COMMISSION E: ELECTROMAGNETIC NOISE AND INTERFERENCE

Edited by Zen Kawasaki

Activities of Commission E in Japan can be roughly categorized into major six subjects, and those are lightning physics, Sprites/Elves, Electromagnetic waves related with earthquakes, Electromagnetic noise in wireless communications, Electromagnetic noise related with printed circuit boards and EMC related with electrical power engineering. The first three subjects are natural phenomena, and the latter three seem to be man made issues. That is why this Activity Report consists of six sessions from E1 to E6.

E1. Lightning Physics

One of the most current topics in the research field of lightning physics is the VHF/UHF source location, which is believed to highly depend on the charge distribution inside the thundercloud. To make VHF/UHF source location two different principles are well known. The one is the Time of Arrival (TOA) technique, and the experimental system named LDAR (Lightning Detection and Ranging) has been operating in U.S. The other one is based on the technique of interferometory, and has been accomplished as an operational and commercially available system by a French organization. Under this situation, University of Tokyo lightning research group has been concerned with the TOA technique, and Lightning Research Group of Osaka University (LRGOU) has been engaged in the interferometers. Both groups have been conducting filed campaigns independently at the Hokuriku Coast, where they can observe the lightning activity during winter thunderstorms. Lightning activity during winter thunderstorms was discovered in mid 70's, and since then many related researchers have been paying their attention on its unique features. Both UT and OU groups are quite vigorous and productive. UT group has presented the possible interpretations on the initiation of lightning discharges during winter thunderstorms by observing with their TOA system. LRGOU has partly revealed the positive charge distributions, which can contribute positive cloud-to-ground discharges with long continuing currents.

Optical observation of lightning flashes is another interesting issue in this filed. Central Research Institute of Electrical Power Industry (CRIEPI) has contributed for developing an optical measuring system based on CCD matrix with high speed A/D converters for all CCD components. They name this ALPS (Automatic Lightning Progression measuring System), and the function is equivalent to a digital flaming camera and/or a streak camera. They have achieved the sub micro-second time resolution, and they have mainly operated this for the upward triggered lightning from tall constructions. The main objective of their observations is to understand the mechanism of upward initiated lightning discharges to design the protection of power apparatus. ALPS are widely operated by other organizations, like Gifu University, and Suzuka Technical Collage. CRIEPI and Gifu University have collaborated campaigns with Florida University. In Florida they have been concerned with the rockets triggered lightning instead of upward initiate lightning from tall constructions.

LRGOU has been concerned with TRMM/LIS (Tropical Rainfall Measuring Mission/ Lightning Imaging Sensor) as one of principal investigators. LRGOU has discovered following three items. The first issue is lightning activity during El-Nino period over west Indonesia is higher than the normal period instead of less precipitation. The second issue is the immigration of winter thunderstorm activity over the Pacific Ocean at mid latitude. The last issue is that the

relation ship between lightning activity and snow depth observer by TRMM PR is uniform. The analysis of TRMM/LIS observations are on going.
The Fifth International Workshop on Physics of Lighting (5^{th} IWPL) was held from September 10 through 13, 2001, in Nagoya. This workshop was organized by Prof. Nakamura, Nagoya Institute of technology.

(Z.-I. Kawasaki)

