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and
Ministry of Research, Innovation and Digitization

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In partnership with:

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13/2022

INTERNATIONAL WORKSHOP of ELECTROMAGNETIC COMPATIBILITY

HYBRID SCIENTIFIC EVENT

The 13rd edition of CEM 2022
Suceava, ROMANIA
14th—16th September, 2022

BOOK of ABSTRACTS

CEM2022

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BOOK of ABSTRACTS

of the

13th International Workshop of Electromagnetic Compatibility

Suceava, ROMANIA
14th - 16th September, 2022

Hybrid scientific event

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NOTE:
CEM 2022 Book of Abstracts present abstracts from ***The 13th edition of International Workshop of Electromagnetic Compatibility*** (Suceava, 14th - 16th September, 2022).

13th edition of CEM 2022 Book of Abstracts is printed edition having
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THE 13TH INTERNATIONAL WORKSHOP OF ELECTROMAGNETIC COMPATIBILITY

CEM 2022

Suceava - ROMANIA
September 14th – 16th, 2022
Hybrid scientific event

with support of:

MINISTRY OF EDUCATION
and
MINISTRY OF RESEARCH, INNOVATION AND DIGITIZATION

Organized by:

NATIONAL INSTITUTE FOR RESEARCH AND DEVELOPMENT IN ELECTRICAL ENGINEERING ICPE-CA BUCHAREST

in collaboration with

„ȘTEFAN CEL MARE" UNIVERSITY OF SUCEAVA

UNIVERSITY "POLITEHNICA" OF BUCHAREST

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On behalf of National Institute for Research and Development in Electrical Engineering ICPE-CA Bucharest, we welcome you to attend 13th International Workshop of Electromagnetic Compatibility ***CEM 2022***, Suceava, Romania. We hope that over the next three days you'll get theoretical and practical knowledge, and personal contacts that will help you build long-term and fruitful communication among researches in a wide variety of scientific areas with a common interest in the thematic field.

On behalf of Workshop Committees, we would like to thank all the authors, keynote speakers and panelists. Their high competence, enthusiasm, dedication and knowledge enabled us to prepare this quality program and helped us to make the workshop a successful event.

Also, we feel the need to express to Mrs. Georgeta Alecu a thought of thanks and appreciation for her involvement and dedication in organizing of 12 editions of the EMC Workshop.
Good luck, health and strength in the future!

Once again, thank you for coming to this workshop and we are looking forward to meeting you next time.

CEM 2022 Organizing Committee

September 2022

SCIENTIFIC COMMITTEE

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Marcel OPRIŞ (Romania)

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Mircea POPESCU - ICPE-CA Bucharest

Dorinel TĂLPEANU - ICPE-CA Bucharest

Andreea VOINA - ICPE-CA Bucharest

WORKSHOP GOALS AND TOPICS

The National Institute for Research & Development in Electrical Engineering ICPE-CA Bucharest (INCDIE ICPE-CA), in partnership with the „Ștefan cel Mare" University of Suceava, University „Politehnica" of Bucharest and Romanian EMC Association is organizing the **13th International Workshop of Electromagnetic Compatibility CEM 2022**, in Suceava, Romania.

The workshop will address the following topics and other related issues:

- electromagnetic compatibility in the fields of electronics, communications systems, transportation systems, industrial systems;
- materials for electromagnetic compatibility;
- electromagnetic shielding and solutions;
- wireless power transfer;
- electricity quality and consumption efficiency;
- electronic packaging;
- the effects of human exposure to electromagnetic fields;
- bio-electromagnetic compatibility;
- 5G technology and health;
- issues related to EMC standardization.

- PROGRAM -

On-site address:
***Building D** of "Ștefan cel Mare" University of Suceava –*
"Dimitrie Leonida" Conference Hall
University Street no. 13, Suceava – 720229,
Suceava County, Romania

***Online address:** ZOOM Link*
https://us02web.zoom.us/j/82002577061?pwd=QUtRMVoySlI0N0IzUnR5TzV2YVh3dz09

Wednesday, 14 September 2022	
12⁰⁰ - 15⁰⁰	**Accommodation.** **Preliminary information.** **USV Campus Visit.**
15⁰⁰ – 15⁴⁵	**Registration of participants.** **Coffee Break**
15⁴⁵ - 16¹⁵	**Opening Ceremony** Sergiu NICOLAIE, *General Director INCDIE ICPE-CA Bucharest* Mihai DIMIAN, *Vice-Rector of "Ștefan cel Mare" University of Suceava* Eros-Alexandru PĂTROI, *Scientific Director INCDIE ICPE-CA Bucharest* *Representative of the MCID*
16¹⁵ – 18⁴⁵	**Plenary Session, INVITED LECTURES** **Chairs:** Marcel OPRIȘ and Adrian GRAUR
	16¹⁵ – 16⁴⁵ **BIOELECTROMAGNETISM AND QUANTUM BIOMAGNETOMETRY BIOLOGIC INTERACTIONS WITH ELECTROMAGNETIC FIELDS - A LIVED HISTORY IN IASI** **Octavian BALTAG** "Grigore T. Popa" Univ. of Medicine and Pharmacy of Iasi, Romania Terraflux Control Ltd., Iasi, Romania
	16⁴⁵ – 17¹⁵ **EMC AND PQ PROBLEMS IN TRANSPORTATION ELECTRIC DRIVE SYSTEMS, INCLUDING RAILWAY SYSTEMS** **Petre-Marian NICOLAE** (online) University of Craiova, Faculty of Electrical Engineering, Craiova, Romania

Wednesday, 14 September 2022	
	$17^{15} – 17^{45}$ **TIME VARIABILITY FEATURES OF 4G AND 5G (SUB-6 GHz) EMISSIONS OF MOBILE TERMINALS** **Simona MICLĂUȘ[1,2], Vivian-Mihaela MAFTEI[1], Delia Bianca DEACONESCU[2], Andreea Maria BUDA[2], David VATAMANU[1,2]** (online) [1]"Nicolae Balcescu" Land Forces Academy, Sibiu, Romania [2]Technical University of Cluj-Napoca, Doctoral School, Cluj-Napoca, Romania
	$17^{45} – 18^{15}$ **LOW AND VERY LOW FREQUENCY ELECTROMAGNETIC SHIELDING OF CONDUCTIVE MATERIALS WITH OR WITHOUT MAGNETIC PROPERTIES** **Mihai BĂDIC, Cristian MORARI, Eros-Alexandru PĂTROI** National Institute for Research and Development in Electrical Engineering ICPE-CA Bucharest, Romania
	$18^{15} – 18^{45}$ **ELECTROMAGNETIC COMPATIBILITY FOR e-MOBILITY** **Andrei MARINESCU[1,2]** (online) [1]ASTR, Craiova Branch, Romania [2]ACER Association, Craiova, Romania
$18^{45} – 19^{45}$	**Sponsors Exhibition / Presentations** *D Building, "Dimitrie Leonida" Conference Hall & Hallway*
	$18^{45} – 19^{00}$ **ORACLE**
	$19^{00} – 19^{15}$ **Marc Tel S.I.T.**
	$19^{15} – 19^{30}$ **COMTEST S.R.L.**
	$19^{30} – 19^{45}$ **ELECTRIC PRODUCTS CERTIFICATION INDEPENDENT BODY**
$20^{00} – 22^{00}$	**Welcome Cocktail and Dinner** *Continental Hotel Restaurant, 4 Mihai Viteazul Str., Suceava 720057*

Thursday, 15 September 2022	
09^{00} – 10^{30}	**Plenary Session, INVITED LECTURES** **Chairs:** Andrei MARINESCU and Gheorghe SAMOILESCU
	09^{00} – 09^{30} ADVANCED EMC DESIGN AND RISK ANALYSIS THROUGH MACHINE LEARNING TECHNIQUES **Philippe BESNIER** (online) University Rennes, INSA Rennes, CNRS, Rennes, France
	09^{30} – 10^{00} ANALYSIS OF THE UNINTENDED PROPAGATION OF AUDIO SIGNAL EMITTED BY WIRELESS HEADPHONES **ALEXANDRU MĂDĂLIN VIZITIU[1,3], BOGDAN CĂTĂLIN TRIP[1,3], VLAD FLORIAN BUTNARIU[1,3], VALENTIN VELICU[2,3], LIDIA DOBRESCU[1], SIMONA HALUNGA[1]** [1]University "Politehnica" of Bucharest, Faculty of Electronics, Telecommunications and Information Technology, Bucharest, Romania [2]University "Politehnica" of Bucharest, Faculty of Electrical Engineering, Bucharest, Romania [3]The Special Telecommunications Service, Bucharest, Romania
	10^{00} – 10^{30} DEVELOPING HYBRID WIRELESS COMMUNICATIONS AND INFORMATION TECHNOLOGIES FOR VEHICLE SAFETY AND DRIVER ASSISTANCE **MIHAI DIMIAN[1], ALIN CĂILEAN[1,2], EDUARD ZADOBRISCHI[1,3], LUCIAN COSOVANU[1], CĂTĂLIN BEGUNI[1], SEVASTIAN AVĂTĂMĂNIŢEI[1]** [1]Ştefan cel Mare University of Suceava, Romania [2]University of Paris-Saclay, France [3]Technical University of Cluj-Napoca, Romania
10^{30} – 11^{00}	**Coffee Break**
11^{00} – 13^{00}	**Plenary Session, INVITED LESSONS** **Chairs:** Alexandru MOREGA and Mihai DIMIAN
	11^{00} – 11^{30} ACHIEVING AN EFFICIENT MANAGEMENT OF NAVIGATION EQUIPMENT AND ANALYSIS OF A COMPUTER MODEL FOR THE TRAINING OF MARINE OFFICERS **Bogdan ASALOMIA[1], Gheorghe SAMOILESCU[2], Cătălin CLINCI[3]** [1]Northern Marine Management, Military Technical Academy, Bucharest, Romania [2]Department of Electrical Engineering and Naval Electronics, Faculty of Marine Engineering, "Mircea cel Batran" Naval Academy, Constanta, Romania [3]Scientific Research Department, "Mircea cel Batran" Naval Academy, Constanta, Romania

Thursday, 15 September 2022	
	11^{30} – 12^{00} **LIGHTNING PROTECTION OF RENEWABLE POWER SYSTEMS – A REVIEW** **Elena HELEREA, Marius Călin DANIEL** (online) Transilvania University of Brasov, Brașov, Romania
	12^{00} – 12^{30} **RECENT RESEARCH ON THE BIOLOGICAL EFFECTS IN SEVERAL CASES OF ENVIRONMENTAL AND SPECIFIC PROFFESIONAL EXPOSURE TO ELECTROMAGNETIC FIELDS** **Georgiana ROȘU[1], Sonia SPANDOLE-DINU[2], Ana-Maria CATRINA[2], Leontin TUȚĂ[1], Lars Ole FICHTE[3], Octavian BALTAG[4]** (online) [1]"Ferdinand I" Military Technical Academy, Bucharest, Romania [2]„Cantacuzino" National Military-Medical Institute for Research and Development, Bucharest, Romania [3]"Helmut Schimdt" University, Hamburg, Germany [4]"Grigore T. Popa" University of Medicine and Pharmacy, Iasi, Romania
	12^{30} – 13^{00} **ELECTROMAGNETIC INTERFERENCE OF EMISSION NOISE ON MOBILE COMMUNICATIONS INSIDE INDUSTRIAL UNMANNED AERIAL VEHICLES** **Koh WATANABE, Ryota SAKAI, Satoshi TANAKA, Makoto NAGATA** (online) Graduate School of Science, Technology and Innovation, Kobe University, Kobe, Japan
13^{00} – 15^{00}	**Lunch** *Continental Hotel Restaurant, 4 Mihai Viteazul Str., Suceava 720057*
15^{00} – 16^{30}	**Oral Session** **Chair:** Mircea POPESCU
	15^{00} – 15^{15} **MATLAB OPTIMIZATION OF SELF AND MUTUAL INDUCTANCE CALCULATION FOR FLAT SPIRAL AND LOOP COILS UTILIZED IN WIRELESS DRONE CHARGING** **Vlad MOCANU, Vasile DOBREF, Florențiu DELIU** (online) „Mircea cel Bătrân" Naval Academy, Department of Electrical Engineering, Constanța, Romania
	15^{15} – 15^{30} **ELECTROMAGNETIC SCREENING PROPERTY TESTING FOR A CONDUCTIVE METAL MATERIAL** **Mircea-Emilian ARDELEANU[1], Viorica VOICU[2], Livia-Andreea DINA[1]** (online) [1]Faculty of Electrical Engineering, University of Craiova, Craiova, Romania [2]National Institute for Research, Development and Testing in Electrical Engineering – ICMET Craiova, Romania

Thursday, 15 September 2022	
	15^{30} – 15^{45} **SIGNAL MODEL ADEQUACY INDICATOR FOR POWER QUALITY MONITORING** **Anca BRÎNCOVEANU, Efstathios FIORENTIS, Radu PLĂMĂNESCU, Ana-Maria DUMITRESCU, Mihaela ALBU** University "Politehnica" of Bucharest, Faculty of Electrical Engineering, Bucharest, Romania
	15^{45} – 16^{00} **IMPACT OF DIODE EMULATION MODE ON EMC-RELATED PERFORMANCE OF DrMOS-BASED BUCK CONVERTER** **Josip BAČMAGA, Franjo MIKIĆ, Adrijan BARIĆ** (online) University of Zagreb Faculty of Electrical Engineering and Computing, Zagreb, Croatia
	16^{00} – 16^{15} **SMART ADJUSTABLE OPTICAL ATTENUATOR** **Lilia SAVA, Ana NISTIRIUC, Andrei CHIHAI, Pavel NISTIRIUC, Serghei ANDRONIC** Technical University of Moldova, Chisinau, Republic of Moldova
	16^{15} – 16^{30} **SPECIFIC ABSORPTION RATE (SAR) ASSESING IN TISSUE MODELS MIMICKING THE HUMAN HEAD AT 5G FREQUENCIES** **Delia Bianca DEACONESCU[1], Simona MICLĂUȘ[2]** (online) [1]Technical University of Cluj-Napoca, Doctoral School, Cluj-Napoca, Romania [2]"Nicolae Balcescu" Land Forces Academy, Sibiu, Romania
16^{30} – 17^{00}	**Coffee Break**
17^{00} – 19^{15}	**Oral Session** **Chair:** Simona MICLĂUȘ
	17^{00} – 17^{15} **HIGHLY DIRECTIVE VHF ANTENNA FOR APPLICATIONS IN THE 118-137 MHz RANGE** **David VATAMANU[1,2], Simona MICLĂUȘ[1,2]** (online) [1]"Nicolae Balcescu" Land Forces Academy, Sibiu, Romania [2]Technical University of Cluj-Napoca, Doctoral School, Cluj-Napoca, Romania
	17^{15} – 17^{30} **PEOPLE COUNTING IN A COVID-19 AND GDPR CONTEXT, USING AN IR-UWB RADAR, BASED ON ARTIFICIAL INTELLIGENCE ALGORITHMS** **Cristina POPOVICI[1], Emanuel RĂDOI[2], Leontin TUȚĂ[1]** (online) [1] "Ferdinand I" Military Technical Academy, Bucharest, Romania [2]University of Western Brittany, Brest, France

Thursday, 15 September 2022	
	17^{30} – 17^{45} **THE LOCAL RADIATED EMISSION OF AN WI-FI 6 CLIENT: PRELIMINARY OBSERVATIONS** **Andreea-Maria BUDA[1], Annamaria Sârbu[2]** (online) [1]Technical University of Cluj-Napoca, Doctoral School, Cluj-Napoca, Romania [2]“Nicolae Balcescu” Land Forces Academy, Sibiu, Romania
	17^{45} – 18^{00} **DEFECTOSCOPY TOOLS FOR THE EVALUTION OF NEAR FIELD RADIATED EMISSIONS** **Cezar-Ion ADOMNIȚEI, Cezar-Eduard LEȘANU, Adrian DONE** ”Ștefan cel Mare” University of Suceava, Suceava County, Romania
	18^{00} – 18^{15} **ABOUT THE ELECTROMAGNETIC COMPATIBILITY OF RADIO COMMUNICATION SYSTEMS** **Lilia SAVA, Ana NISTIRIUC, Andrei CHIHAI, Pavel NISTIRIUC, Serghei ANDRONIC** Technical University of Moldova, Chisinau, Republic of Moldova
	18^{15} – 18^{30} **OPTIMIZATION OF ENERGY CONSUMPTION IN EDUCATIONAL INSTITUTIONS** **Victor ABABII, Viorica SUDACEVSCHI, Silvia MUNTEANU, Victoria ALEXEI, Ana ȚURCAN** (online) Technical University of Moldova, Chisinau, Republic of Moldova
	18^{30} – 18^{45} **USING THE SPECTRAL FINGERPRINT OF MOBILE TACTICAL PLATFORM TO ENSURE EMISSIONS CONTROL AND PERSONNEL SAFETY** **Călin POPESCU[1], Cătălin NACIU[1,2], Mihai NICOLAE[1,2], Mircea POPESCU[2]** [1]University “Politehnica” of Bucharest, Romania [2]National Institute for Research and Development in Electrical Engineering ICPE-CA Bucharest, Romania
	18^{45} – 19^{00} **ELECTROMAGNETIC FIELD LEVEL ANALYSIS IN DENSELY POPULATED AREAS** **Cătălin NACIU[1,2], Mircea POPESCU[1], Lucian PETRESCU[2], Mihai NICOLAE[1,2]** [1]National Institute for Research and Development in Electrical Engineering ICPE-CA Bucharest, Romania [2]University “Politehnica” of Bucharest, Romania

