011], "A common mode noise filter for high speed and wide band differential mode signal transmission," 2011 International Symposium on Electromagnetic Compatibility (EMC EUROPE 2011 York), pp.732-736, 26-30 Sept. 2011.

Okuyama, S., K. Osabe, K. Tanakajima, H. Muramatsu [2013], "Investigation on effectiveness of very high frequency line impedance stabilization network (VHF-LISN) for measurement reproducibility," 2013 International Symposium on Electromagnetic Compatibility (EMC EUROPE), pp.174-179, 2-6 Sept. 2013.

Ono, Y., Y. Ida, Y. Kasahara, Y. Hobara, M. Hayakawa, A. Rozhnoi, M. Solovieva, O.A. Molchanov, K. Ohta [2012], "Ionospheric perturbations associated with two huge earthquakes in Japan, using principal component analysis for multiple subionospheric VLF/LF propagation paths," Annals of Geophysics, Vol 55, No 1, pp. 139-148.

Osabe, K., T. Kato [2011], "Estimation of standards compliance uncertainty for radiated emission measurement in the pt program," 2011 IEEE International Symposium on Electromagnetic Compatibility (EMC), pp.994-998, 14-19 Aug. 2011.

Osabe, K., T. Kato [2012], "Consideration of data evaluation criteria for radiated emission test in the PT program," 2012 International Symposium on Electromagnetic Compatibility (EMC EUROPE), P1-1:10, pp.1-4, 17-21 Sept. 2012.

Osabe, K., T. Kato [2013], "Proposal for evaluation method of proficiency test results on EMI measurement," 2013 IEEE International Symposium on Electromagnetic Compatibility (EMC), pp.138-143, 5-9 Aug. 2013.

Paoletti, U.; T. Suga [2012], “The printed reverberation board and its characterization,” 2012 International Symposium on Electromagnetic Compatibility (EMC EUROPE), B:8:5, pp.1-6, 17-21 Sept. 2012.

Saito, S., T. Kobayashi, S. Nitta [2011], “High speed signal transmission compatibility with noise suppression by common mode chokes,” 2011 International Symposium on Electromagnetic Compatibility (EMC EUROPE 2011 York), pp.334-338, 26-30 Sept. 2011.

Sasaki, H., T. Tsukuda, Y. Fujimura, T. Murakami, H. Terai [2011], “Investigation of noise coupling in mixed-signal system-in-packages (SiPs),” 8th Workshop on Electromagnetic Compatibility of Integrated Circuits (EMC Compo), pp.194-197, 6-9 Nov. 2011.

Sato, K., Y. Kashimura, Y. Kamimura [2013], “A real-time measuring method of 3D EMF distributions using the Wiimote,” 2013 International Symposium on Electromagnetic Compatibility (EMC EUROPE), pp. 867-870, 2-6 Sept. 2013.

Sauvage, J.-L. Danger, S. Guilley, N. Homma, Y.-I. Hayashi [2013], “Advanced Analysis of Faults Injected Through Conducted Intentional Electromagnetic Interferences,” IEEE Trans. on Electromagnetic Compatibility, vol. 55, no. 3, pp. 589-596.

Sawada, T., T. Toshikawa, K. Yoshikawa, H. Takata, K. Nii, M. Nagata [2011], “Immunity evaluation of SRAM core using DPI with on-chip diagnosis structures,” 8th Workshop on Electromagnetic Compatibility of Integrated Circuits (EMC Compo), pp.65-70, 6-9 Nov. 2011.

Sejima, K., Y. Toyota, K. Iokibe, L.R. Koga, T. Watanabe [2012], “Experimental model validation of mode-conversion sources introduced to modal equivalent circuit,” 2012 IEEE International Symposium on Electromagnetic Compatibility (EMC), pp.492-497, 6-10 Aug. 2012.

Sekiguchi, H., S. Seto [2013], “Study on Maximum Receivable Distance for Radiated Emission of Information Technology Equipment Causing Information Leakage,” IEEE Trans. on Electromagnetic Compatibility, vol. 55, no. 3, pp. 547-554.

Sekine, T.; H. Asai [2011-a], “Mixed finite element time domain method based on iterative leapfrog scheme for fast simulations of electromagnetic problems,” 2011 IEEE International Symposium on Electromagnetic Compatibility (EMC), pp.596-601, 14-19 Aug. 2011.