E2. Sprites/elves-related study in Japan

E2-1 Optical Observations
Japanese groups have been conducting ground-based and aircraft observations since 1995. Tohoku University developed a hi-speed multi-anode array photometer (MAP) that has 16 channels in vertical direction. Using 2 MAPs with two different color filters, the electron energies producing sprites and elves were estimated. A hi-speed CCD camera, a near-infrared CCD camera and an image-intensified CCD camera were also operated in US and Japan. A hi-speed photometer operated by Tohoku University found elves in 1995. Japanese groups also took important roles in discoveries of sprites and/or elves in Japan, Australia and the Mediterranean. The stored data sets are now under detail analysis
Projects:
Colorado (1995 – 1999): Tohoku University
The international observation campaign has been conducted since 1994 at Yucca Ridge Field Station (YRFS) in Colorado, US. Tohoku University group participated in the campaign in 1995 – 1999 with several optical instruments as well as an ULF receiver.
Japan (1998 – present): Tohoku University, University of Electro-Communications
Tohoku University started the ground based optical observation at two sites in Japan in December 1998. Every winter season activity of sprites and elves was confirmed.
Australia (1996-present): Osaka University
International observation team including New Zealand, Australia and Japan found sprites in Australia during a summer lightning campaign.
Mediterranean (1999): ISAS
The Leonid meteor shower campaign using an aircraft was conducted by an international science team in November 1999. Japanese scientist caught some sprites and elves with a high resolution TV camera over the Mediterranean Sea.
Results:
Discovery of elves (1995)
Four channel hi-speed photometer found new optical emission appearing with a horizontal extent over 200 km.
Time delay of optical emissions from causative CG
Hi-speed measurement with photometers revealed the relationship between the time delay of sprites emissions from the causative cloud to ground (CG) discharge. According to the result, the sprites can be classified into three types.
Vertical motion of sprites
MAP data showed that the appearance of sprites and vertical motion of sprites are closely related.
Quantitative measurements of luminosity with photometers
Well-calibrated photometers enable us to examine the absolute luminosity of optical emissions precisely, suggesting 1000 times as bright as what we considered before.

Height estimation of elves
Assuming thin optical layer of elves, the emission height are calculated precisely to be ~90 km.
Characteristics of sprite hal
Characteristics of "sprite halo" , such as dimensions, luminosity, motion and color, were investigated in detail for the first time with photometric and imaging data.
Estimation of electron energy
Measurement by MAPs with two broad band filters enable us to estimate the electron energy of sprites, elves and sprite halo with a high temporal resolution. The results show sometimes over 15 eV for sprites.
Discovery of sprites in Australia (1997)
Sprites were imaged outside North America for the first time in summer Australia.
Discovery of sprites and elves induce by winter storms (1998)
Winter sprites and elves were found for the first time in Japan. Also the precise height and horizontal distribution of elements for one sprites event were calculated by triangulation from two sites.
Discover of sprites and elves over the Mediterranean (1999)
From aircraft flying for the Leonid campaign, activities of sprites and elves were identified in the European area for the first time. The elves imaged showed considerably long life, 10 times of normal elves' life times.
Discovery of sprites appearing over the Pacific Ocean (2000)
During the winter sprites campaign in Japan sprites were observed at a distance of >500 km from the closest coast of Japan. Their feature seems something different from sprites near the west cost of Japan in the same season.
Morphology of summer and winter sprites
Characteristics of sprites and elves in summer US and in winter Japan were compared carefully. Sprites' features look quite different, though no clear difference was found for elves.

E2-2 Electromagnetic Wave Observations

Electromagnetic measurements in the frequency range of VLF, ELF and ULF have been conducted by two Japanese groups.

Projects:

Colorado (ULF: 1995 - 1999): Tohoku University
During the summer campaigns at YRFS in Colorado, a set of searchcoil magnetometer for ULF waves were employed.

Japan (VLF: 1998- present, ELF 2001 - present): University of Electro-Communications, Tohoku University
VLF receivers have been operated in Japan continuously by Univ. Electro-Communications. The Schumann resonance (~8Hz) in ELF range is recorded by a searchcoil magnetometer (the same type installed at Syowa) installed at Onagawa observatory in Miyagi by Tohoku University.

Antarctica (2000 - present):
ELF searchcoil magnetometer systems installed at Syowa station, Antarctica, started data acquisition in 2000. The sensor has sensitivity in the frequency range of 0.5 – 150 (or 400) Hz and the sampling rate is 1 kHz (or 400Hz).