Thursday, 15 September 2022	
	19^{00} – 19^{15} MEASUREMENT METHODS IN 5G MOBILE COMMUNICATIONS **Mihai NICOLAE[1,2], Mircea POPESCU[1], Cătălin-Andrei NACIU[1,2]** [1]National Institute for Research and Development in Electrical Engineering ICPE-CA Bucharest, Romania [2]University "Politehnica" of Bucharest, Romania
20^{00} – 23^{00}	**Official Dinner** *Continental Hotel Restaurant, 4 Mihai Viteazul Str., Suceava 720057*
Friday, 16 September 2022	
09^{30} – 10^{30}	**Plenary Session, INVITED LECTURES** **Chair**: Dan MILICI
	09^{30} – 10^{00} THE FUTURE OF THE USE OF ELECTROMAGNETIC FIELDS AND BEAMS IN MEDICINE AND BIOLOGY **Nicolae I. VERGA** "Carol Davila" University of Medicine and Pharmacy, Bucharest, Romania
	10^{00} – 10^{30} 5G EMF: REAL EXPOSURE LEVELS AND FALSE CLAIMS **Jack ROWLEY** (online) GSMA, London, UK
10^{30} – 11^{00}	**Poster Sessions & Coffee Break** **Chair:** Eugen COCA MATLAB ALGORITHMS FOR CHARACTERIZATION OF DETECTED FREQUENCIES AS STRATEGIES TO DETECT PATHOLOGICAL AGENTS OF TROPICAL DISEASES IN THE DIGITAL AMPRENT FROM THE BREATH TESTS **Alexandru TOPOR[1], Dumitru ULIERU[2], Cristian RAVARIU[3], Florin BABARADA[3]** [1]SDETTI Doctoral School from Polytechnical University of Bucharest, Romania [2]SC Sitex 45 SRL, Bucharest, Romania [3]University "Politehnica" of Bucharest, Faculty of Electronics ETTI, DCAE Department, Bucharest, Romania

Friday, 16 September 2022

10^{30} – 11^{00}	**Poster Sessions & Coffee Break** **Chair:** Eugen COCA **EVALUATION OF INDOOR EXPOSURE TO RADIOFREQUENCY ELECTROMAGNETIC RADIATION FROM RADIOCOMMUNICATION PUBLIC SERVICES BY OUTDOOR MONITORING IN URBAN ENVIRONMENT OF WARSZAWA** **Jolanta KARPOWICZ[1], Krzysztof GRYZ[1], Szymon CYGAN[2], Alicja ŁYJAK[2], Piotr TULIK[2]** [1]Central Institute for Labour Protection - National Research Institute (CIOP-PIB), Department of Bioelectromagnetics, Warszawa, Poland [2]Warsaw University of Technology, Faculty of Mechatronics, Institute of Metrology and Biomedical Engineering, Warszawa, Poland **MEASUREMENTS AND NUMERICAL MODELLING OF ELECTROMAGNETIC HAZARDS RELATED TO THE USE OF SURGICAL DIATHERMY DEVICES** **Jolanta KARPOWICZ, Patryk ZRADZIŃSKI, Krzysztof GRYZ** Central Institute for Labour Protection-National Research Institute (CIOP-PIB), Department of Bioelectromagnetics, Warszawa, Poland **ELECTROMAGNETIC COMPATIBILITY ISSUES IN NANOPORE BIOSENSING TECHNOLOGIES** **Iuliana ȘOLDĂNESCU[1], Mihai DIMIAN[2], Andrei LOBIUC[3]** [1]MANSID Integrated Center for Research, Development and Innovation, ”Ștefan cel Mare” University of Suceava, Romania [2]Department of Computer, Electronics and Automation, ”Ștefan cel Mare” University of Suceava, Romania [3]Department of Biomedical Sciences, ”Ștefan cel Mare” University of Suceava, Romania **EFFECTIVE SCREEN BASED ON COPPER – MAGNETIC COMPOSITION OF FLUOROSILOXANE RUBBER** **Lilia SAVA, Ana NISTIRIUC, Andrei CHIHAI, Pavel NISTIRIUC, Serghei ANDRONIC** Technical University of Moldova, Chisinau, Republic of Moldova **AN OVERVIEW OF THE “STUDY ON THE EVALUATION OF THE ELECTROMAGNETIC COMPATIBILITY DIRECTIVE 2014/30/EU (EMCD)”** **Jana PINTEA** National Institute for Research and Development in Electrical Engineering ICPE-CA Bucharest, Romania

Friday, 16 September 2022	
10^{30} – 11^{00}	**Poster Sessions & Coffee Break** **Chair:** Eugen COCA **ON THE ELECTROMAGNETIC COMPATIBILITY OF A SHIELDED ROOM IN PRESENCE OF PENETRATING WALL POWER AND DATA/SIGNAL CABLES** **Vicențiu-Mario PETRACHE[1], Olguța Gabriela IOSIF[2]** [1]Beia Consult International, Bucharest, Romania [2]National Institute for Research and Development in Electrical Engineering ICPE-CA Bucharest, Romania **EMC AND TEMPEST - COMMON OBJECTIVES** **Petruș BĂDULESCU, Daniel PETRESCU** BlueSpace Technology SRL, Bragadiru, Ilfov County, Romania **LOOP ANTENNA FOR PROXIMITY IMMUNITY TEST** **Adrian CONSTANTINESCU, Alexandru STĂNESCU, Mihai DIMITRIU** OICPE, Bucharest, Romania
11^{00} - 12^{00}	**Workshop closing Ceremony** **Award ceremony** ”*The best communications at oral and poster presentation sessions*” **for a junior participant** **Concluding remarks**
12^{00} – 19^{00}	**Box Lunch & CEM2022 Workshop Visit**

ORAL PRESENTATION GUIDELINES

Devices provided by the conference organizer:

Laptops (with MS Office and Adobe Reader)
Projectors and Screens
Laser pointers

Materials provided by the presenters:

PowerPoint or PDF files
Presentation handouts (optional)
Note: Presenters should arrive 15 minutes before the session to copy the presentation file to the provided laptop and try if it works.

Duration of each presentation:

Regular oral session: about 10 minutes of presentation, 15 minutes including Q&A.
Keynote Speech: about 20 minutes of presentation, 30 minutes including Q&A.

ABSTRACTS

KEYNOTE SPEECHES

1. BIOELECTROMAGNETISM AND QUANTUM BIOMAGNETOMETRY BIOLOGIC INTERACTIONS WITH E.M. FIELDS - A LIVED HISTORY IN IASI

Octavian BALTAG

”Grigore T. Popa” Univ. of Medicine and Pharmacy of Iasi, Romania

Terraflux Control Ltd., Iasi, Romania

2. EMC AND PQ PROBLEMS IN TRANSPORTATION ELECTRIC DRIVE SYSTEMS, INCLUDING RAILWAY SYSTEMS

Petre-Marian NICOLAE

University of Craiova, Faculty of Electrical Engineering, Craiova

3. TIME VARIABILITY FEATURES OF 4G AND 5G (SUB-6 GHz) EMISSIONS OF MOBILE TERMINALS

Simona MICLĂUȘ[1,2], Vivian-Mihaela MAFTEI[1],

Delia Bianca DEACONESCU[2], Andreea Maria BUDA[2],

David VATAMANU[1,2]

[1]“Nicolae Balcescu” Land Forces Academy, Sibiu, Romania

[2]Technical University of Cluj-Napoca, Doctoral School, Cluj-Napoca, Romania

4. LOW AND VERY LOW FREQUENCY ELECTROMAGNETIC SHIELDING OF CONDUCTIVE MATERIALS WITH OR WITHOUT MAGNETIC PROPERTIES

Mihai BĂDIC, Cristian MORARI, Eros-Alexandru PĂTROI

National Institute for Research and Development in Electrical Engineering ICPE-CA Bucharest, Romania

5. ELECTROMAGNETIC COMPATIBILITY FOR e-MOBILITY

Andrei MARINESCU[1,2]

[1]ASTR, Craiova Branch, Romania

[2]ACER Association, Craiova, Romania

6. ADVANCED EMC DESIGN AND RISK ANALYSIS THROUGH MACHINE LEARNING TECHNIQUES

Philippe BESNIER

University Rennes, INSA Rennes, CNRS, France

7. ANALYSIS OF THE UNINTENDED PROPAGATION OF AUDIO SIGNAL EMITTED BY WIRELESS HEADPHONES

Alexandru Mădălin VIZITIU[1,3], Bogdan Cătălin TRIP[1,3],
Vlad Florian BUTNARIU[1,3], Valentin VELICU[2,3], Lidia DOBRESCU[1],
Simona HALUNGA[1]

[1]University Politehnica of Bucharest, Faculty of Electronics, Telecommunications and Information Technology, Bucharest, Romania

[2]University Politehnica of Bucharest, Faculty of Electrical Engineering, Bucharest, Romania

[3]The Special Telecommunications Service, Bucharest, Romania

8. DEVELOPING HYBRID WIRELESS COMMUNICATIONS AND INFORMATION TECHNOLOGIES FOR VEHICLE SAFETY AND DRIVER ASSISTANCE

Mihai DIMIAN[1], Alin CĂILEAN[1,2], Eduard ZADOBRISCHI[1,3],
Lucian COSOVANU[1], Cătălin BEGUNI[1], Sevastian AVĂTĂMĂNIŢEI[1]

[1] "Ştefan cel Mare" University of Suceava, Romania

[2] University of Paris-Saclay, France

[3]Technical University of Cluj-Napoca, Romania

9. ACHIEVING AN EFFICIENT MANAGEMENT OF NAVIGATION EQUIPMENT AND ANALYSIS OF A COMPUTER MODEL FOR THE TRAINING OF MARINE OFFICERS

Bogdan ASALOMIA[1], Gheorghe SAMOILESCU[2], Cătălin CLINCI[3]

[1]Northern Marine Management, Military Technical Academy, Bucharest, Romania

[2]Department of Electrical Engineering and Naval Electronics, Faculty of Marine Engineering, "Mircea cel Batran" Naval Academy, Constanta, Romania

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10. LIGHTNING PROTECTION OF RENEWABLE POWER SYSTEMS - A REVIEW

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11. RECENT RESEARCH ON THE BIOLOGICAL EFFECTS IN SEVERAL CASES OF ENVIRONMENTAL AND SPECIFIC PROFFESIONAL EXPOSURE TO ELECTROMAGNETIC FIELDS

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12. ELECTROMAGNETIC INTERFERENCE OF EMISSION NOISE ON MOBILE COMMUNICATIONS INSIDE INDUSTRIAL UNMANNED AERIAL VEHICLES

Koh WATANABE, Ryota SAKAI, Satoshi TANAKA, Makoto NAGATA

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13. THE FUTURE OF THE USE OF ELECTROMAGNETIC FIELDS AND BEAMS IN MEDICINE AND BIOLOGY

Nicolae I. VERGA

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14. 5G EMF: REAL EXPOSURE LEVELS AND FALSE CLAIMS

Jack ROWLEY

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1. BIOELECTROMAGNETISM AND QUANTUM BIOMAGNETOMETRY BIOLOGIC INTERACTIONS WITH E.M. FIELDS - A LIVED HISTORY IN IASI

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Abstract

The paper presents results (on relatively recent historical research) regarding complementary fields of medicine: bioelectromagnetism, quantum biomagnetometry and some interaction between the living matter and electromagnetic fields. A Bioelectromagnetism and Quantum Biomagnetometry Laboratory were realized at the ”Grigore T. Popa” Univ. of Medicine and Pharmacy of Iasi, Faculty of Medical Bioengineering. The emplacement of the laboratory in the building was made considering the disturbing factors (communications antennas, high voltage lines, transformers and auto traffic). This lab was mainly focused on creating an educational and research environment in bioelectromagnetism domain for master students, PhD students, professors and researchers.

The main areas of research were:

- detection and measurement of biomagnetic fields,
- thermography in IR and microwave range exploration,
- bioelectromagnetic compatibility, generation and control of the magnetic and electromagnetic fields,
- research and obtaining materials for the protection of life against electromagnetic fields.

The main equipment was: anechoic chamber, SQUID biogradiometer, large Helmholtz coil system for dynamic environmental field control, microwave radiometer for medical applications, infrared camera, and different systems for measurement and control of magnetic and electromagnetic fields. All these devices and installations were built by the research team, using original concepts.

In 2004, research was conducted on the influence of magnetic fields on living structures. The studies were performed on adult Wistar rats. Research has continued in the upper extremity of the electromagnetic field, with the study of microwave effects.

In 2007, for the first time in Romania a thermographic image of the human body using microwave radiometry was realized. The research was carried out as part of a project on the early detection of breast cancer.

In 2011 was detected and recorded the first magnetocardiogram of a human subject.

Another preoccupation was related to the interaction of living structures with electromagnetic fields, a particular domain related to electromagnetic biocompatibility. Other research focuses on the influence of microwaves on the germination of plant seeds used in food: wheat, sunflower, lentils. The research results were communicated, published, patented and presented in doctoral theses. These researches are carried out for the first time in Romania, and the laboratory is presented as a unique structure in the academic and university space. The laboratory and the research carried out were an absolute premiere both through the field approached and through the experimental and theoretical results obtained.

The present civilization is an electromagnetic one, due to the deeper and deeper presence and influence of electromagnetic fields, both in the people's life and in the environment. The spectrum of the ambient E.M. field extended, reaching limits that go beyond microwave range. The biologic effects became more subtle and more obvious together with the development of communication technologies. Microwave e.m. fields are now considered potentially dangerous due to some disputed experimental results and clinical observations; low frequency e.m. fields must be still be carefully supervised and their biotropic effects need to be analyzed.

Keywords: bioelectromagnetism, biomagnetometry, SQUID, electromagnetic interaction

2. EMC AND PQ PROBLEMS IN TRANSPORTATION ELECTRIC DRIVE SYSTEMS, INCLUDING RAILWAY SYSTEMS

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Abstract

Some theoretical and practical aspects of harmonics from a railway traction system supplying line, including the compatibility with the network, are discussed. A typical structure of a traction drive system in high-speed trains (traction transformer, traction converter including four quadrant converters, a dc link; a three-phase inverter and motors) is presented. The traction transformer has multiple secondary windings, four-quadrant converters and traction transformer. The analyzed railway traction system was submitted to experimental tests to check its compliance with the EN 50388 standard. The interraction between the system supplying, the traction system and the rolling stock determines overvoltages in the line supplying voltage (the aerian line from the contact and the return circuit) and influences the stability in this system. Several phenomena are able to produce harmonic overvoltages. Overvoltages generated by harmonics are analyzed. The case with one or two locomotive(s) on the supplying line without resonance filter are discussed. Cases with locomotive(s) on the supplying line using regenerative braking without/ with resonance filter are presented. The line voltage analysis revealed a functional instability, mainly during the regenerative braking stages with two locomotives. Therefore it was compulsory to design, realize and place a resonance filter corresponding to a frequency of 800 Hz. Evaluating the non-sinusoidal and non-symmetrical regimes from a railway supplying substation using Wavelet Package Transform (WPT) is discussed. Reducing emissions from an AC-DC-AC converter to improve the behavior of the underground train’s power delivery network are discussed, based on implementation of anti-disturbance measures at input and output respectively.