Sekine, T., H. Asai [2011-b], “Simulation of multiconductor transmission lines using block-latency insertion method and model order reduction technique," 2011 8th Workshop on Electromagnetic Compatibility of Integrated Circuits (EMC Compo), pp.203-206, 6-9 Nov. 2011.

Sekine, T., H. Asai [2011-c], "Block-Latency Insertion Method (Block-LIM) for Fast Transient Simulation of Tightly Coupled Transmission Lines," IEEE Trans. on Electromagnetic Compatibility, vol. 53, no. 1, pp. 193-201.

Sekine, T., H. Asai, J.S. Lee [2012], "Unified circuit modeling technique for the simulation of electrostatic discharge (ESD) injected by an ESD generator," 2012 IEEE International Symposium on Electromagnetic Compatibility (EMC), pp.340-345, 6-10 Aug. 2012.

Sekine, T., H. Asai [2013], "A framework for the simulation of electrostatic discharge immunity using the unified circuit modeling technique," 2013 IEEE International Symposium on Electromagnetic Compatibility (EMC), pp.869-874, 5-9 Aug. 2013.

Sekioka, S., I. Matsubara, S. Yokoyama [2011], "Return-Stroke Model Segmentation and its Application to Lightning-Induced Surges Calculation," IEEE Trans. on Electromagnetic Compatibility, vol. 53, no. 1, pp. 122-130.

Shimada, H., Y.-I. Hayashi, N. Homma, T. Mizuki, T. Aoki, H. Sone, L. Sauvage, J.-L. Danger [2012], "Efficient mapping of EM radiation associated with information leakage for cryptographic devices," 2012 IEEE International Symposium on Electromagnetic Compatibility (EMC), pp.794-799, 6-10 Aug. 2012.

Shinohara, J., N. Michishita, Y. Yamada, H. Hada [2012], "Thin wave absorber composed of mushroom structures," 2012 IEEE Antennas and Propagation Society International Symposium (APSURSI), pp. 1-2.

Sugiura, A., M. Alexander, D. Knight, K. Fujii [2012-a], "Equivalent capacitance substitution method for monopole antenna calibration," 2012 IEEE International Symposium on Electromagnetic Compatibility (EMC), pp.708-713, 6-10 Aug. 2012.

Sugiura, A., Y. Kami [2012-b], "Generation and Propagation of Common-Mode Currents in a Balanced Two-Conductor Line," IEEE Trans. on Electromagnetic Compatibility, vol. 54, no. 2, pp. 466-473.

Takada, T., T. Sekine, H. Asai [2012], "Circuit/Electromagnetic hybrid simulation of electrostatic discharge in contact discharge mode," 2012 International Symposium on Electromagnetic Compatibility (EMC EUROPE), C4:2, pp.1-6, 17-21 Sept. 2012.

Takahashi, J., Y. Hayashi, N. Homma, H. Fuji, T. Aoki [2012], "Feasibility of fault analysis based on intentional electromagnetic interference," 2012 IEEE International Symposium on Electromagnetic Compatibility (EMC), pp.782-787, 6-10 Aug. 2012.

Takamori, H., C. Chen, Y. Kamiji, T. Anada, D. Xu, C. Christopoulos [2011], "Study on error suppression in broadband characterization of complex EM-parameters," 2011 International Symposium on Electromagnetic Compatibility (EMC EUROPE 2011 York), pp.801-804, 26-30 Sept. 2011.

Takano, S., T. Yasuzumi, K. Moriuchi, T. Sakata, T. Ozaki, O. Hashimoto [2011], "Optimum design of wave absorbers using foamed polyimide containing carbon black based on genetic algorithm," 2011 International Conference on Electromagnetics in Advanced Applications (ICEAA), pp. 664-667.

Tatematsu, A., K. Yamazaki, K. Miyajima, H. Motoyama [2013], "Experimental study of lightning and switching surges-induced overvoltages in low-voltage control circuits," 2013 International Symposium on Electromagnetic Compatibility (EMC EUROPE), pp.771-776, 2-6 Sept. 2013.

Tohya, H., T. Osato, T. Shimasaki, N. Kuwabara, K. Mori, H. Muramatsu [2012], "Simple and convenient EMI managenant method for modules of IT equipment," 2012 International Symposium on Electromagnetic Compatibility (EMC EUROPE), P3-5:1, pp.1-6, 17-21 Sept. 2012.

Tosaka, T., Y. Yamanaka, K. Fukunaga [2011], "Method for Determining Whether or Not Information is Contained in Electromagnetic Disturbance Radiated From a PC Display," IEEE Trans. on Electromagnetic Compatibility, vol. 53, no. 2, pp. 318-324.