Results:
Determination of location for CG producing Q-burst
Using Q-burst data obtained by ELF receiver at Syowa and at Onagawa, the location of CG

that produces sprites can be determined by triangulation. The accuracy is ~400 km or better.
Estimation of charge moment
Charge moments of sprites occurring in Japan, US and other regions in the world, has been derived from ELF observation in Japan and Antarctica.
Discovery of ULF emissions associated with sprites
ULF recording in the summer observation campaign at YRFS, Colorado resulted in finding of transient ULF waves induced by sprites-related discharge phenomena.

E2-3 Numerical Simulation

Two groups in Japan have performed numerical simulations to investigate the mechanisms of sprites, sprite halo and elves.

Projects:

Full wave (1996 – present): Kanazawa University
Using a workstation network linking several tens of machines, the full wave simulation has been conducted.

Quasi electro static model (2001 – present): Tohoku University
Numerical simulation based on the Quasi electrostatic model has been started.

Results:

Full wave simulation
Considering magnetic filed effect at the ionospheric height, the calculation suggests modulation of elves' form. The dynamics of the sprite halo were also reproduced.
- Seasonal change of sprite halo feature
Effect of vertical profile of electron density in summer and winter seasons are examined, suggesting height variation of optical emissions.

E2-4 Summary of International Collaboration

In many cases sprites/elves study has been carried out by international collaboration. Here we summarize the projects and participated universities / institutes working with Japanese groups for sprites/elves research.

Projects:

Colorado Summer Campaign
FMA research Inc., Stanford Univ., Utah State Univ., Univ. Alaska (US), etc
Leonid Meteor Shower observation
NASA, Utah State Univ. (US), etc
Japan Winter Campaign
Stanford Univ. (US)
Student exchange
Utah State Univ. (US)
ELF Observation
Frankfurt Univ., Duke Univ., Univ. Alaska (US), National Chung Kong Univ. (Taiwan)
International Meeting in Japan:
AP-RASC and get together in Sendai [August 2001]
Participants from Germany, Taiwan, Israel, USA, and New Zealand

E2-5 Future Projects

Some future projects of sprites/elves study are now going or under planning in Japan collaborating with many countries.
Spacecraft Missions

- ROCSAT-2/ISUAL (development of instruments: 1998 – present)
Taiwan will launch ROCSAT-2 spacecraft with sprites instrument unit (ISUAL) in 2003. Tohoku University is developing Array Photometer which measures vertical motion of sprites/elves/jets at two colors.
- Ground support of spacecraft mission
Space shuttle mission planned by Israel will be launched in July 2002. Japanese groups supports from ground with optical and ELF measurements.
ELF global network
To monitor the global activity of sprites and CG discharges, global network of ELF magnetometrs will be employed continuously in Antarctica, Japan, and Germany.
Polar region
The discovery of winter sprites in Japan strongly suggests the existence of sprites and elves in polar region where aurora appears in the winter season.
Equatorial region
Equatorial area of Asia is one of the most active regions for lightning. Collaborative study with atmospheric radar will be fruitful.

(Y. Takahashi)

E3. EM waves related with earthquakes

After the Kobe Earthquake disaster in Japan (January 14, 1995), Japanese government established the special research programs to investigate short-term earthquake prediction in 1996. These programs included RIKEN (The Institute of Physical and Chemical Research) international frontier research group on earthquakes and NASDA (National Space Development Agency of Japan) remote sensing frontier research, which investigated electromagnetic effects associated with earthquakes. RIKEN project deals with earthquake-related electromagnetic effects occurred under the ground at lower frequency (mainly DC-ULF) phenomena and NASDA's one treats those occurred in atmosphere or ionosphere at higher frequency (VLF, HF). These projects terminated on March, 2002. Over the last five years, especially the last three years, Japan or Japanese researchers did outstanding contributions to earthquake related electromagnetics. First, they set up network station system in Japan. Also sophisticated stations have been installed not only in Japan but also Kamchatka, Russia. Second, RIKEN and NASDA frontier groups organized several international workshops in Japan, two in the last three years and member of these groups organized many sessions in the international conferences. These contributions extend the population with interest in earthquake related electromagnetic phenomena. For example, India started their own frontier project toward the short-term prediction of a large earthquake. And Taiwan will start this September. The third a lot of papers were published.