3. TIME VARIABILITY FEATURES OF 4G AND 5G (SUB-6 GHz) EMISSIONS OF MOBILE TERMINALS

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Abstract

One mobile phone (model Motorola Moto g 5G plus) was used to emphasize the differences between the time-stamp characteristics over 24 s long usage of the emitted field in a single point in air situated at 10 cm from the terminal, when it was connected to either 4G LTE or to 5G NR-FR1 mobile network. The measurement method was based on signal spectrum measurements with a real-time spectrum analyzer [1] set on a sample rate of 100ms. Two different channels were emitted during the communication: in 4G the central frequency was f1=2.59 GHz with a bandwidth BW1=20 MHz while in 5G f2=3.7 GHz and BW2=40 MHz, while both links transmitted in time division duplexing. Based on signal spectrum recordings we determined the sequential values of the channel power and finally, by using the calibration file of the miniature electric (E)-field probe used, we expressed the local rms E-field strength at each 100ms. The strings of E-field level data which consisted in 240 values each, were determined for five different mobile applications usage: file download, streaming, file upload, video call and voice call. They formed a set of 5 x 2 = 10 cases of field emission by the terminal's antennas for which a characterization of the time-dynamics of field level was made by statistical and recurrence analysis tools and by time-frequency analysis. In order to eliminate the dependence of the field strength on the emitting antenna characteristics at the two frequencies f1 and f2, we used normalization of all the data in a string to the maximum value, i.e. the raw data were composed of relative E-field strengths values in each case. Therefore, no information on the absolute exposure level belonging to 4G comparatively to 5G can be given. Differences between time-features of emissions evolved, either for inter-applications corresponding to one communication standard (4G / 5G) or for the same application corresponding to a different standard. The most important features of the dynamics of emissions were: a) upload and video call showed the highest differences between 4G and 5G statistics (Fig.1); b) cumulative distribution functions of E-field levels were much steeper for all cases of 5G communications, with streaming showing the steepest curve in both standards; c) video call in 4G had the highest slope of field level local accumulation in time; the same was true in 5G, if compared with the other applications running in the same standard; d) generally, 5G emissions showed coefficient of variations of field levels 45% higher (on average) than 4G emissions; e) correlation between 4G and 5G strings of field levels was the largest for file upload but no correlations were obtained for voice call (Fig. 2); f) recurrence quantifications showed very low recurrence percentage for all the cases; g) Pointcare plots however indicated a regularity: short-term variability was always consistently smaller than long-term variability in all 4G applications, while a vice-versa rule resulted for 5G emissions (Fig.2); h) time-frequency analysis indicated clear differences between 4G and 5G emissions mainly

for cases of upload, video call and streaming (Fig.3). Presently it is considered that mobile phone is the main source of human exposure both in 5G [2] and in 4G mobile communications. The present research focused on the complementary approach which considers that time-variability of exposure is very important. Not only dose matters, but even more it matters the dose rate. In this regard, a careful analysis of peculiarities of emissions represents a valuable tool for further understanding the impact of electromagnetic environment on human functions and health.

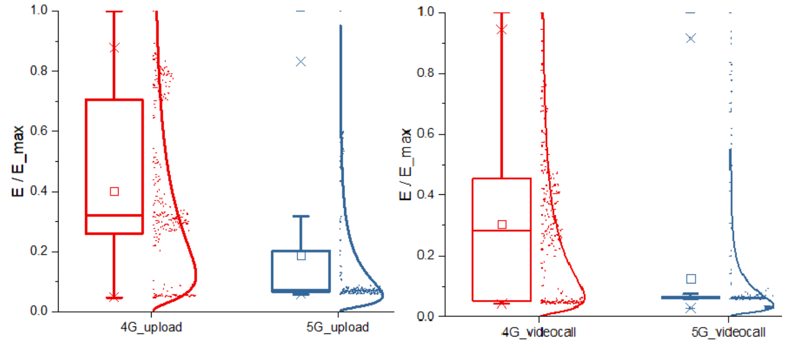

Fig. 1. Boxplots of relative E-field strengths and their distributions (log-normal curves) while mobilephone was connected in a 4G or 5G network while uploading or having a video call

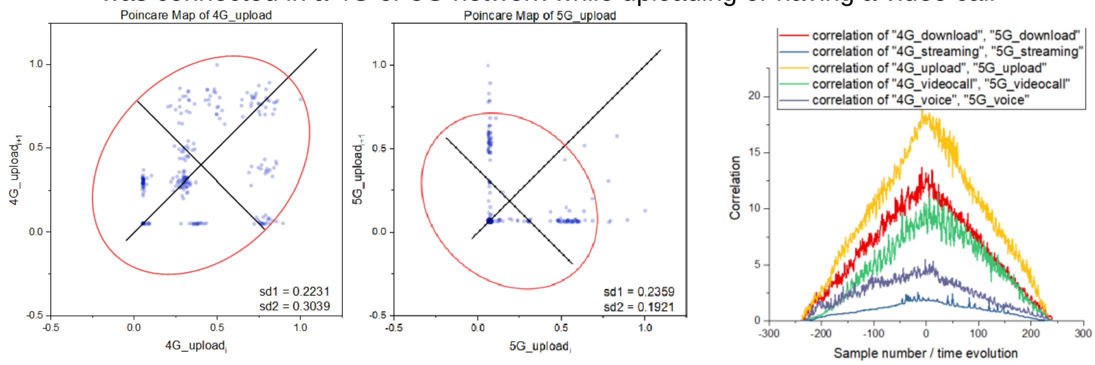

Fig. 2. Pointcare plots indicating self-similarity differences for 4G and 5G emissions (left double ellipses) and correlations between strings of field levels during the same applications in 4G and 5G (right image)

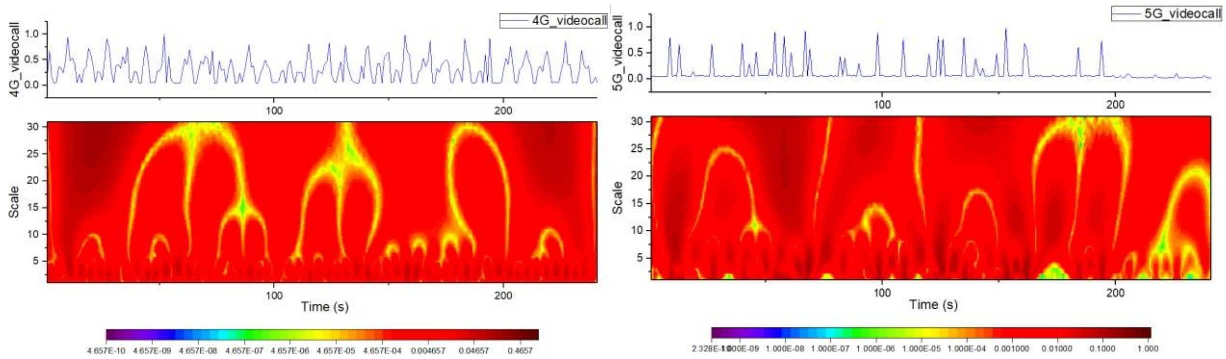

Fig. 3. Time-frequency analysis graphs for video call in 4G (left) and 5G (right)

Keywords: 5G mobile phone; human exposure; microwaves; mobile applications; sub-6 GHz Networks

References

[1] Miclaus S., Deaconescu D.B., Vatamanu D., Buda A.M., Sarbu A., Pindaru B., *Peculiarities of the radiated field in the vicinity of a mobile terminal connected to 4G versus 5G networks during various applications usage*, AIMS Electronics and Electrical Engineering, 2022, 6(2): 161-177.

[2] Castellanos G., De Gheselle S., Martens L., Kuster N., Joseph W., Deruyck M., Kuehn S., *Multi-objectiveoptimization of human exposure for various 5G network topologies in Switzerland*, Computer Networks, August 2022, DOI: 10.1016/j.comnet.2022.109255.

4. LOW AND VERY LOW FREQUENCY ELECTROMAGNETIC SHIELDING OF CONDUCTIVE MATERIALS WITH OR WITHOUT MAGNETIC PROPERTIES

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Abstract

The experiments presented in this paper are of particular importance, in the context of an effervescence in the field of production of new shielding materials, in an extended frequency range (10 Hz-18GHz) and even higher. The article is part of a series of works dedicated to the experimental validation of the electromagnetic shielding theory in the frequency range mentioned above.

This chapter of EMC, electromagnetic shielding, is currently in an uncertain situation. Thus, although there are a series of standards that somewhat establish a methodology for determining the shielding effectiveness (SE_{dB}), based on a well-known analytical demonstration, which includes the theory of transmission lines, the Schelkunoff-Schulz isomorphism, and the phenomenology of the Fabry Perot interferometer in optics, until now this theory has only been partially validated experimentally, on narrow frequency domains.

So, the article presents the methodology, measurement setups and experimental results for determining SE_{dB} at low and very low frequency, for conductive materials with or without magnetic properties in the 10 Hz-10 MHz range. Conductive materials without magnetic properties (copper, aluminum, graphite-based processed materials), as well as materials with magnetic properties (iron, steel) were tested. The concordance of the experimental results with the theory is very good, with a difference of maximum +/- 5% compared to the theoretical prediction.

The theoretical and practical importance of these experiments includes at least 5 areas of expertise:

Ensuring the premises for the experimental validation of the existing theory with the perspective of developing consistent standards from a theoretical and technical point of view.

Through the experimental validation of the methodology and setups for materials whose SE_{dB} curve as a function of frequency can be constructed analytically, the possibility of testing materials that cannot be calculated theoretically (anisotropic, composite, multilayer, etc.) is also created.

It is demonstrated the possibility of determining the magnetic permeability characteristic, $\mu r=F(f)$, for ferromagnetic materials, in an extended range of frequencies, through SE_{dB} measurements.

Accurate determination of the intersection point of the two SEdB=F(f) curves corresponding to conductive materials, one of which has magnetic properties, in order to establish an optimum for the low-frequency magnetic shielding of the enclosures.

The premises are ensured for the experimental validation of the theoretical curve $SE_{dB}=F(f)$ for an analytically calculable material, in the entire range of frequencies, of technical interest (10 Hz-18 GHz), which constitutes an absolute novelty, relative to the specialized, current, literature from the EMC field.

5. ELECTROMAGNETIC COMPATIBILITY for e-MOBILITY

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Abstract

The rapid increase in the number of electric vehicles we are witnessing (personal vehicles, buses, trucks, scooters, etc.) has led to an activity supported by tests and specific standards/regulations of EMC at the international level. The classical problems of electromagnetic interference and susceptibility have been completed both for the EV itself and for various electronic subsystems and components like DC-DC converter, inverter, electric motor, high-power cables distributed around the vehicle and chargers (on board or in residential or public stations). The paper reviews the new EMC standards and also the issues related to the health influence of electric and magnetic field emissions level. In Romania, compliance tests can be carried out for numerous components of electric vehicle construction.

Keywords: e-Mobility, Automotive EMC, EMC Automotive Tests and Standards

References

[1] B. Deutschmann, G. Winkler and P. Kastner, “Impact of electromagnetic interference on the functional safety of smart power devices for automotive applications”, Elektrotechnik und Informationstechnik, vol. 135, no. 4-5, pp. 352-359, Aug. 2018.

[2] UN Regulation No. 10, Revision 6, Electromagnetic compatibility, 2019.

[3] J. Hu, X. Xu, D. Cao, G. Liu, Analysis and Optimization of Electromagnetic Compatibility for Electric Vehicles, IEEE Electromagnetic Compatibility Magazine, pp.50-55, Volume 8, Quarter 4, 2019.

6. ADVANCED EMC DESIGN AND RISK ANALYSIS THROUGH MACHINE LEARNING TECHNIQUES

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Abstract

Introduction

A design methodology, with regard to electromagnetic compatibility (EMC) potential issues, aims to provide a secure path toward homologation or certification procedures according to relevant standards or specifications. These are very stringent and are likely to become even more so, looking at specific threats (high power electromagnetics, advanced mobile communication standards, security of autonomous devices, systems or cyber systems, internet of things …). A number of guidelines, recipes, accumulated from years of complex electronic systems development testify to the general high-level of know-how in many industries at the forefront of EMC design issues, both in civil and military sectors.

However, EMC design remains very specific and complex for several reasons. Despite the use of constantly in-progress commercial software and the development of computer resources, no one is able to address the complexity of any advanced electronic equipment to perform an accurate estimation of an EMC coupling scenario. Modeling the possible failure of any function would require a complete time domain simulation of all signals associated with the targeted operation under study. This is not available and even not a goal to pursue. However, one may access to equivalent circuit of many electronic components, seen from their inputs / outputs or their supply connections. We could also perform susceptibility analysis of families of equipment to access some distribution functions. Behavioral models, instead of entirely descriptive ones, are possible even in complex scenarios and can also provide physically interpretable results. This enables multi-parametric analysis accounting for the variety of design possibilities. Performance of different design strategies could therefore be assessed. This is where simulations are certainly useful. Handling the uncertainties of many input parameters and conclude about relevant EMC design strategies remain a challenge. In this communication, we aim at highlighting how machine learning techniques and accelerated sensitivity analysis could play an important role for the future of EMC engineering.

Assessment of input uncertainties from Bayesian calibration

Cables harnesses are a good example of source of uncertainty in EMC scenarios. Propagation of electromagnetic interferences in cable harnesses, particularly in aircrafts, is a well-known challenge with regard to numerical prediction of currents induced from conducted or radiated sources. This is mainly due to numerous factors of variability from one cable harness assembly to another. The sources of uncertainty in cable harnesses are due to intrinsic variabilities of wires manufacturing involving tolerances pertaining to their and dielectric permittivity of the coating material. In addition, the major factors of variability are those associated to their hand-assembly, which introduces large uncertainties about their relative position inside harnesses. As a result, prediction of induced currents, due to crosstalk and other effects, cannot be deterministic and must account for these various sources of uncertainty. Before being able to propagate these uncertainties in a numerical model, a major challenge consists of evaluating the range of these uncertainties (spread and distribution).

The Bayesian calibration of models is an inverse propagation technique allowing to estimate the likelihood of a parameterized distribution of an aleatory input variable or the scalar value of an epistemic input variable [1]. It is based on Bayes theorem of conditional probability. Given a numerical model, some random experiments performed with a limited series (typically a few tens) allows for a better knowledge of uncertainty budget according to some distribution hypothesis. A limited example of such an approach is given for illustration. This type of approach used in the frame of many engineering science topics (e.g. [2], [3]) deserves attention regarding EMC studies.

Investigation of EMC risk analysis through kriging

As another example, the design of sophisticated multilayer PCBs with large number of interconnections requires the determination of strict guidelines to reduce the risk of non-compliant EMC tests. Investigation about guidelines often requires numerical simulations. Regarding radiated emission they are based on solving Maxwell equations with 3D numerical solvers. However, using such solvers can be very time and resource consuming especially when carrying out parametric analysis with a large number of parameters. One way to overcome this problem is to use a replacement model called a surrogate-model (SM) or metamodel. SMs approximate or interpolate the initial model with much simple functions using known experiments. SMs have become very popular in many engineering fields to efficiently evaluate model output(s) as a function of its inputs only [4]. Different types of SMs can be found in the literature such as support vector machine (SVM), Gaussian process, polynomial chaos or neural networks, to name a part of them [5], [6].

According to some investigations, kriging (or Gaussian process) performs reasonably well among these methods due to at least an acceptable fulfillment of Gaussianity and stationarity of the first two moments of the random process. The use of kriging together with adequate pre-processing to discard unimportant features [7] open new perspective for quick post-processing of data. Figure 1 illustrate how the total efficiency (total radiated power) of a microstrip line may be further limited once some restriction is applied to the width a slotted ground plane. This restriction was adjusted once extreme value analysis is performed using the simple kriging metamodel. This example will be further detailed during the communication.

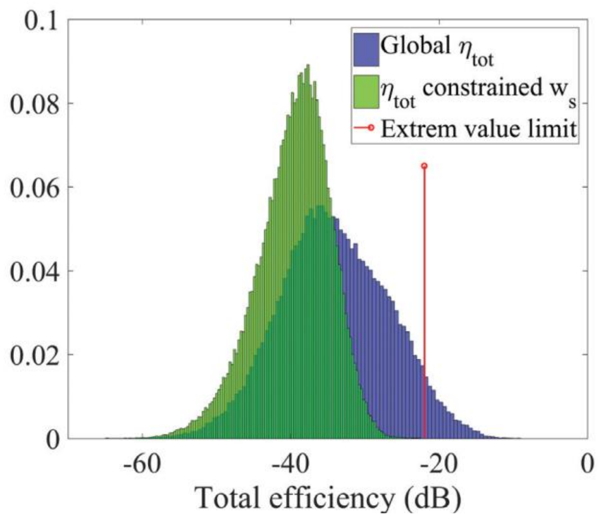

Fig .1 Initial pdf of the total efficiency (total radiated power) obtained from a kriging metamodel of a parametrized microstrip line over a slotted ground plane and its modified version after restricting the slot width (Ws). This restriction was adopted once extreme value analysis was performed using this metamodel

Conclusion

We are probably at the beginning of new area for EMC design where machine learning and artificial intelligence algorithms will enrich the exploitation of deterministic software tools thus enabling a useful analysis of full sets of data to eventually gain a more accurate view about EMC scenarios through sensitivity analysis.