Toyonaga, M., K. Murakawa, M. Hosoda [2011], "Lightning damage to underground cables," 2011 International Symposium on Electromagnetic Compatibility (EMC EUROPE 2011 York), pp.445-448, 26-30 Sept. 2011.

Toyota, Y., K. Iokibe, K. Kondo, S. Yoshida [2013], "Suppression of power-bus resonance by lossy resonator filter consisting of open stub and magnetic thin film," 2013 International Symposium on Electromagnetic Compatibility (EMC EUROPE), pp.943-948, 2-6 Sept. 2013.

Tsuda, Y., T. Yasuzumi, O. Hashimoto [2011-a], "A Thin Wave Absorber Using Closely Placed Divided Conductive Film and Resistive Film," IEEE Antennas and Wireless Propagation Letters, Vol.10, pp. 892-895.

Tsuda, Y., T. Yasuzumi, O. Hashimoto [2011-b], "Design of thin wave absorbers using closely placed divided conductive film and resistive film," 2011 Asia-Pacific Microwave Conference Proceedings (APMC), pp. 1798-1801.

Tsutaoka, T., T. Ono, A. Tsurunaga, T. Kasagi, K. Hatakeyama, M.Y. Koledintseva [2011], "High frequency permeability of Fe-Al-Si granular composite materials," 2011 IEEE International Symposium on Electromagnetic Compatibility (EMC), pp.78-83, 14-19 Aug. 2011.

Tsutaoka, T., A. Tsurunaga, T. Kasagi, K. Hatakeyama, M.Y. Koledintseva [2012], "Electromagnetic properties of metal granular composite materials for EMC applications," 2012 IEEE International Symposium on Electromagnetic Compatibility (EMC), pp.411-415, 6-10 Aug. 2012.

Tsutaoka, T., T. Kasagi, K. Hatakeyama, M.Y. Koledintseva [2013-a], "Analysis of the permeability spectra of spinel ferrite composites using mixing rules," 2013 IEEE International Symposium on Electromagnetic Compatibility (EMC), pp.545-550, 5-9 Aug. 2013.

Tsutaoka, T., H. Kinoshita, T. Kasagi, S. Yamamoto, K. Hatakeyama [2013-b], "Towards electromagnetic metamaterial: Negative permeability spectra of YIG composite materials," 2013 IEEE International Symposium on Electromagnetic Compatibility (EMC), pp.380-385, 5-9 Aug. 2013.

Uchida, T., C. Miyazaki, N. Oka [2013], "Design of electromagnetic field immunity test system applying with 128-element array antenna," 2013 IEEE International Symposium on Electromagnetic Compatibility (EMC), pp.445-449, 5-9 Aug. 2013.

Unno, M., S. Aono, and H. Asai [2012], "GPU-Based Massively Parallel 3-D HIE-FDTD Method for High-Speed Electromagnetic Field Simulation," IEEE Trans. on Electromagnetic Compatibility, vol. 54, no. 4, pp. 912- 921.

Wada, O., Y. Saito, K. Nomura, Y. Sugimoto, T. Matsushima [2011], "Power supply current analysis of micro-controller with considering the program dependency," 8th Workshop on Electromagnetic Compatibility of Integrated Circuits (EMC Compo), pp.93-98, 6-9 Nov. 2011.

Wakatsuchi, H., T. Sakai, S. Watanabe, M. Kojima, Y. Yamashiro, H. Sasaki, K. Sasaki, O. Hashimoto [2012], "Application of Reproducible Measurements of Complex Permittivities to Crystalline Lens From 500 MHz to 50 GHz," IEEE Trans. on Electromagnetic Compatibility, vol. 54, no. 6, pp. 1298-1301.

Xiao, F., T. Takatsu, K. Murano, Y. Kami [2012], "Complex near electromagnetic field scanning on printed circuit board," 2012 International Symposium on Electromagnetic Compatibility (EMC

EUROPE), A5:2, pp.1-4, 17-21 Sept. 2012.

Xiao, J., D. Pommerenke, J. L. Drewniak, H. Shumiya, J. Maeshima, T. Yamada, and K. Araki [2012], "Model of Secondary ESD for a Portable Electronic Product," IEEE Trans. on Electromagnetic Compatibility, vol. 54, no. 3, pp. 546-555.