For these three years, the papers corresponding to moderately large (M6 class) earthquakes such as 1999 Iwate-Ken Nairiku Hokubu EQ, 2000 Izu Islands Swarm, and so on have been published. They have much convincing evidence in ULF geomagnetic changes, abnormal signal changes in VLF transmitter signal, geoelectric potential differences, borehole antenna analysis, Ionsopheric disturbances, and so on.

The important point to find out is to recognition or separation of earthquake related electromagnetic signals in the methodology. In general, electromagnetic signals associated with earthquakes are considered to be weaker and the principle component analysis and polarization analysis have been proposed and developed in ULF geomagnetic approach. As for VLF subionospheric phenomena, significant changes in terminator time are found be appeared a few

days before the earthquake. Direction finding method of this field is also highly required.
The perturbation in the ionospheric or the subionospheric data suggests that there are coupling process between Lithosphere, Atmosphere and Ionosphere. That is the forth important findings. It is expected that a convincing scenarios for the generation of earthquake related electromagnetic phenomena will be proposed soon based on the detailed observation.

(K. Hattori)

E4. EM Noise and Interference in Wireless Communications Systems

As the increase of the demands for mobile communications services, many kinds of wireless communications systems have been developed. In wireless communications systems, a transmitter transmits signal through open space, and a receiver receives it. This means that the transmitter emits the electromagnetic waves in open space, and the receiver receives the electromagnetic waves radiated from any radiation source. As the increase of the wireless communications systems, electromagnetic environment in open space becomes complex, and then electromagnetic compatibility concerning wireless communications systems becomes important issue. Though there are many considerable research activities related with electromagnetic compatibility concerning wireless communications systems, we intend to pay our attention on some special topics to review these three-year's activities and introduce them.

E4-1 Measurements and Statistics of Man-made Noise and Interference

Measurements of radio frequency unnecessary electromagnetic wave (man-made noise or interference) remain to be one of the basic research theme, and the measurements of electromagnetic waves radiated from electrical apparatus, automobiles have been reported in many papers. In addition, since wireless communications systems also become to be noise (interference) sources for another kinds of wireless communications systems, electromagnetic wave emitted from wireless communications systems have been measured. Especially, because of the widespread use of 2.4 GHz band wireless communications systems such as IEEE 802.11b wireless LAN systems and Bluetooth, many efforts to measure the electromagnetic waves radiated from IEEE 802.11b wireless LAN systems, Blutooth and ISM apparatus such as microwave ovens have been done.

In wireless communications systems, since the man-made noise (interference) radiated from electrical apparatus or other wireless communications systems propagates multipath channel from the noise (interference) source to the receiver, the statistics of noise (interference) observed at the receivers point are different from those observed at noise (interference) source point. Propagation of man-made noise (interference) emitted from ISM apparatus or 2.4 GHz band wireless LAN systems through indoor environment has also been discussed in several papers.

E4-2 Effect of Man-made Noise and Interference on the Performance of Wireless Communications Systems

In wireless communications systems, it is well-known that the man-made noise (interference) radiated from electrical apparatus degrades the performance of wireless communications systems. In unlicensed radio frequency bands such as 2.4 GHz radio frequency band, since many kinds of wireless communications systems are operated in same radio frequency bands. Therefore, if these wireless communications systems exist on same place, each wireless communication system degrades the performance other wireless communication system.

Although there are many kinds of wireless communications systems subject to man-made noise (interference), IEEE 802.11b wireless LAN systems and Bluetooth have taking a great attention, as it provides the unlicensed wireless communications services using ISM radio frequency band. Several paper reports the effect of man-made noise emitted from microwave ovens on the throughput performance of IEEE 802.11b wireless LAN system and Bluetooth. In addition, some papers discuss the co-existence of IEEE 802.11b wireless LAN system and Blutooth, and reports the effect of mutual interference on the performance of each wireless communication system.