References

[1] Kennedy, M. C., & O'Hagan, A. (2001). Bayesian calibration of computer models. Journal of the Royal Statistical Society: Series B (Statistical Methodology), 63(3), 425-464.

[2] B. J. Minsley, N. L. Foks, and P. A. Bedrosian, “Quantifying model structural uncertainty using airborne electromagnetic data,” Geophys. J. Int., vol. 224, no. 1, pp. 590–607, Nov. 2020, doi: 10.1093/gji/ggaa393.

[3] H. Ren, J. Ray, Z. Hou, M. Huang, J. Bao, and L. Swiler, “Bayesian inversion of seismic and electromagnetic data for marine gas reservoir characterization using multi-chain Markov chain Monte Carlo sampling,” J. Appl. Geophys., vol. 147, pp. 68–80, Dec. 2017, doi: 10.1016/j.jappgeo.2017.10.004.

[4] A. Franczyk, ”Engineering design via surrogate modelling: a practical guide”, John Wiley and Sons, 2008.

[5] P. Besnier, F. Delaporte and T. Houret, "Extreme Values and Risk Analysis: EMC Design Approach Through Metamodeling," in IEEE Electromagnetic Compatibility Magazine, vol. 10, no. 4, pp. 80-93, 4th Quarter 2021, doi: 10.1109/MEMC.2021.9705309.

[6] R. Trinchero and F. Canavero, "Machine Learning Regression Techniques for the Modeling of Complex Systems: An Overview," in IEEE Electromagnetic Compatibility Magazine, vol. 10, no. 4, pp. 71-79, 4th Quarter 2021, doi: 10.1109/MEMC.2021.9705310.

[7] A. Plot, P. Besnier, B. Azanowsky, “Efficient EMC Risk Analysis of PCB Using Iterative Surrogate Model Enrichment and Morris Sensitivity Analysis”, 2022 International Symposium on Electromagnetic Compatibility - EMC EUROPE, Sep. 2022, Goteborg, pp.1-6.

7. ANALYSIS OF THE UNINTENDED PROPAGATION OF AUDIO SIGNAL EMITTED BY WIRELESS HEADPHONES

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Abstract

This article presents an unexplored security breach for wireless headsets that are widespread electronic devices in today's IT&C market. Specialty literature confirms that an unintended signal that represents transmitted audio waveform may occur during propagation, this signal also being known as audio compromising emanations (CE). The possibility of intercepting these transmission media represents a quantification of the security and the integrity of communications. The vulnerability is described as the possibility of reconstructing pieces of information of the audio CE using specialized TEMPEST equipment at different distances between antenna and tested device. The novelty for this domain consists in the type of the studied devices, the measurements being performed on 2 such items.

Keywords: audio signal, electromagnetic compatibility, wireless headphones, TEMPEST.

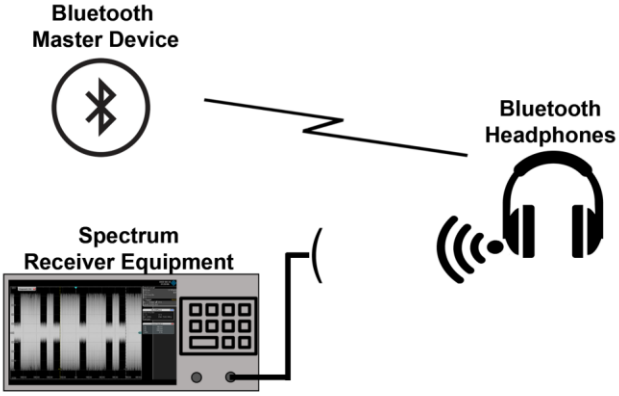

Fig. 1. Detection of audio CE

References

[1] MIL-STD 461G, Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment, 2015.

[2] P. R. Clayton, Introduction to Electromagnetic Compatibility, 2nd ed., John Wiley & Sons, Hoboken, 2006.

[3] J. Choi, H-Y Yang, D-H Cho, TEMPEST Comeback: A Realistic Audio Eavesdropping Threat on Mixed-signal SoCs, CCS'20: Proceedings of the 2020 ACM SIGSAC Conference on Computer and Communication Security, 2020, pp.1085-1101.

[4] B. Trip, V. Butnariu, V. Velicu, S. Halunga, A. Boitan, Analysis of the compromising audio signal from the emission security perspective, 13th International Conference on Communications (COMM), 2020.

8. DEVELOPING HYBRID WIRELESS COMMUNICATIONS AND INFORMATION TECHNOLOGIES FOR VEHICLE SAFETY AND DRIVER ASSISTANCE

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Abstract

This paper presents the progress made in our research group in developing vehicle communication systems in visible light, radiofrequency and microwave bands, as well as in-vehicle information technologies for driver assistance and for improvement of vehicle safety [1]-[7]. Taking into account that car accidents are generating more than one million deaths annually and they are the leading cause of death among children and young adults [8], the improvement of traffic safety and transportation efficiency are very important challenges for automotive industry and associated governmental agencies. Various studies show that the use of communication and information technologies for developing vehicle active safety systems has the potential to reduce the number of road accidents by more than 80%. USA Department of Transportation has already announced a new safety standard proposal to mandate vehicle-to-vehicle communications for new cars, stimulating car manufacturers to develop communication and information technologies and applications to improve safety, mobility, and gas emission [9].

Keywords: visible light communications, dedicated short range communications, vehicular communication, active safety systems, driver assistance.

References

[1] S. Avătămăniţei, A. Căilean, A. Done, M. Dimian, M. Prelipceanu "Noise Resilient Outdoor Traffic Light Visible Light Communications System Based on Logarithmic Transimpedance Circuit: Experimental Demonstration of a 50 m Reliable Link in Direct Sun Exposure", *Sensors*, 2020.

[2] 6. E. Zadobrischi, L.M. Cosovanu, M. Dimian, "Traffic Flow Density Model and Dynamic Traffic Congestion Model Simulation Based on Practice Case with Vehicle Network and System Traffic Intelligent Communication", *Symmetry*, 12, 1172, 2020.

[3] 8. Avătămăniței, S.-A.; Căilean, A.-M.; Done, A.; Dimian, M.; Popa, V.; Prelipceanu, M., "Design and Intensive Experimental Evaluation of an Enhanced Visible Light Communication System for Automotive Applications", Sensors, 2020.

[4] 9. C. Beguni, A. Căilean, S.Avătămăniței, M. Dimian, "Analysis and Experimental Investigation of the Light Dimming Effect on Automotive Visible Light Communications Performances", *Sensors*, vol. 21 (13), 2021.

[5] E. Zadobrischi and M. Dimian, "Inter-Urban Analysis of Pedestrian and Drivers through a Vehicular Network Based on Hybrid Communications Embedded in a Portable Car System and Advanced Image Processing Technologies", *Remote Sensing*, vol. 13, no. 7 / 1, 2021.

[6] "Global Road Safety Facility Annual Report". Washington DC: Global Road Safety Facility, World Bank, 2021.

[7] "Federal Motor Vehicle Safety Standards; V2V Communication," National Highway Traffic Safety Administration, United States of America Department of Transportation, 82 FR 3854, 2017.

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9. ACHIEVING AN EFFICIENT MANAGEMENT OF NAVIGATION EQUIPMENT AND ANALYSIS OF A COMPUTER MODEL FOR THE TRAINING OF MARINE OFFICERS

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Abstract

This paper presents a way to perform the management of navigation equipment and installations on the bridge. The automation of this equipment is supervised by an alarm system that constitutes the Bridge Alarm Management which is intended to facilitate decision making and prioritization. In order to train navigation officers, a computer model is proposed, presented and analyzed using Python language for the generation of signals and simulation of real ones and Jupyter Notebook and Python are used to run the simulator program. The thesis presents an opportunity, a versatility and at the same time an entry point into the sphere of modern technology trends - from development technologies to new infrastructures.

Equipment with a high degree of automation both electrically and electronically is used to equip ships. These automations are accompanied by alarms. On the bridge of a seagoing vessel there are more than 20 navigation equipment that help the officer of the watch to steer and keep the ship safe throughout the voyage. A management of these alarms that are present on the bridge has been developed, the so-called Bridge Alarm Management (BAM). BAM does not reduce the alerts coming from the equipment present, instead it prioritizes them and can change the way they are brought to the attention of the officers on the bridge as well as to the crew members present at any given time on watch duty on the navigation bridge. Using this BAM, alerts can be categorized and therefore they can be more easily identified as well as more clearly targeted as to who is responsible for tracking and interpreting them. This simplifies decision making and allows the officer of the watch to immediately identify problems and take appropriate action to keep operations on board safe.

This BAM must be shaped and organized in such a way that it complies with all the international regulations and provisions currently in force. It has been implemented for the GMDSS station as of 30 August 2021, according to European maritime directives (EU Marine Equipment Directive) - IEC 62923-1 / IEC 62923-2.

A good officer should be familiar with the operation of the navigation equipment, be familiar with the specific characteristics of the model of equipment that is provided with the ship, and the periodic maintenance procedures that must be carried out to keep it in good working order.

The execution of the simulator program using Jupyter Notebook and Python is shown below.

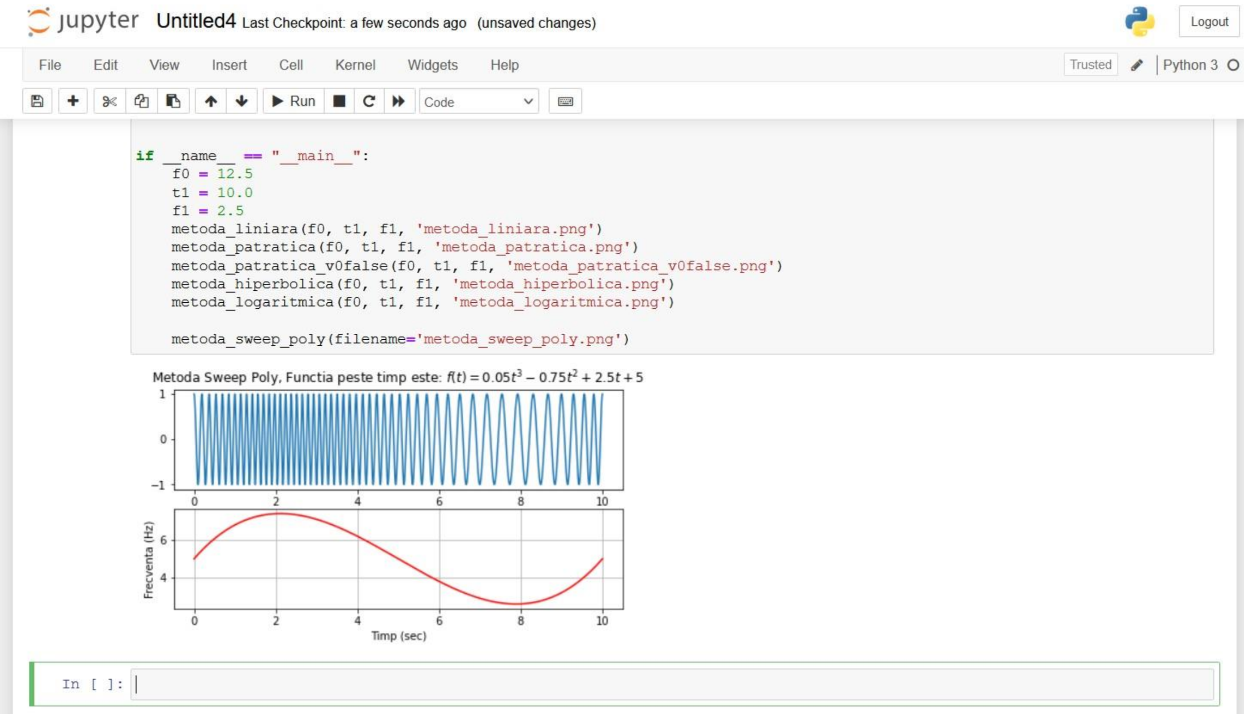

Fig. A. Computer execution and modeling of signals using Python and Jupyter Notebook

The present computer model and software application brings to the fore modern aspects for building a computer model and computer software application for processing signals from various electrical and electronic equipment located on the bridge. The computer model enables the training of navigation officers and the development of software applications for signal processing.

Navigation equipment is part of the responsibilities and tasks of the officer on the bridge on board ships. By achieving this efficient management of the mechanical, electrical and electronic equipment in terms of supervisory control and maintenance, it is intended to maximize the safety and efficiency of the decisions made by the officer on the bridge during the watch.

10. LIGHTNING PROTECTION OF RENEWABLE POWER SYSTEMS - A REVIEW

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Abstract

Environmental concerns and energy shortages have driven progress in the development and implementation of renewable energy sources.

A major challenge in the development of modern power systems is safely and reliably operating of renewable energy sources. In this sense, one of the disadvantages of photovoltaic (PV) and wind systems is their susceptibility to lightning strikes. During a lightning strike, an induced surge is generated in the system that can damage parts or the entire system.

This investigation reviews and compares the information from research literature to bring more understanding and knowledge of the field of lightning protection of renewable power systems, with emphasis on photovoltaic power system protection.

For searching, finding and selecting data, the bibliometric method was used, which was applied to the IEEE Explorer, Web od Science Core Collection and Elsevier's Scopus databases. rom this data, only data found in IEEE Explorer are considered, because the topic of photovoltaic systems and lightning protection is better described, including the field of electrical engineering, but also other advanced sciences and different disciplines.

Research related to this topic is still at the beginning and the number of papers is increasing: for the keyword “lightning protection” there have been found 142 papers for PV, 22 papers for wind, compared with 871 papers for power overhead lines.

Regarding the works that address topic PV systems and lightning protection, in this review paper specific aspects are analyzed and described, such as: distribution of the magnetic field under the action of direct or indirect lightning strikes, determination of overvoltage and transients, effect of the grounding grid structure (arrangement of the electrodes and variation of the soil characteristics), methods of selecting surge protective devices, but also the aspect of risk assessment and economic lightning protection schemes.

Finally, the most significant literature gaps and directions for future research are highlighted.

Keywords: lightning protection, renewable systems, PV and Wind, bibliometric method

11. RECENT RESEARCH ON THE BIOLOGICAL EFFECTS IN SEVERAL CASES OF ENVIRONMENTAL AND SPECIFIC PROFFESIONAL EXPOSURE TO ELECTROMAGNETIC FIELDS

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Abstract

The interaction between electromagnetic fields and biological processes is still not fully understood; however, it clearly depends on biophysical and biochemical properties of exposed organism, as well as electromagnetic field parameters. There are presented the results obtained in several biological experiments carried out by experiments carried out by electrical and electronic engineers and medical specialists, within the RFBIO project developed under the aegis of the European Defense Agency. The RFBIO project addresses the investigation of the effects of electromagnetic fields specific to military preffesional exposure. However, the analyzed exposure scenarios also include electromagnetic field sources pertaining to the indoor electromagnetic residential exposure – such as WiFi routers. The ongoing research manages to achieve a multidisciplinary approach, through cellular and biochemical studies, studies on the nervous system of animals and the translation of the conclusions at the level of the human body and, more precisely, in the military environment.

12. ELECTROMAGNETIC INTERFERENCE OF EMISSION NOISE ON MOBILE COMMUNICATIONS INSIDE INDUSTRIAL UNMANNED AERIAL VEHICLES

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Abstract

Unmanned aerial vehicles (UAVs) becomes proliferated among industrial applications, such as in the field of agriculture, inspection and distribution, which makes our society more productive, resilient, and reachable [1].

One can maneuver a personal UAV generally with a remote controller over a wireless communication network that uses unlicensed wireless bands such as Wi-Fi. This limits its flight area to a few kilometers in diameter. In contrast, industrial UAVs are to be controlled over cellular communication networks, such as long-term evolution (LTE) and 5th generation (5G), allowing their flights even over cities.

An UAV is integrated with a lot of electronic modules that are densely mounted inside its frame. Electromagnetic interference (EMI) is likely to occur inside an UAV. Integrated circuit (IC) chips, which often emanate EM noise, are placed nearby. This potentially degrade the communication quality, which is problematic for mobile communication systems for aircraft operations specially above densely populated areas. The EMI problems and countermeasures should be exploited for the safety of UAVs.