Yagitani, S., K. Katsuda, M. Nojima, Y. Yoshimura, H. Sugiura [2011], "Imaging Radio-Frequency Power Distributions by an EBG Absorber," IEICE Trans. on Communication, E94-B, No.8, pp.2306-2315.

Yamada, K., M. Ishida, S. Yutaka, M. Yamaguchi [2011], "High-performance laminated thin-film shield with conductors and magnetic material multilayer," 2011 IEEE International Symposium on Electromagnetic Compatibility (EMC), pp.432-437, 14-19 Aug. 2011.

Yamada, K., S. Hiura, M. Ciappa [2013], "Analysis of conducted and radiated noise propagation using comprehensive electromagnetic model of power MHz-switching circuit," 2013 International Symposium on Electromagnetic Compatibility (EMC EUROPE), pp.545-550, 2-6 Sept. 2013.

Yamaguchi, M., S. Dhungana [2011], "Analysis of the source bus line current in LCD panel based on a new MSL model," 2011 IEEE International Symposium on Electromagnetic Compatibility (EMC), pp.384-387, 14-19 Aug. 2011.

Yamaguchi, M., S. Muroga, S. Nanba, K. Arai, K. Yanagi, Y. Endo [2013], "A 60 x 60 um^2 size planar shielded loop probe for low lift-off on-chip magnetic near field measurements," 2013 International Symposium on Electromagnetic Compatibility (EMC EUROPE), pp.977-980, 2-6 Sept. 2013.

Yamaguchi, T., Y. Hatogai, T. Sudo [2013], "Influence of anti-resonance peak in power supply network on power and signal integrity," 2013 International Symposium on Electromagnetic Compatibility (EMC EUROPE), pp.224-228, 2-6 Sept. 2013.

Yamamoto, S., D. Ishihara, K. Hatakeyama [2011], "Design of electromagnetic wave absorber by use of metal wire array sheet," 2011 IEEE International Symposium on Electromagnetic Compatibility (EMC), pp.68-71, 14-19 Aug. 2011.

Yamamoto, S., D. Ishihara, K. Hatakeyama [2012-a], "Design of Electromagnetic Wave Absorber Panels for Oblique Incidence Using Wire Array Sheet," IEICE Trans. on Communication, E95-B, No.2, pp.631-634.

Yamamoto, S., K. Hatakeyama [2012-b], “Design method of EM absorber and shielding screen using wire array sheet,” 2012 IEEE International Symposium on Electromagnetic Compatibility (EMC), pp.416-421, 6-10 Aug. 2012.

Yamamoto, S., K. Hatakeyama, T. Tsutaoka [2013], “Reflection and transmission of laminated structures using finite- and infinite-length metal wire array,” 2013 IEEE International Symposium on Electromagnetic Compatibility (EMC), pp.557-562, 5-9 Aug. 2013.

Yasuzumi, T., S. Kato, Y. Ishii, R. Suga, O. Hashimoto [2012-a], “Multi-Layered Translucent Wave Absorber Using Carbon Fibers and Applying to Portable Anechoic Chamber,” IEICE Trans. on Communication, E95-B, No.11, pp.3830-3836.

Yasuzumi, T., N. Kamiya, R. Suga, O. Hashimoto, Y. Matsushita, Y. Matsuda [2012-b], “Miniaturization of Parallel-Plate Lens Antenna for Evaluation of Wave Absorber Placed on Ceiling of ETC Gate,” IEICE Trans. on Communication, E95-B, No.10, pp.3225-3231.

Yoshikawa, K., Y. Sasaki, K. Ichikawa, Y. Saito, M. Nagata [2011], “Measurements and co-simulation of on-chip and on-board AC power noise in digital integrated circuits,” 8th Workshop on Electromagnetic Compatibility of Integrated Circuits (EMC Compo), pp.76-81, 6-9 Nov. 2011.

Yuda, S., S. Sawaki, Y. Baba, N. Nagaoka, and A. Ametani [2013], “Application of the TLM Method to Transient Simulations of a Conductor System With a Lossy Ground: Grounding Electrodes and an Overhead Wire,” IEEE Trans. on Electromagnetic Compatibility, vol. 55, no. 1, pp. 175- 182.

Yutthagowith, P., A. Ametani, N. Nagaoka, and Y. Baba [2011], “Application of the Partial Element Equivalent Circuit Method to Analysis of Transient Potential Rises in Grounding Systems,” IEEE Trans. on Electromagnetic Compatibility, vol. 53, no. 3, pp. 726-736.