E4-3 Improvement of the Performance of Wireless Communications Systems against Man-made Noise and Interference

As the increase of the wireless communications systems and electrical apparatus, unnecessary electromagnetic wave radiated from electrical apparatus and wireless communications systems becomes more serious problem. In order to establish the electromagnetic compatibility concerning wireless communications systems, several methods have been proposed. For example, in 2.4 GHz band wireless communications systems, in order to establish the co-existence of IEEE 802.11b wireless LAN systems, Bluetooth and ISM apparatus, the propagation control technique using adaptive array antenna have been proposed. Similarly, electromagnetic wave absorber which control the propagation paths of man-made noise, interference and desired signal, have been proposed. These techniques have taking an great attention to overcome the effect of unnecessary man-made noise (interference) and to establish the electromagnetic compatibility in wireless communications systems.

(S. Miyamoto)

E5. EM Noise related with Print Circuit Boards

Excitation mechanisms of radiated emission from high-speed digital systems have been investigated and considerably understood in recent years. Some topics are common mode generation caused by imperfect ground planes in printed circuit boards (PCBs), radiation from bent transmission lines on PCBs, crosstalk from high-speed signal lines to a victim line acting as an EMI antenna, and radio frequency (RF) noise on power supply interconnections such as power bus noise related to resonance of power and ground planes in multilayer PCBs. To suppress the EMI, some noise reduction techniques have been proposed, and have been studied theoretically and experimentally. In this section, these topics on excitation and radiation mechanisms and noise reduction techniques are reviewed.

Electromagnetic susceptibility, or immunity, is another concern related to PCB and electronic system design. Some papers were published on immunity of semiconductor devices and PCBs. In the last part of this section some papers related to device immunity and immunity test methods are reviewed.

Common mode current due to relatively narrow ground return path on a PCB causes strong radiated emission. Influence of ground width to common mode current and emission spectrum were investigated [Oka *et al*., 1999]. The mechanism of the common mode generation was explained with the unbalance factor of a transmission line called “current division factor”. Connection of transmission lines having different current division factors generates common-mode excitation source voltage, which is proportional to the difference of the factor [Watanabe, *et al*., 2000]. High impedance connection of ground planes causes common mode current on a PCB. Dependence on ground structure and its connection to far-field emission was

investigated experimentally [Sasabe *et al*., 2000.11]. Far-field emission was estimated from measured common-mode current and also from FDTD simulation [Sasabe *et al*., 2000.12, 2001.9], and good agreement with measured field was demonstrated. For the purpose of evaluating immunity of printed circuits, the authors also analyzed the conversion from common-mode to differential-mode on a PCB [Sasabe *et al*., 2000.4].

Radiation from bent transmission lines was evaluated and dependence of radiation on the curve shape and bend shape was estimated with FDTD method and the method of moments (MoM) [Takahashi, *et al*., 1999] [Lee, *et al*., 2000]. Transmission line impedance of a printed line and its near-field were simulated with FDTD method [Kasuga, *et al*., 2000]. Resonance of a transmission line may cause strong emission, and the resonance frequency is affected by metallic structures close to the line. The effect of a metal plate near a microstrip line to its resonance frequency was simulated with MoM [Sakurai, *et al*., 2000]. These traditional methods are effective to investigate electromagnetic characteristics of printed circuit structures, though they consume computational resources. As a new approach, the fuzzy inference method was applied to analyze transmission line characteristics [Tayarani and Kami, 2001].

Crosstalk plays a very important role not only in the signal integrity problems but also in the emission problems. Crosstalk from a high-speed signal line to a victim line may cause strong emission even though the signal speed on the victim line is slow. Hence, in design of PCB, we need some guidelines for controlling the crosstalk. For that purpose crosstalk on parallel printed traces was evaluated [Takahashi, *et al*., 1999], and radiated emission from a PCB was also evaluated for coupling between a low frequency signal trace and a digital signal trace [Oka, *et al*., 2000]. In some applications such as wireless terminals, coupling between an antenna or RF analog circuits and high-speed digital circuits may cause serious problems in design. The coupling between a monopole antenna and a strip line in a shielding case with slits was investigated numerically with FDTD method and the results were compared with measured ones [Fukasawa, *et al*., 2000].