This brief presents the EMI consideration on UAV, through near-field EM noise measurements in a wide frequency band. The impact of EM noise on mobile communications is also analyzed by a wireless communication system level simulator [2]. The UAV under our EMI experiment is equipped with the essential functions for industrial applications. The proximate EM noise was explored up to 6 GHz, covering cellular wireless bands, with the measurement antenna positioned horizontally around 50 cm from the center of the UAV. We also analyzed the EMI problem by the simulator for 4G and 5G systems based on 3GPP specifications [3]. The minimum receiver sensitivity deviates from the standard value by 22 dB due to the proximate EM noise from the UAV in the 800 MHz band.

Keywords: Electromagnetic interference, Emission noise measurement, Unmanned aerial vehicle, Mobile wireless communication

References

[1] H. C. Nguyen, R. Amorim, J. Wigard, I. Z. KováCs, T. B. Sørensen, P. E. Mogensen, "How to Ensure Reliable Connectivity for Aerial Vehicles Over Cellular Networks," in IEEE Access, vol.6, pp.12304-12317, Feb. 2018. DOI:10.1109/AC CESS.2018.2808998.

[2] M. Nagata, K. Watanabe, Y. Sugimoto, N. Miura, S. Tanaka, Y. Miyazawa, M. Yamaguchi, "Evaluation of Near-Field Undesired Radio Waves from Semiconductor Switching Circuits," in Proceedings of the 2019 International Symposium on Electromagnetic Compatibility (EMC Europe 2019), #_Th_B_2_1, pp.866-869, Barcelona, Sep. 2019. DOI:10.1109/EMCEurope.2019.8871554.

[3] 3GPP, "LTE; Evolved Universal Terrestrial Radio Access (EUTRA); User Equipment (UE) Radio Transmission and Reception" 3GPP TS 36.101 version 8.8.0 Release 8, Feb. 2010.

Acknowledgement - This work was supported in part by Development of Technical Examination Services Concerning Frequency Crowding (JPJ000254), MIC, Japan.

13. THE FUTURE OF THE USE OF ELECTROMAGNETIC FIELDS AND BEAMS IN MEDICINE AND BIOLOGY

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Abstract

The use of electromagnetic fields and beams in medicine and biology, with the different aspects related to the effects they produce, ionizing and non-ionizing, thermal and athermal, continues and progresses, discovering new or optimized applications. One of the interesting effects can be that of hormesis when ionizing radiation is used in small doses, obtaining the stimulation of cell multiplication. Another effect can be the short-term blocking of transmembrane phenomena, providing a useful tool in the control of metabolic activities and cell multiplication.

A lesser-known field is that of the thermal effects produced and controlled by means of EMF, including here the knowledge of hyperthermia as a therapeutic method but also clinical thermography and high-speed thermography that would open new horizons in the knowledge of thermobiological phenomena. Another exploitable field in the knowledge of electromagnetobiological effects is electromagnetobiology, for which compatibility issues with living systems are still unsystematized and without a clear relationship between incident EMF and different levels of organization of living matter.

Although it is stated, even by institutions like the WHO, that there are no negative effects on the health of humans and animals useful to humans, this belief is not fully demonstrated either, continuing an attitude of expectation marked by uncertainty, an attitude that does not stimulate the continuation of research in this field.

14. 5G EMF: REAL EXPOSURE LEVELS AND FALSE CLAIMS

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Abstract

Introduction

The launch of fifth generation (5G) mobile services promises new capabilities but it has been accompanied by misunderstandings and misinformation in some countries. An extreme example is the false claims in 2020 linking 5G with COVID-19 that was linked to violence against telecommunications staff and infrastructure [1].

5G RF-EMF levels

Recent measurements of 5G EMF levels from sites operating in the low-band, mid-band and high-band show typical levels far below international RF-EMF limits and comparable to existing mobile and wireless technologies. This has been summarized in an interactive map (see Figure 1) maintained by the GSMA with data from 30 surveys conducted in 19 countries [2]. The 5G EMF levels across all surveys ranged from 0.0000005% to 2% of the ICNIRP limit for the public [3], with the typical maximum level less than 1% of the public limit.

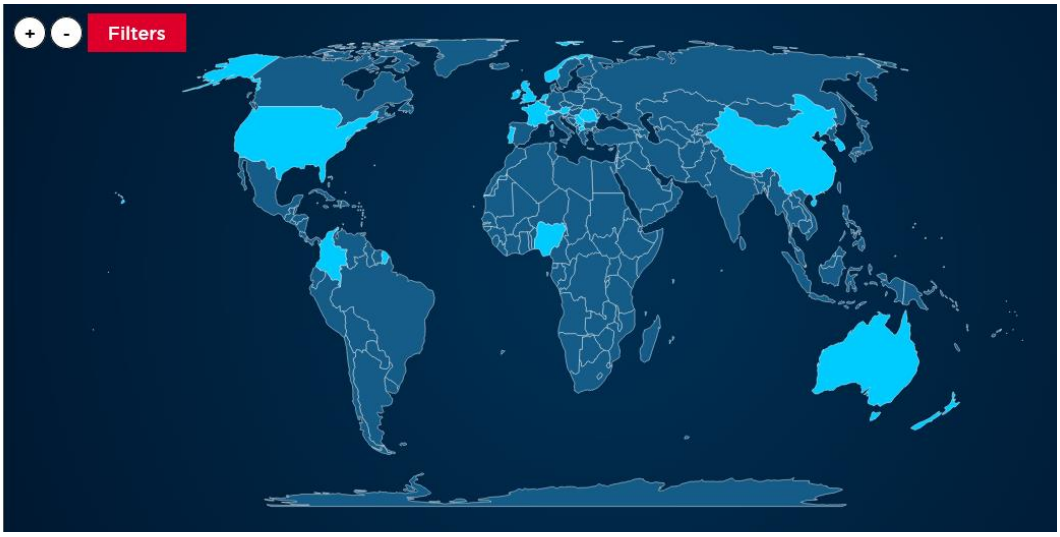

Fig. 1. GSMA interactive map of 5G EMF surveys

Note: light blue colours indicate countries with data and the filters allow selection of surveys by band.

There is more variability in RF-EMF levels from 5G base stations compared to earlier mobile technologies due to traffic variations and expanded use of beamforming antennas. The actual maximum approach set out in IEC62232 provides greater accuracy and has been validated in real-world assessments [4, 5].

It should also be noted that 5G device output power levels are similar to 3G/4G device powers [6].

5G RF-EMF false claims

Some of the false claims about 5G include are summarized in Table 1, along with responses.

Table 1: Some 5G EMF false claims and responses

False Claim	Factual Response
5G is unstudied	5G is an evolution of 4G and all planned frequencies are covered by international EMF guidelines [3].
Small cells increase RF-EMF exposure	Small cell RF-EMF levels are similar to macro networks and improve phone performance [7].
5G densification will increase RF-EMF levels	RF-EMF levels will remain mostly unchanged [8], similar to the experience of other mobile technologies [9].

5G offers significant improvements regarding capacity, data rates and energy efficiency. 5G is covered by existing international EMF limits and according to health agencies no health risks are expected.

References

[1] D. Jolley and J. L. Paterson, "Pylons ablaze: Examining the role of 5G COVID-19 conspiracy beliefs and support for violence," *British Journal of Social Psychology,* vol. 59, no. 3, pp. 628-640, July 2020 2020.

[2] GSMA. (2022, 30 August). *5G EMF Surveys*. Available: https://www.gsma.com/publicpolicy/emf-and-health/safety-of-5g-networks/5g-emf-surveys

[3] International Commission on Non-Ionizing Radiation Protection (ICNIRP), "Guidelines for Limiting Exposure to Electromagnetic Fields (100 kHz to 300 GHz)," *Health Physics,* vol. 118, no. 5, pp. 483-524, May 2020 2020.

[4] B. Xu *et al.*, "A Summary of Actual Maximum Approach Studies on EMF Compliance of 5G Radio Base Stations," in *2022 16th European Conference on Antennas and Propagation (EuCAP)*, 2022, pp. 1-5.

[5] D. Colombi, P. Joshi, B. Xu, F. Ghasemifard, V. Narasaraju, and C. Törnevik, "Analysis of the Actual Power and EMF Exposure from Base Stations in a Commercial 5G Network," *Applied Sciences,* vol. 10, no. 15, p. 5280, Published: 30 July 2020 2020.

[6] P. Joshi, F. Ghasemifard, D. Colombi, and C. Törnevik, "Actual output power levels of user equipment in 5G commercial networks and implications on realistic RF EMF exposure assessment," *IEEE Access,* 9 November 2020 2020.

[7] T. Mazloum, S. Aerts, W. Joseph, and J. Wiart, "RF-EMF exposure induced by mobile phones operating in LTE small cells in two different urban cities," *Annals of Telecommunications,* journal article vol. 74, no. 35-42, 1 February 2019 2019.

[8] L. Chiaraviglio, S. Turco, G. Bianchi, and N. Blefari-Melazzi, ""Cellular Network Densification Increases Radio-Frequency Pollution": True or False?," *IEEE Transactions on Wireless Communications,* Date of Publication: 28 September 2021 2021.

[9] A. C. Markussen, T.-M. Sjoemoen, E. H. Unander, and L. Klaeboe, "Regular measurements of EMF in a representative Norwegian city—constant exposure over time despite introduction of new technologies," *Environmental Monitoring and Assessment,* vol. 194, no. 10, p. 694, 19 August 2022 2022.

ORAL PRESENTATIONS

1. MATLAB OPTIMIZATION OF SELF AND MUTUAL INDUCTANCE CALCULATION FOR FLAT SPIRAL AND LOOP COILS UTILIZED IN WIRELESS DRONE CHARGING

Vlad MOCANU, Vasile DOBREF, Florențiu DELIU

„Mircea cel Bătrân” Naval Academy, Department of Electrical Engineering, Constanța, Romania

2. ELECTROMAGNETIC SCREENING PROPERTY TESTING FOR A CONDUCTIVE METAL MATERIAL

Mircea-Emilian ARDELEANU[1], Viorica VOICU[2], Livia-Andreea DINA[1]

[1]Faculty of Electrical Engineering, University of Craiova, Craiova, Romania

[2]National Institute for Research, Development and Testing in Electrical Engineering – ICMET Craiova, Romania

3. SIGNAL MODEL ADEQUACY INDICATOR FOR POWER QUALITY MONITORING

Anca BRÎNCOVEANU, Efstathios FIORENTIS, Radu PLĂMĂNESCU, Ana-Maria DUMITRESCU, Mihaela ALBU

University "Politehnica" of Bucharest UPB, Faculty of Electrical Engineering, Bucharest, Romania

4. IMPACT OF DIODE EMULATION MODE ON EMC-RELATED PERFORMANCE OF DrMOS-BASED BUCK CONVERTER

Josip BAČMAGA, Franjo MIKIĆ, Adrijan BARIĆ

University of Zagreb Faculty of Electrical Engineering and Computing, Zagreb, Croatia

5. SMART ADJUSTABLE OPTICAL ATTENUATOR

Lilia SAVA, Ana NISTIRIUC, Andrei CHIHAI, Pavel NISTIRIUC, Serghei ANDRONIC

Technical University of Moldova, Chisinau, Republic of Moldova

6. SPECIFIC ABSORPTION RATE (SAR) ASSESING IN TISSUE MODELS MIMICKING THE HUMAN HEAD AT 5G FREQUENCIES

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7. HIGHLY DIRECTIVE VHF ANTENNA FOR APPLICATIONS IN THE 118-137 MHz RANGE

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[1]"Nicolae Balcescu" Land Forces Academy, Sibiu, Romania

[2]Technical University of Cluj-Napoca, Doctoral School, Cluj-Napoca, Romania

8. PEOPLE COUNTING IN A COVID-19 AND GDPR CONTEXT, USING AN IR-UWB RADAR, BASED ON ARTIFICIAL INTELLIGENCE ALGORITHMS

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9. THE LOCAL RADIATED EMISSION OF AN WI-FI 6 CLIENT: PRELIMINARY OBSERVATIONS

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[2]"Nicolae Balcescu" Land Forces Academy, Sibiu, Romania

10. DEFECTOSCOPY TOOLS FOR THE EVALUTION OF NEAR FIELD RADIATED EMISSIONS

Cezar-Ion ADOMNIȚEI, Cezar-Eduard LEȘANU, Adrian DONE

"Ștefan cel Mare" University of Suceava, Suceava County, Romania

11. ABOUT THE ELECTROMAGNETIC COMPATIBILITY OF RADIO COMMUNICATION SYSTEMS

Lilia SAVA, Ana NISTIRIUC, Andrei CHIHAI, Pavel NISTIRIUC, Serghei ANDRONIC

Technical University of Moldova, Chisinau, Republic of Moldova

12. OPTIMIZATION OF ENERGY CONSUMPTION IN EDUCATIONAL INSTITUTIONS

Victor ABABII, Viorica SUDACEVSCHI, Silvia MUNTEANU,
Victoria ALEXEI, Ana ȚURCAN

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13. USING THE SPECTRAL FINGERPRINT OF MOBILE TACTICAL PLATFORM TO ENSURE EMISSIONS CONTROL AND PERSONNEL SAFETY

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14. ELECTROMAGNETIC FIELD LEVEL ANALYSIS IN DENSELY POPULATED AREAS

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15. MEASUREMENT METHODS IN 5G MOBILE COMMUNICATIONS

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1. MATLAB OPTIMIZATION OF SELF AND MUTUAL INDUCTANCE CALCULATION FOR FLAT SPIRAL AND LOOP COILS UTILIZED IN WIRELESS DRONE CHARGING

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Abstract

This paper presents a scientific method for calculating mutual inductance and self-inductance for two types of coils used in wireless power transfer. Therefore, in order to improve accuracy and processing time, computational software in Matlab program was used, based on complex mathematical formulas. The coils used in the study are loop and flat spiral coils as they have a uniformly circular magnetic field arrangement, unlike square coils. A comparison between the software and the analytical method of calculating the inductances of the coils is also presented, the theoretical results are then compared with real measurements using an RLC-meter.

Keywords: self-inductance, mutual inductance, circular coil, flat spiral coil, wireless power transfer

The self inductance for a planar loop coil with N turns is calculated as follows:

$$L(r,w) = \mu_0 N^2 R\left(\ln\left(\frac{8R}{r}\right) - 2\right) \quad (1)$$

where: R - transmitter/receiver coil radius turn, r - transmitter/receiver coil conductor radius.

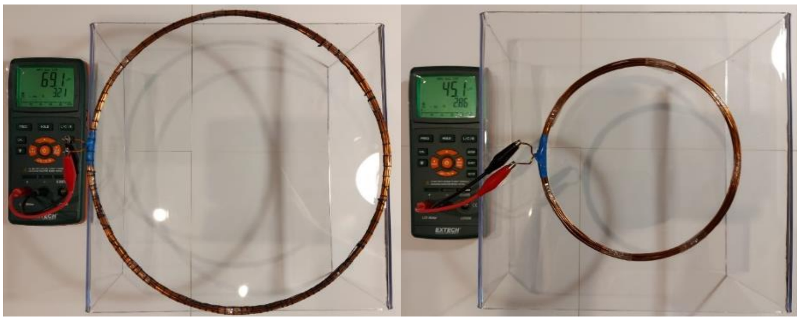

Fig. 1. Different planar loop coils self inductance real measurements

The self inductance for a planar spiral coil, consisting of a sequence of N concentric turns of different radii R_i (i=1,2,....N) and conductor radius r, is defined as follows:

$$L_{tot} = \sum_{i=1}^{N} L(R_i, r_i) + \sum_{i=1}^{N_i} \sum_{\substack{j=1 \\ i \neq j}}^{N_j} M(R_i, R_j) \rightarrow \quad 2)$$

$$L_{tot} = \sum_{i=1}^{N} \mu_0 r_i \left(\ln\left(\frac{8R_i}{r_i}\right) - 2\right) + \sum_{i=1}^{N_i} \sum_{i \neq j}^{N_j} \mu_0 \sqrt{R_i R_j} \left[\left(\frac{2}{s} - s\right) K(s) - \frac{2}{s} E(s)\right]$$

where: L_{tot} - coil self inductance, $i \neq j$.

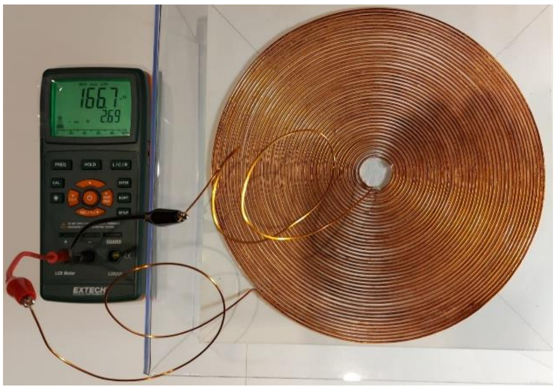

Fig. 2. Planar spiral coil self inductance real measurements

Self inductance-simplified formula, to calculate the inductance (in μH) for a planar coil (dimensions in inches) apply the following formula:

$$L = \frac{A^2 N^2}{30A - 11D_i}$$

$$A = \frac{D_i + N(w + p)}{2} \qquad 3)$$

where: D_i - inside diameter of the coil.

The self inductance calculation assumption for planar spiral and planar loop coils, both with concentric circular turns, must satisfy the condition r/R≪1.

Analytically it was found that the r/R ratio results must be between 0.0041322-0.0016667, to obtain calculation errors of about 5% between the results of equation (2) and the results of equation (3) or real measurement.

Conclusions

Following the experiments carried out in this paper, it can be concluded that:

- for planar loop coils, the self inductance calculation equation (1) produces significant and variable errors and cannot be used in this form, therefore it will be modified, $L(r,w) = \mu_0 N^2 R\left(\ln\left(\frac{3.5R}{r}\right) - 2\right)$, which reduces the deviation to about 3% compared to real measurements.
- for planar spiral coils, the self inductance calculation equation (2) also produces significant and variable errors (24.89%) and cannot be used for calculations, instead equation (3) produces very small errors ≈ 1% and can be used for accurate calculations.

As for the mutual inductance, if identical coils are used in both transmit and receive, the error found in the case of self inductances is added to the mutual inductance for correction.

References

- M. Zierhofer, E. S. Hochmair, Geometric Approach for Coupling Enhancement of Magnetically Coupled Coils, IEEE TRANSACTIONS ON BIOMEDICAL ENGINEERING, VOL. 43, NO. 7, JULY 1996, DOI: 10.1109/10.503178.

- Rikard Vinge, Wireless Energy Transfer by Resonant Inductive Coupling, Master of Science Thesis, Department of Signals and systems, CHALMERS UNIVERSITY OF TECHNOLOGY, Göteborg, Sweden 2015.

- Constantinescu Stelian, Practical and theoretical radiotenics, Vol. I, Military Publishing House of the Ministry of Armed Forces of the P.R.R., Bucharest, 1959.

- Alicia Triviño-Cabrera, José M. González-González, José A. Aguado, Wireless Power Transfer for Electric Vehicles: Foundations and Design Approach, Springer Nature Switzerland AG 2020, https://doi.org/10.1007/978-3-030-26706-3, Power Systems ISBN 978-3-030-26705-6.

- Vlad Mocanu; Petrică Popov; Vasile Dobref; Florenţiu Deliu; Ovidiu Cristea, Improving the Inductive Wireless Power Transfer for Marine Aerial Drones Charging, Electrotehnica, Electronica, Automatica: EEA; Bucharest Vol. 69, Iss. 3, (Jul-Sep 2021): 55-63. DOI:10.46904/eea.21.69.3.110.

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2. ELECTROMAGNETIC SCREENING PROPERTY TESTING FOR A CONDUCTIVE METAL MATERIAL

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Abstract

In this paper, the shielding efficiency of a material used for the manufacture of electrical transformers was measured. It was first proposed to check the shielding performance on a single sheet of material. After that first measurement, the measurements were repeated on the same frequency range with two overlapping sheets of material. This procedure of repeating the measurement in the 2 cases was performed in order to comparatively analyze the obtained results.

The tests were performed in the Electromagnetic Compatibility laboratory within Development and Testing in Electrical Engineering-ICMET, National Institute for Research Craiova. The following equipment was used according to the measurement location:

Used important equipment for determining the material properties used for shielding:

- Signal generator;
- Electromagnetic distortion receptor;
- Loop antennas;
- Biconical antennas;
- Diploe antennas;
- Horn antennas;

Explanation regarding the performing mode of the experiments:

Antenna position: Horizontal and vertical

Measurements of the shielding effectiveness in the 9 kHz – 20 MHz range. Measuring frequencies: 10kHz, 150 kHz, 15 MHz;

Measurements of the shielding effectiveness in the 20 MHz - 300 MHz range. Measuring frequencies: 80 MHz, 290 MHz;

Measurements of the shielding effectiveness in the 300 MHz - 6 GHz range. Measuring frequencies: 500 MHz, 800 MHz, 1 GHz, 1,5 GHz, 2 GHz, 2,5 GHz, 3 GHz, 3,5 GHz, 4 GHz, 4,5 GHz, 5 GHz, 5,5 GHz, 6 GHz;

The receptor's detector: Peak value;

Verified zone: The wall with aperture.

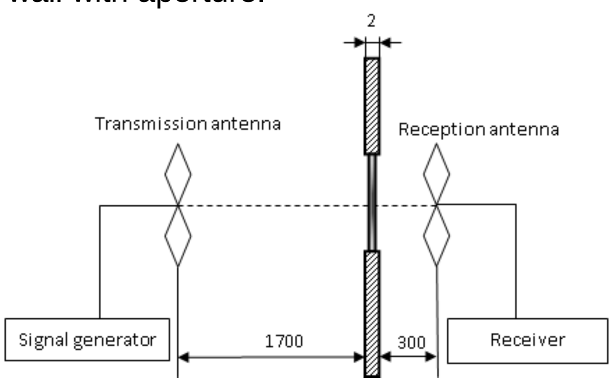

Fig. 1. Schematic diagram used to measure the screening performance of the material

Fig. 2. The location used to measure the shielding performance of the material

Keywords: electromagnetic shielding material, conductive metal, shielding efficiency

References

[1]. J.Schwab, Wolfgang W.Kurner, "Electromagnetic compatibility", Ed. A.G.I.R., 2013.
[2]. Ignea, "Electromagnetic compatibility", West Ed., Timișoara, 2007.
[3]. George Mihai, Calin Vărgatu, Paul Nicoleanu, Andrei Marinescu, "ICMET experience in measuring the effectiveness of shielding in shielded rooms and enclosures, Workshop "Electromagnetic shielding in modern technology" Craiova, 10 June 2010.
[4]. Andrei MARINESCU, "The structure and properties of some materials used in architectural shielding", Workshop "Electromagnetic shielding in modern technology" Craiova, 10 June 2010.
[5]. *** IEEE Std 299-1997 (Revision of IEEE Std 299-1991) - IEEE Standard Method for Measuring the Effectiveness of Electromagnetic Shielding Enclosures.

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3. SIGNAL MODEL ADEQUACY INDICATOR FOR POWER QUALITY MONITORING

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Abstract

The identification process for the parameters that characterize a deterministic signal is equivalent to a matching mathematical problem. The matching equation is based on the model of the physical phenomenon to which the signal is associated. The measurement process provides measurement results based on the matching of the observed signal and its associated (implicit) model [1].

In particular, power quality analysis performed on the voltage signal is based on the RMS computation done on measurement windows of 3 seconds, 10 min and 2 hours according to the standard IEC 61000- 4-30 [2].

This process is adequate when the premise of a steady state phenomenon is valid and is not capturing the signal dynamics when these are predominant. Therefore, associating a metric to the assumed signal model will help acquiring more information on the phenomenon [3].

Let's consider the model of alternate voltage described by the signal function:

$$u(t)=U\sqrt{2}\,\sin(2\pi f t+\varphi 0)$$

where the parameters able to fully describe the voltage:

$U \rightarrow$ RMS value estimated over the measurement window T_w

$f \rightarrow$ system frequency implicitly assumed to be 50 or 60 Hz

$\varphi_0 \rightarrow$ initial phase estimated from a chosen time reference for a selected reference framework

For a digital voltmeter with a sampling frequency $f_s \gg f$ the parameters are calculated based on the samples of the acquired signal using the following sequence of formulas:

$$uk=u(tk),$$
$$ukm=Um\sqrt{2}\,\sin(2\pi f tk+\varphi 0);\ \mathrm{k}=1\div \mathrm{N}w$$
$$\mathrm{N}w=[fs/f]$$
$$Um=Umodel$$

where u_{km} is the k–sample of the assumed implicit model for the measured signal.

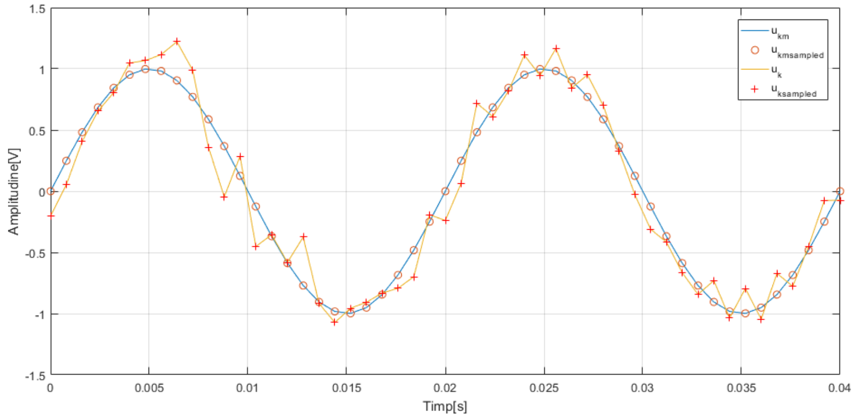

Fig.1. Example of the comparison between the implicit model and the measured signal

To estimate the deviation of u_k from u_{km} on the entire measurement window we can use one of the following indicators [4]:

- Mean absolute error (MAE) – a linear measure of the errors between two data sets that express the same phenomenon. This method is one of the most used to compare a real data set with a prescribed one.
- Mean squared error (MSE) – measures the average of the squares of the errors (the average squared difference between the estimated values and the actual value).
- Root mean squared error (RMSE) – is the standard deviation of the residues (assumed errors). Residues are a metric that tells how far from the regression line the points are, thus showing how scattered they are.
- Coefficient of variation of RMSE (CV-RMSE) – normalize the RMSE value using the mean estimated value (in case of studying sinusoidal waves for the mean value of the estimation parameter, the most commonly used method of calculation is the root mean squared value, $\bar{y}=rms(yi)$.
- Mean Absolute Percentage Error (MAPE) – the mean absolute percentage error (MAPE) is the mean or average of the absolute percentage errors of forecasts. This method is usually easier to understand because it is measured in percentages.
- Mean Squared Percentage Error (MSPE) – represents the sum of the absolute values obtained by the difference between the actual and the estimated value divided by the realvalue of each sample, squared, which is then divided by the number of samples and multiplied by 100.
- Coefficient of determination (R^2) – is a metric that evaluates the ability of a model to predict or evaluate a result in linear regression. Its value shows the normalized goodness of fit factor. The value of R^2 increases as new estimated variables are added, resulting in an adjusted model that will be the most realistic estimate of the proportion of the variation.
- Mean Absolute Scaled Error (MASE) – is the mean absolute error of the estimated valuesdivided by the mean absolute error of the naive forecast in a single step in the sample. This method was proposed, for the first time in 2005, by Rob J. Hyndman and Anne B. Koehler and it is used for forecast accuracy.

In this paper, two metrics have been chosen (CV-RMSE and R^2) and their applicability is demonstrated. Both indicators are suitable for power quality assessment. For voltage analysis several tests for a time window of T_W = 10min have been performed for several single-phase office appliances.

The data has been acquired using a PQ analyzer [5] and two sampling frequencies: $fs1=128 \cdot f$ and $fs2=1024 \cdot f$. The two chosen statistical indicators have been calculated for the sampled voltage and for the currents in each case. Applicability for other signals is investigated and several conclusions and proposals are presented as part of the final work.

Keywords: power quality, electrical measurements, statistical indicators, high reporting rates

References

[1]. H. Kirkham, R. White and M. Albu, "Dealing with Definitional Uncertainty Better Measurements in Power Systems," 2019 IEEE 10th International Workshop on Applied Measurements for Power Systems (AMPS), 2019, pp. 1-6, doi: 10.1109/AMPS.2019.8897707.

[2]. IEC 61000-4-30 Standard, Edition 3.0: Electromagnetic compatibility – Part 4-30: Testing and measurement techniques – Power quality measurement methods',” International Electrotechnic Committee, IEC Standard, 2015.

[3]. D. M. Laverty, H. Kirkham, D. J. Morrow and X. Liu, "Estimation of goodness of fit of synchrophasors during transient faults," 2017 IEEE Power & Energy Society General Meeting, 2017, pp. 1-5, doi: 10.1109/PESGM.2017.8274707.

[4]. Joint Committee for Guides in Metrology, WG 1, "GUM: Guide to the expression of uncertainty in measurement," 2008.

[5]. ELSPEC-Where Power meets Quality. Available online: https://www.elspec-ltd.com/metering- protection/power-quality-analyzers/g4400-power-quality-analyzer/ (accessed on 13 July 2022).

Acknowledgement - This work was supported by a grant of the Romanian Ministry of Education and Research, CNCS—UEFISCDI, project number PN-III-P4-ID-PCE-2020-2876, within PNCDI III - EMERGE.

4. IMPACT OF DIODE EMULATION MODE ON EMC-RELATED PERFORMANCE OF DrMOS-BASED BUCK CONVERTER

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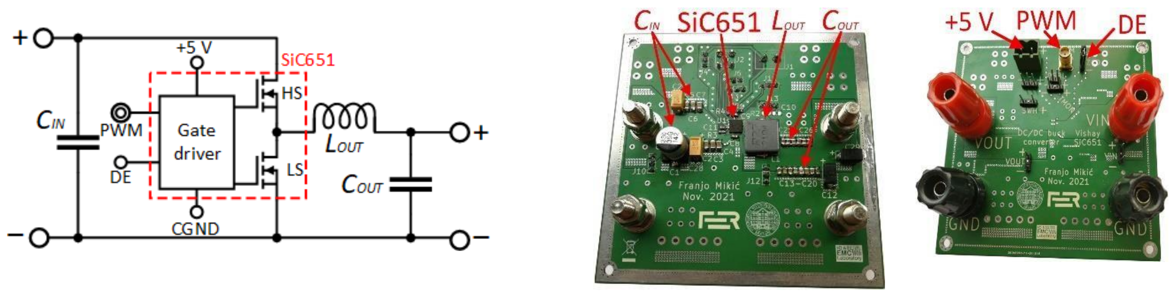
Abstract

Integrated synchronous buck converters offer the advantage over discrete converters by being smaller and less expensive. This is particularly reflected in the use of the DrMOS device, a power module that combines MOSFET switches and a gate driver in a single package [1], reducing parasitics and conduction losses, resulting in higher power efficiency and lower electromagnetic interference (EMI). In addition, the DrMOS concept enables diode emulation (DE) mode, in which the buck converter can operate asynchronously if required. The DE mode allows the inductor current to reach zero, i.e. it prevents negative inductor currents.

A synchronous buck converter based on a Vishay SiC651 DrMOS power module [2] is designed to analyze the effects of the DE mode on the electromagnetic compatibility (EMC) of the buck converter. The simplified schematic of the designed converter and the top and bottom view of the 4-layer PCB with dimensions 100 mm × 100 mm are shown in Fig. 1.



a) b) c)

Fig. 1. Designed circuit: a) simplified schematic, b) bottom PCB view – component side, c) top PCB view.

The SiC651 device contains a gate driver and high-side (HS) and low-side (LS) MOSFETs. The 220-nH power inductor L_{OUT}, and the input and output capacitive networks (C_{IN} and C_{OUT}) are placed on the component side of the PCB, while the PWM and DE connectors and power supply terminals are placed on the other side of the designed PCB. The photo of the measurement setup used to analyze the performance of the designed converter is shown in Fig. 2.

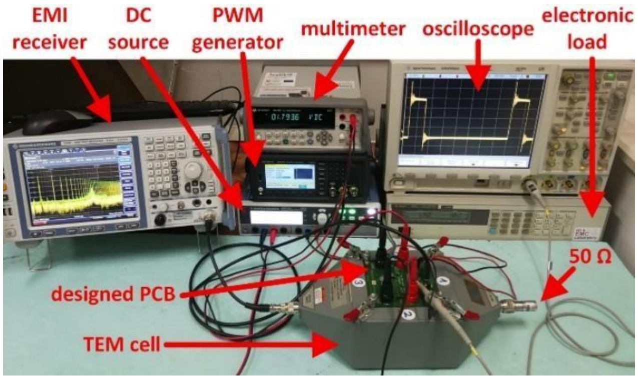


Fig. 2. Photo of the measurement setup.

EMI receiver	R&S ESRP 9
DC source	R&S HMP2020
PWM generator	Keysight 33600A
multimeter	Keysight 34410A
oscilloscope	Agilent MSO7034B
electronic load	Agilent 6060B
TEM cell	FCC-TEM-JM2

Table 1. List of measurement equipment.