For reducing EMI and unintended coupling through lines, ferrite materials are often used. However, the details of their frequency characteristics or loading effects have not been well understood yet. The noise reduction effect of ferrite beads was evaluated with an equivalent circuit [Miyashita, *et al*., 1999]. More precise matrix-form expression of the load effect of a ferrite core was given [Samir, et al., 2000], in which a practical method for determining the equivalent parameters was given by measuring the scattering parameters. The expression of the load effect of a ferrite was used to analyze crosstalk on parallel two-wire lines [Fujiwara, et al., 2001] and to evaluate far-field radiation and its reduction effect in relation to the position of a ferrite [Maekawa, et al., 2001]. Loading effect of a noise suppression component as a function of loading position was investigated theoretically and experimentally for PCBs exposed to external electromagnetic field [Yamamoto, *et al*., 2000]. Magnetic film tape was investigated as a counterpart of ferrite cores for noise reduction on cables [Mori and Senda, 2000]. Effect of lossy rubber absorber was analyzed for suppression of coupling between microstrip lines in a metal case of a microwave amplifier module [Saito and Nishikata, 2001]. Shielding effectiveness of an enclosure of an electronic equipment was modeled and analyzed with a spherical shell model [Horagai and Ikeda, 2000].

In the development of electronic systems such as printed circuit boards of digital circuits, to know electric current on a PCB or in components and near-field distribution is helpful to evaluate their electromagnetic characteristics and to improve the design. A method for estimating current distribution on a PCB was proposed, and a mother-board for a workstation was evaluated with small loop magnetic probes [Masuda, *et al*., 1999]. Position of magnetic

field source on a micro processing unit was also estimated with near-field measurement [Doi and Masuda, 2000]. A new method to estimate both current and voltage distributions with one probe was proposed, and the distributions in packaged ICs were evaluated [Kazama, *et al*., 2000].

In designing high-speed digital circuit boards, it is practically important to control RF noise on power supply interconnections and DC power distribution circuits, such as power and ground planes in multilayer PCBs. The power distribution circuit is usually called as a "power bus", which could supply electric power only having low frequency current. However, in practical cases, high-speed operation current should be supplied to a circuit; and since impedance of the power distribution circuit is usually low especially in a multilayer PCB, the high frequency current tends to flow over the power distribution circuit, which may cause radiated emission. To prevent the high-frequency current on the power distribution circuit, decoupling techniques were investigated. The decoupling can be achieved by increasing the RF impedance from a high-speed device to the power bus, or by using decoupling capacitors near the device or on the power bus. For the decoupling, a power wiring technique with long printed traces and another with embedded inductances in a multilayer PCB were demonstrated [Tohya, 1999] [Iwanami, *et al*., 2000]. Resonance of power bus, which is responsible for strong radiated emission, was investigated theoretically and experimentally, and a technique to control the resonance was presented [Harada, *et al.*, 2000], which utilized decoupling capacitors on a PCB. A technique to optimize the location of the decoupling capacitors was proposed [Kamo, *et al.*, 2001]. To reduce the quality (Q) factor of the power bus resonance, resistive metal films were introduced between power and ground planes in a multilayer PCB, and the resonance characteristics were investigated to optimize the film thickness and its conductivity [Wang, *et al*., 2001]. For the calculation of the resonance characteristics of the power bus, an improved closed-form expression of the Green's function was adopted to perform fast numerical calculation. The power bus resonance can be excited also by high-speed signal routed through via holes, and improvement of the routing to reduce the power bus noise was investigated experimentally [Tanaka, *et al*., 2001].