The designed converter is set to operate at switching frequency of 500 kHz (PWM generator), an input voltage of 12 V (DC source), an output voltage of 1.8 V (multimeter) and an output (load) current of 1 A (electronic load). When the DE mode is not used, the output voltage is determined by the duty cycle D of the PWM signal ($D \approx V_{OUT} / V_{IN}$), while for the DE mode, the D has to be readjusted to achieve the output voltage of 1.8 V for the 12-V input voltage. The oscilloscope is used to monitor the waveform at the switching node of the designed converter. The comparison of power efficiency between the on and off states of the DE mode is shown in Fig. 3.

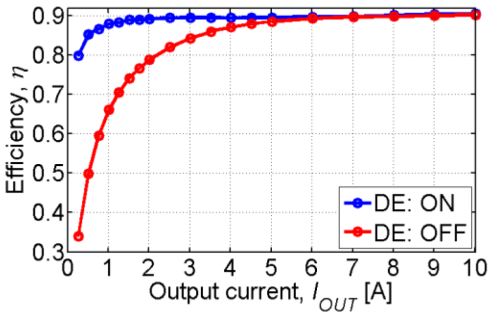


Fig. 3. Impact of DE on power efficiency.

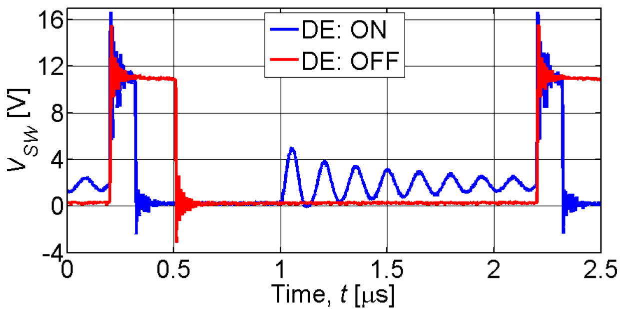


Fig. 4. Impact of DE on switching node waveform.

Power efficiency with DE mode turned off is significantly lower at small output currents I_{OUT} (light loads) due to the large conduction losses of the LS FET (negative inductor current), which are not present in the DE (asynchronous) mode. The advantage of DE mode on power efficiency diminishes as I_{OUT} increases. The effect of DE mode on the switching node waveform is shown in Fig.4. The lower duty cycle for the DE mode can be observed to achieve the same output voltage of 1.8 V. The ringing observed during zero inductor current is typical for DE mode and may cause EMC-related problems [4]. Therefore, the EM coupling between the designed converter and the TEM cell is measured to analyze the effects of the DE mode on the generated EMI.

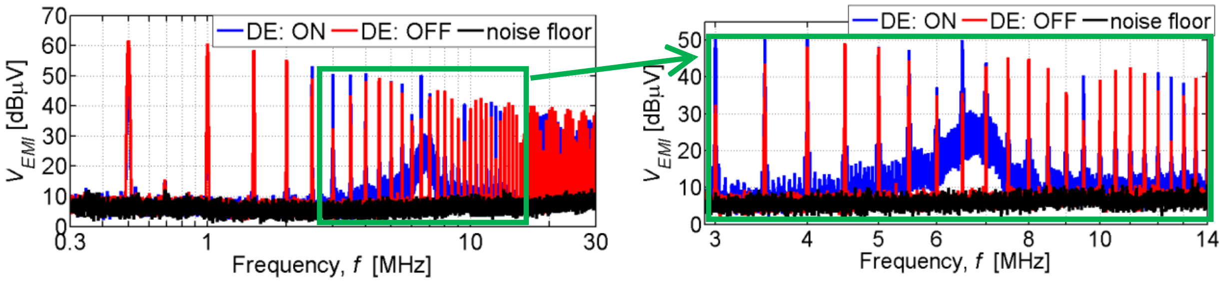


Fig. 5. Impact of DE mode on EM voltage coupled to the septum of TEM cell. The noise floor is shown in black. The settings of the EMI receiver: 30 kHz to 30 MHz, 120 kHz RBW filter, positive peak, 20000 pts. with 10 sweep counts.

It can be observed that the amplitude at the fundamental (switching) frequency of 500 kHz and the first three harmonics of the measured spectrum is larger when the DE mode is off due to the larger duty cycle, i.e. the larger input current of the buck converter required to achieve the same test case for both modes of operation (I_{OUT} = 1 A). The spectrum measured in DE mode becomes larger than in the off-state of DE mode starting at about 2.5 MHz, which is due to ringing at the switching node. For example, the amplitude of the measured spectrum in DE mode at 3 MHz and 6 MHz is almost 20 dB larger than in the off-state of DE mode. In addition to the discrete spectrum, the contribution of the continuous spectrum, which resembles to noise, increasing the measured coupled EMI can be observed when the DE mode is used.

Suppression of generated EMI requires various techniques that reduce power efficiency, i.e. puts a tradeoff in using a switching converter in DE mode [5].

Keywords: electromagnetic compatibility, synchronous switching power converter, TEM cell

References

[1] Intel®, *DrMOS Specifications*, Revision 1.0, Nov. 2004, www.intel.com.

[2] Vishay Siliconix, SiC651, SiC651A – 50 A VRPower® Integrated Power Stage, Rev. B, Oct. 2019.

[3] C. I. Fong, B. K. Lim, Addressing RDS(on) Challenges in PQFN for Enhanced DrMOS Device Performance, IEEE Regional Symposium on Micro and Nanoelectronics (RSM), Aug. 2021.

[4] M. Walczak, Impact of inductor current ringing in DCM on output voltage of DC-DC buck power converters, Archives of Electrical Engineering, vol. 66, 2017, DOI: 10.1515/aee-2017-0023.

[5] L. Yajun et al., High efficiency and low electromagnetic interference boost DC–DC converter, Journal of Semiconductors, Vol. 35, No. 4, April 2014.

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5. SMART ADJUSTABLE OPTICAL ATTENUATOR

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Abstract

Adjustable optical attenuator (AOA) based on magnetoreological fluid (MRF), which possesses SMART properties, can be used to adjust the power level of the optical signal when adjusting and measuring the parameters of various optoelectronic devices, optical communication networks, optical information storage and processing systems and as well as for decoupling the laser diode from the next device which it interacts. MRF consists of carbonyl iron powder and polyethylsiloxane oil.

In the initial state, the electromagnet is disconnected and the iron carbonyl powders are separated by means of permanent magnets at the extreme points of the hole AOA, thus releasing the gap between the front surfaces of the optical fibers. When the intensity of the magnetic field created by the electromagnet changes from 0 to 50 A/m, the attenuation AOA based on FMR changes from minus 2 to minus 60 dB with the resolution of 0.5 dB and works within the temperature limits -60 …+90°C [1].

Keywords: Adjustable optical attenuator, magnetoreological fluid.

References

[1] Nistiriuc A. Investigation of the Optical Attenuator in the Base of the Magnetoreological Fluid. Materials of the Conference of Collaborators, Phd Students and Students Technical University of Moldova, Chisinau, March, pp. 17-20, 2019.

6. SPECIFIC ABSORPTION RATE (SAR) ASSESING IN TISSUE MODELS MIMICKING THE HUMAN HEAD AT 5G FREQUENCIES

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Abstract

Multiple simulations were performed in CST Microwawe Studio Software in order to determine the specific absorption rate (SAR) of energy deposition in tissue models mimicking the human head/part. Two cases were considered: a) a stratified tissue block with a volum of 5.12 x 10^6 mm^3 b) a pure dielectric stratified sphere with an external radius of 88.9 mm and a volume of 2.94 x 10^6 mm^3 [1]. The tissue layers and their widths are: skin – 1mm, fat – 0.3 mm, bone – 7 mm, dura – 0.2 mm, CSF – 0.4 mm, brain – 80 mm. A plane wave (E_inc= 1V/m and circular polarization) at 3.5 GHz and 28 GHz frequencies was used as a radiation source. Regarding the dielectric properties of the tissues, they were extracting from a free program depending on the working frequency [2]. Figure 1 highlight the maximum local SAR at 28 GHz, exactly with 0.456 mW/kg higher than at 3.5 GHz. In the case of dielectric sphere model, lower SAR values were obtained by approximately 50% compared to those obtained in the case of the layered tissue block. Therefore, on large areas of tissue, a greater amount of energy is absorbed when a higher frequency is used. In the dielectric stratified sphere at both frequencies, higher SAR values were computed either on the surface but also deeper at the level of the brain tissue location when compared to the planar tissue layers (Fig. 1 & 2). An important aspect at 28 GHz in case of the spherical multilayer model is the concentration of SAR on a much smaller surface compared to the case of the other frequency, which indicates a more pronounced heating of the tissues.

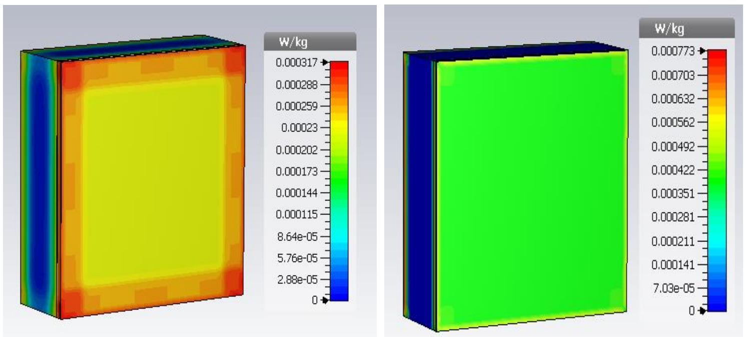

Fig. 1. SAR_{10g}(W/kg) values distribution in the multi-layer tissue block at 3.5 GHz (left) and 28 GHz (right)

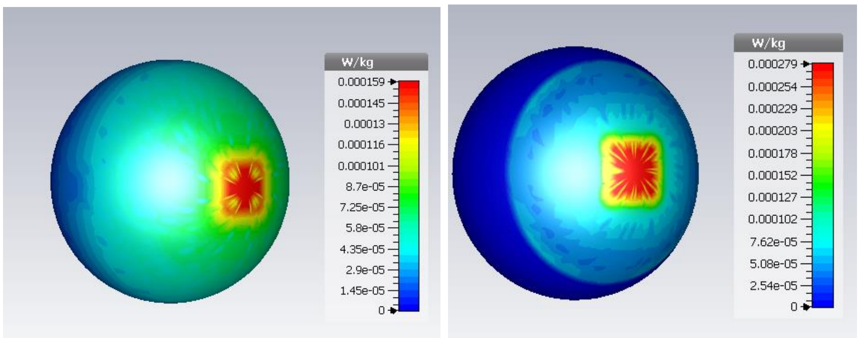

Fig. 2. SAR_{10g}(W/kg) values distribution on the dielectric stratified sphere at 3.5 GHz (left) and 28 GHz (right)

In order to determine the SAR_{10g} and the point SAR variation inside the two models, a transverse reference plane passing through their center was chosen. So we kept the x and y coordinates constant (both at 0) and varied the z coordinate - the axis that is perpendicular to the tissue surface. In that way, we notice that the SAR (Fig. 3) varies differently at the two frequencies, showing closer values at the 3.5 GHz,and at the 28 GHz showing a sudden decrease inside the brain, where it shows very low values. Although at 28 GHz we obtained the maximum SAR right at the level of the brain, the graph shows a very uneven distribution that reaches insignificant values. SAR is lower, especially in the depth of the brain, and the maximum was identified in the first impinged layers. According to the results from Fig. 4, SAR varies similarly inside the tissues as in Fig. 3. So we can state that changing the geometry of the exposed tissue model, namely the use of a spherical shape, implies the achievement of higher SAR values, but the average of all values is lower than in the case of exposing a planar multi-layer tissue (more hot-spots appear in the spherical model than in the planar one). We also observe that the SAR has a linear decrease at the exit from the tissue because the plane wave to which the sphere is exposed generates an electromagnetic field around it, thus producing the phenomenon of diffraction. So the tissues are heated more on the outside part, but on a much larger surface and lesser in depth.

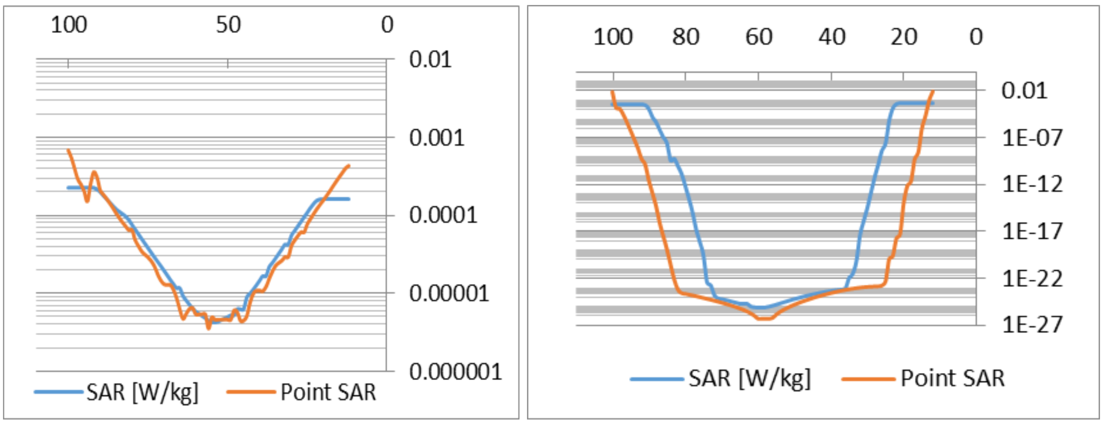

Fig. 3. SAR (W/kg) variation in a section plane through the centre of the tissue block at 3.5 GHz (left) and 28 GHz (right)

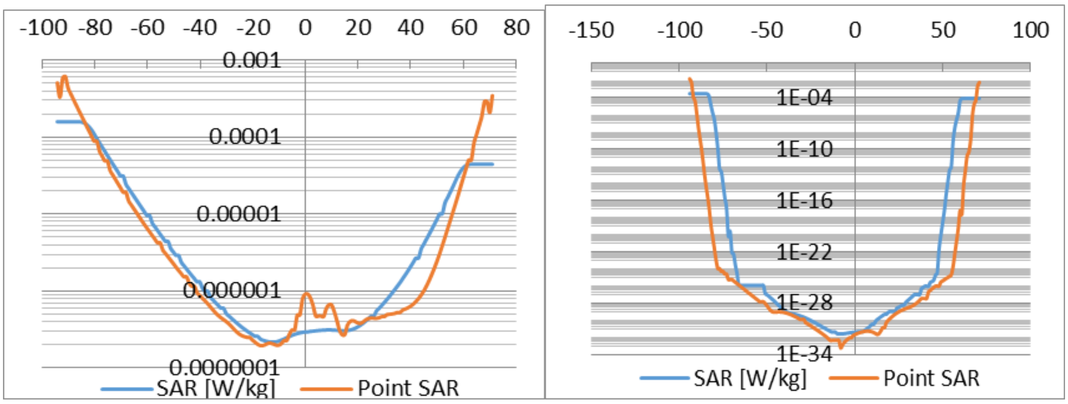

Fig. 4. SAR (W/kg) variation in a section plane through the centre of the dielectric sphere at 3.5 GHz (left) and 28 GHz (right)

Keywords: SAR, brain tissue, microwaves, exposure, dosimetry

References

1. Deaconescu D.B. and Miclaus S., Assesing power losses in magnetic-dielectric tissues exposed to microwaves: Commercial Computational Software Capabilities and Limits, 2021 International Conference on e-Health and Bioengineering (EHB), 2021, pp. 1-4, doi: 10.1109/EHB52898.2021.9657677.
2. Dielectric properties of body tissues: http://niremf.ifac.cnr.it/tissprop/htmlclie/htmlclie.php.

7. HIGHLY DIRECTIVE VHF ANTENNA FOR APPLICATIONS IN THE 118-137 MHz RANGE

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Abstract

A lightweight segmented Yagi antenna is designed and built for specific multipurpose radar applications. The antenna consists of an active dipole, a reflector of approximately the same length and nine directors, the first two having different length and positioning and the remaining seven being identical. The antenna was designed for the aircraft band (118-137MHz) used for radio navigation and communication [1]. All the elements are made of aluminium with a thickness of 1 mm and are attached to a wood framework to maintain the geometry of the solution-antenna. In order to obtain a high gain and directivity, a simulation was made using CST Studio Suite Software. The materials used in the simulation were imported from the program library (Aluminium - electrical conductivity=3.57x10^7 S/m, Mu=1). The support made for fixing the antenna elements is made up of three wooden bars with a length 2.5 meters, positioned along the antenna axis and four other bars arranged to join them together. The only material used is wood, avoiding the re-reflexion effects. The length of the dipole is 1148,36 mm (0.46 λ at 121.5 MHz) and the length of the reflector is 1183,89 mm (0.48 λ at 121.5 MHz) because it must be slightly longer than the driven element [2]. The dimensions and positions of the antenna elements are shown in Fig. 1.