Improvement of packages of active devices was reported to reduce power bus noise. An EMI reduction packaging for LSI was proposed, which achieves the power decoupling with decoupling inductances internally connected to power and ground pins of the package [Fukumoto, *et al.*, 2000]. Ferrite-resin composite material was investigated as package mold of digital ICs to reduce the power bus noise [Akino, *et al*., 2000]. To simulate the power bus noise effectively, a macro-model of a digital IC and LSI was proposed [Fukumoto, *et al*., 2001]. The model consists of a linear equivalent internal circuit and internal current source, and is suitable for high-speed EMI simulation.

Regarding immunity of semiconductor devices and PCBs, papers were published on modeling, evaluation and test methods. To investigate immunity to electric coupling between an IC with a metal heat sink and an adjacent noise source, a capacitive coupling model was proposed [Nonaka, *et al*., 1999]. To achieve fail-safe property of digital systems, a design method of a flip-flop having asymmetric immunity characteristics was proposed [Tsukagoshi, *et al.*, 1999]. Immunity characteristics of MOSFET were investigated and mechanism of its malfunction was presented [Hattori, *et al*., 1999]. The authors also investigated RF noise immunity of operational amplifiers, both the bipolar type and the MOS type [Hattori, *et al* 2000]. Noise immunity diagnosis for a PCB was discussed using an equivalent circuit, and the results of experiments were explained with the common-mode impedances [Sasabe, *et al.*, 2000]. A system to detect malfunction area on a PCB was developed and the validity was demonstrated

with experiment [Onomae and Nagasawa, 2001]. A novel RF radiated immunity test method was proposed and its basic characteristics were investigated. The method adopts electromagnetic field rotating in low speed; the field is rotated electrically with a newly developed circuit so that its characteristics are easily controlled [Murano and Kami, 1999, 2000.11]. The authors investigated another system for radiated immunity test which utilizes a three-dimensional Helmholtz's coil set [Murano and Kami, 2000.3].

(O. Wada)

E6. EMC related with electrical power engineering

The source element of EMC related with electrical power engineering can be categorized in two types. The one is the induction caused by high voltage and large current characteristics of the power line by its own nature. The other is caused by the apparatuses or faults connected to the power line.

The influences of the electric and magnetic fields to the medical infections of human beings and to the mal-operations of electronics apparatuses are attracted and studied as the former difficulties. The electro magnetic field generated by the over head transmission lines voltages and current and the human body exposure strength are calculated and studied by many researchers and groups leaded by IEE-J (Institute of Electrical Engineering Japan). The studies are mainly discussing about the quantitative values of the electro magnetic field its self and they are different from epidemiology approach which is general research trend in Europe. Their results seem to be given highly political consideration to the utilities.

The induction power source of aerial beacon flash light on the top of transmission tower with using the induction by power line magnetic field was proposed and studied, for it is difficult to obtain adequate electric power source at such location. This work is the enterprising usage of the electro magnetic field generated from over head transmission line that is generally annoying public peoples. The proposed power source uses the induced current on the over head ground wire for the asymmetric arrangement of the three phase power lines and obtains several kW electric powers. The inducted current on the ground wire changes with the current on the power line for it changes with load amount, then the suitable junction span of ground wire to tower body and electrical power storage capacity is discussed to obtain the desired induced current and power quality coping with the periodic load change.

Power Line Carrier (PLC) communication is considered one of the EMC difficulties. The PLC on high voltage transmission line for protective relay information transmission has been studied since a long time ago and the system is almost perfect and left no room for study, then the PLC on distribution line is now being studied. The PLC on distribution line is aiming at internet connection, and the PLC study in Japan is behind Europe. There are two reasons for research subordination. The one is regulation restricted by law. The regulation relating PLC is administrated by different two ministries. The ministry of Economy, Trade and Industry administrates the power line related regulation, and the Ministry of Public management, Home affairs, Posts and telecommunications administrates the communication relating regulation. Though, the deregulation by government has been proceeding recently, but the regulation relating with PLC made little progress for it is extended two ministries. The second reason is the highly prepared optic fiber networks. The Japanese utility companies monopolies the generation, transmission and distribution to the respective territories, and they lay down optic fiber along with the distribution line network. Therefore, the communication requirement with using distribution line is low for they can use optic fiber communication. The subsidiary

company of the utility company conducts low power cellular phone system called PHS, and the inspection of the meters is realized by linking the PHS with optical fiber networks. Moreover, the subsidiary company also offers internet provider business with using PHS as the home LAN, and also optical fiber to the home is offered. Therefore, the last one mile difficulty is solved without using PLC. According to those conditions in Japan, it can be expected that the main application of PLC is home LAN system application leaded by household electric appliances with internet access function. The conventional distribution power line inside buildings is not properly twisted and the line impedance is not uniform, then high speed communication has to clear this difficulty and spectrum spread and error correction method are highly expected.

The followings are the EMC problem caused by the harmonics generated by electric apparatus connected to the power line. The dispersed energy system has been growing its number linked to the power system in accordance with the power system deregulation. The isolate operation detection system of the dispersed energy system connected distribution line, which makes the most of the harmonics characteristic in the power system, is proposed. The dispersed energy system can continue its operation even if they are isolated from ac bus by some faults, if the supply and demand is almost balanced. But, this operation continuation gives harmful influences on the power system recovery for the power system protecting relay system does not estimate such operation continuation, then the dispersed energy system must be shut down after such inadequate conditions. The nonlinearity characteristics of the transformer are one of the oldest harmonics difficulties in the power system. The one of the isolate operation detection relay system checks the 3^{rd} order harmonics on the power line, which increases with the nonlinear affection of the transformer, when the distribution system is isolated from the ac bus. There are other isolation operation detection relay system with using power line characteristics, such as the inter harmonics injection method, reactive power modulation method and frequency bias method are proposed.

The increasing number of electronics devices which use inverters, make the difficulty of harmonics current injection to the power line as the server problem. The Japanese utility companies have been encouraging to establish power factor correction capacitors by the users with giving the incentive of power charge discount. Almost all the power factor correction capacitor does not have circuit breakers which open and closes in accordance with the power factor of the user load and remain connected at all times. Therefore, the amount of power capacitor connected to the power distribution line is highly exceeded and shows leading power factor conditions at night light load, and it makes the undesired phenomena of harmonics magnification at the end of distribution line by the small harmonics injected to the transmission line from some sources. The power line active filter is proposed as the solution of the harmonics suppressions, which is consisted from power electronics inverter. The active filter is specified in two types. The one is series connected type, and the other is parallel connected type. The former one is conventional type active filter, which is suitable when the harmonics source is identified. The last one is the mainstream of active filter study, for it can cope with the harmonics from uncertain sources like the above mentioned harmonics magnification phenomena. Not only harmonics suppressions by active filter, but also harmonics reduction generated from the apparatus is studied. This study is enhanced now because the household electric appliances become to use dc power source by ac/dc converter and the conventional capacitor input type converter generates harmonics and it becomes to dominate the harmonics problems. The main difficulty of this type converter is caused by the pulse shape current containing harmonics and the low power factor. The PWM type converters or dc/dc converter

link with PAM operation is studied to cope with these difficulties, which are called PFC and has become to use in the dc power source.
On the other hand, the increasing number of these intelligent type electronics apparatus has made the power quality as the very important issues, such as voltage sag and swells. Though conventional electric apparatuses are not so sensitive, but such new and intelligent apparatuses are very sensitive to the short interruptions or degradation of voltage waveform. The counter measurements to cope with power quality deterioration, the usage of UPS is proposed and studied as the user side local management and DVR is investigated as the aerial management. The configurations and control strategy of the compensation system are enthusiastically discussing now. More over, CRIEPI is proposing demand area power system and several universities unions proposing FRIENDS system as the quality divided power supply system.

(T. Funaki)

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Natural EM Noise

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