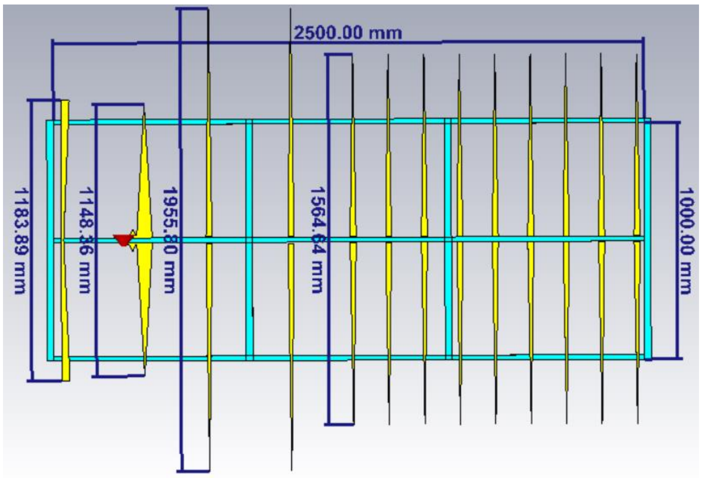

Fig. 1. Dimensions and placement of the antenna elements

In the simulation, good values were obtained for the gain and efficiency of the antenna. Table 1 shows the main parameters obtained in the frequency band of interest. The highest gain was obtained for the frequency of 130 MHz, having a half-power beam-width (HPBW) of 38.6° in azimuth and 52.6° in elevation. Fig. 2 shows the 3D radiation pattern and the polar diagram at 130 MHz, the resonance frequency. Very good responses were obtained, if we compare with results in [3]. Measurements of the reflection coefficient S11 were made by a vector network analyzer model ZNB40 from Rohde&Schwarz. Calibration was performed using the ZV-Z229 calibration kit and standard methodology. The measurements were made in restricted open field, respecting the rules regarding distances. Fig. 3-left shows a picture of the real antenna with measurement equipment, and Fig. 3-right shows the comparison of the S11 coefficient obtained by measurements versus the simulations. The objective of present research was the design of an antenna with very good response in gain and directivity in the 118-137 band to receive and capture airplanes signals.

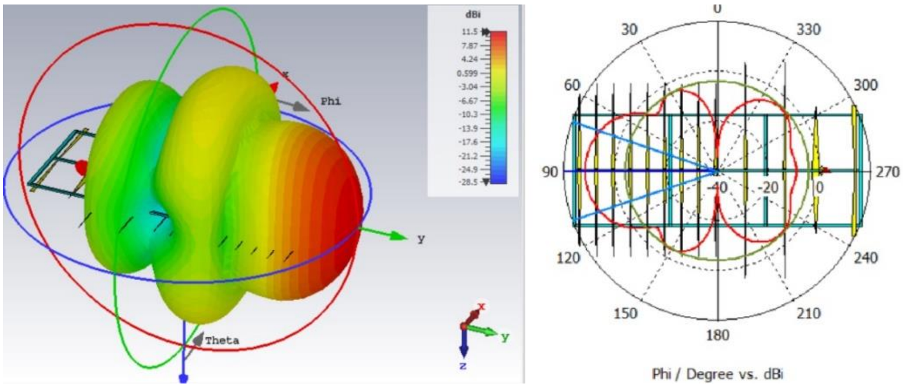

Fig. 2. 3D radiation diagram (left) and polar azimuthal diagram (right) at 130 MHz

Table 1. Antenna gain and HPBW in the range of interest

Frequency (MHz)	Gain (dBi)	$HPBW_{az}$ (°)	$HPBW_{el}$ (°)
118	11.2	45.4	61.0
124	11.3	42.1	56.7
128	11.4	39.8	54.1
130	11.5	38.6	52.6
132	11.4	37.6	51.3
134	11.0	36.6	49.7
137	9.75	35.7	47.6

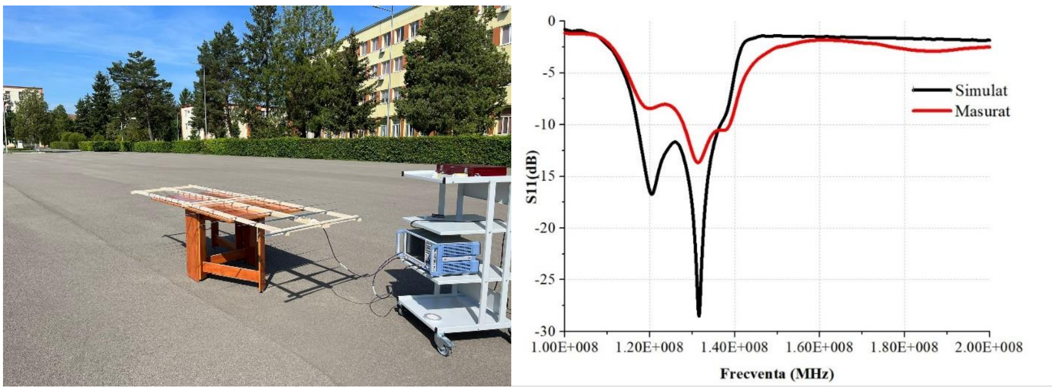

Fig. 3. left – real antenna on the field measurements, right – reflexion coefficient in the band comparatively from simulation and from measurements

Keywords: VHF antenna, directive Yagi, aircraft communication, radio navigation

References

1. T. Bilen, H. Ahmadi, B. Canberk and T. Q. Duong, Aeronautical Networks for In-Flight Connectivity:A Tutorial of the State-of-the-Art and Survey of Research Challenges, IEEE Access, vol. 10, pp. 20053-20079, 2022
2. Balanis CA. Antenna The.ory Analysis and Design. 3rd ed. New Jersey: Wiley; 2005.
3. K. Sungpeel, H. Junyong, J. Younhui , C. Jaehoon, A compact VHF/UHF band quasi-Yagi antenna for multifunction radar applications, Microwave and Optical Technology Letters 60(10):2525-2530, 2018.

8. PEOPLE COUNTING IN A COVID-19 AND GDPR CONTEXT, USING AN IR-UWB RADAR, BASED ON ARTIFICIAL INTELLIGENCE ALGORITHMS

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Abstract

People counting using an IR-UWB radar, based on Artificial Intelligence classification algorithms, is investigated in this paper. Ultra-wideband (UWB) impulses have a duration of nanoseconds in the time domain, occupying a very large frequency bandwidth, from 500 MHz up to 7.5 GHz [1]. UWB technology is used for surveillance, detection, positioning and other applications due to its fine temporal resolution and low emission power [2]. Ultra-wideband echo radar signals are used for people counting, in a COVID-19 and GDPR context, where a one-meter minimum distance between the persons is required, thus limiting their number in a given area, which is important to limit the spread of the COVID-19 virus. The GDPR context refers to the protection of personal data, where an IR-UWB radar is used instead of a video camera to count the people indoors. The dataset is open-source and corresponds to the reference article [3], where four scenarios are considered, involving 0 up to 20 persons randomly walking and standing in a queue, in the radar range. The data are pre-processed, by extracting the direct current component and by applying the Running Average method for clutter removal. Three methods for feature extraction are investigated: (i) the Curvelet Transform together with the Segmented-based method (the hybrid method) [3], (ii) a Convolutional Neural Network (CNN) on the raw dataset, and (iii) the Principal Component Analysis (PCA) algorithm, both for the raw dataset and the set of the extracted hybrid features. The classification is done by using Artificial Intelligence algorithms such as K-nearest neighbours (KNN), Support Vector Machine (SVM), Multilayer Perceptron Neural Network (MLP), and Convolutional Neural Network, where the targets are the number of persons in the radar range. K-NN uses 5 neighbours and is based on Euclidian distances, SVM uses the RBF kernel, MLP is composed of four layers of 50 neurons each, and the CNN is composed of Convolution layers, MaxPooling layers, LazyLinear layers, having as activation function the ReLu function and as logistic function, the SoftMax function. The input data for the classifiers are split into a training set and a test set. The algorithms’ performance is provided in terms of accuracy, precision, recall and f1-score functions, using the test dataset. The paper presents three methods for feature extraction used as input data for AI-supervised algorithms. The results show that the best performance is obtained for the hybrid features based on MLP (the frequency-based features provided by the Curvelet transform and the time-based features provided by the Segmented-based method), where the f1-score is 99.85%. The frequency-based features provide us with salient detail and capture the edges in the radar sample, while the Segmented-based features provide us with resolution in distance. The drawback of this algorithm would be the high computational demand and its complexity. CNN applied on the set of features that resulted from applying PCA on the raw dataset is recommended for real-time applications, which shows an f1-score of 95.41%. CNN has 800 parameters which are optimized during the training process, where the parameters are updated based on minimizing the error between the estimated value and the target value,

using the Minimum Squared Error loss function with one-hot encoding targets and the Adam optimizer. The third method provides fast training and testing, but the data insufficiency can degrade the performance if the dataset is not large enough. The table below shows the algorithms' performance in terms of accuracy, precision, recall and f1-score, which are the most used classification metrics.

Table 1. People counting results

Dataset (No_signalsx No_features)	**Feature exraction method**	**Classification Algorithm**	**Accuracy**	**Precision**	**Recall**	**F1-score**
(6400 x 293)	Hybrid	K-NN	94.08%	94.08%	94.08%	94.08%
(6400 x 293)	Hybrid	SVM	85.12%	85.12%	85.12%	82.76%
(6400 x 293)	**Hybrid**	**MLP**	**99.85%**	**99.85%**	**99.85%**	**99.85%**
(6400 x 3)	Hybrid + PCA	K-NN	73.66%	73.66%	73.66%	73.56%
(6400 x 3)	Hybrid + PCA	SVM	55.74%	55.74%	55.74%	53.43%
(6400 x 3)	Hybrid + PCA	MLP	64.31%	64.31%	64.31%	62.90%
(6400 x 1280)	CNN	CNN	95.44%	95.44%	95.44%	95.44%
(6400 x 6)	**PCA**	**CNN**	**95.41%**	**95.41%**	**95.41%**	**95.41%**

References

1] T. C. a. G. P. M. I. Marco Cavallaro, "Gaussian Pulse Generator for Millimeter-Wave," *IEEE TRANSACTIONS ON CIRCUITS AND SYSTEMS—I: REGULAR PAPERS, JUNE ,* Vols. NO. 6,VOL. 57, 2010. DOI: 10.1109/TCSI.2009.2031706.

2] Y. Rahayu, T. A. Rahman, R. Ngah and P. S. Hall, "Ultra wideband technology and its applications," 2008 5th IFIP International Conference on Wireless and Optical Communications Networks (WOCN '08), 2008, pp. 1-5, doi: 10.1109/WOCN.2008.4542537.

3] X. Yang, W. Yin, L. Li and L. Zhang, "Dense People Counting Using IR-UWB Radar with a Hybrid Feature Extraction Method," *IEEE Geoscience and Remote Sensing Letters,* vol. 16, no. 1, pp. 30-34, 2018.

9. THE LOCAL RADIATED EMISSION OF AN WI-FI 6 CLIENT: PRELIMINARY OBSERVATIONS

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Abstract

The radiated field emitted by a mobile phone connected to a Wi-Fi6 network operating in the 5 GHz band was investigated in one single point in air. A phone model Huawei P40 Pro was connected to a wireless router model TP-Link Archer AX10 and used the IEEE 802.11ax standard of communication. An Android application installed on the mobile terminal continuously monitored a set of signal parameters during file uploads and file downloads.

The interest parameters were: operating frequency, upload speed, download speed, total number of transmitted bits, total number of received bits, received signal strength indicator (RSSI) and total link speed. The electric (E)-field strength was also measured while the phone sequentially performed file upload and file download actions. The measurement system consisted of an ultra-light and small probe model PBS-1 from Aaronia connected to a R&S FSL spectrum analyzer from Rhode & Schwarz. The measurements were accomplished with the help of a Python application that allowed automatic measurements settings and data retrieval. Channel power measurements were conducted at the spectrum analyzer [1].

Six measurement cases were considered in the research (3 operating powers of the router x 2 traffic directions). Data were automatically retrieved as 8 channel power samples per second. For each measurement case the Python application saved 1500 consecutive samples of channel power values (in dBm). The average monitoring duration per case was 160 s.

To better express the human electromagnetic exposure, the values of power density and radiated energy were then calculated and represented graphically.

The overall results demonstrate that:

a) In Fig.1 we observe that the values of E-field strength vary depending on the upload speed. As expected, RSSI values were higher when higher operating power was enabled at the router;

b) In Fig. 2 one can observe that for file download case, as expected, the maximum E-field strength resulted for the high operating power;

c) Due to Fig. 3 - left, in the case of file upload, the calculated values for power density per transmitted bit and the radiated energy are higher in case of medium operating power;

d) Due to Fig. 3 - right, in the case of file download, the calculated values for power density per transmitted bit and the radiated energy are higher in case of high operating power.

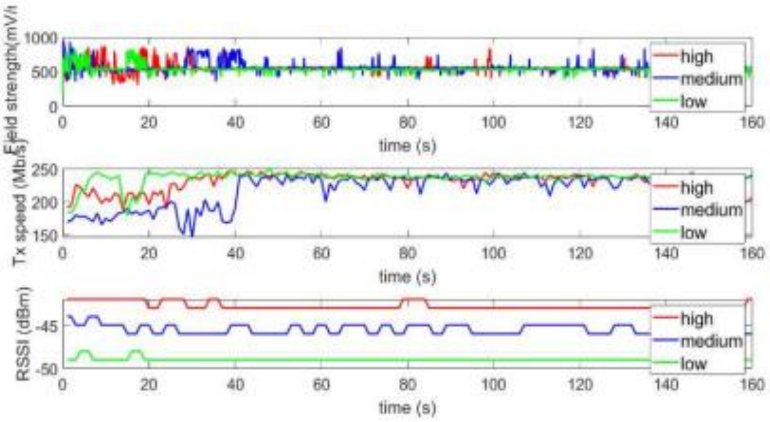

Fig. 1. Temporal variation of field strength (up), Upload speed (middle) and RSSI level (bottom) for file upload

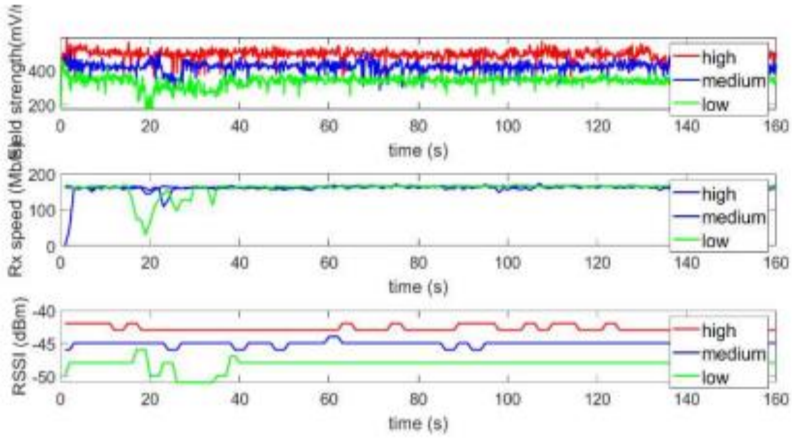

Fig. 2. Temporal variation of field strength (down), Download speed (middle) and RSSI level (bottom) for file download

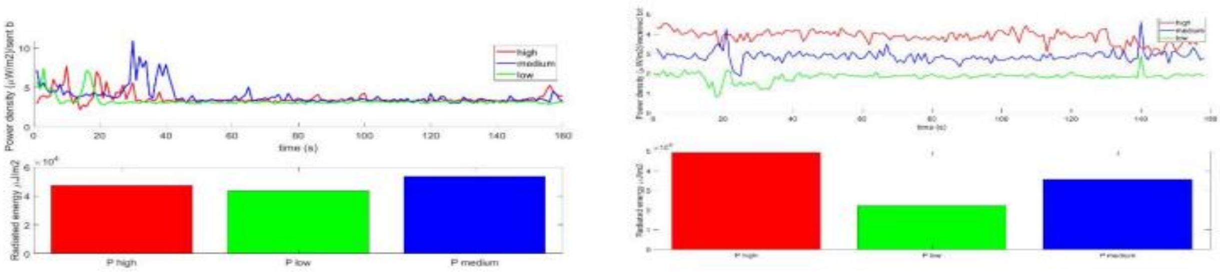

Fig. 3. Power density per transmitted bit - dynamics in time and radiated energy (bars) for file upload (left) and file download (right)

Keywords: Android, Java programming language, 802.11 ax, exposure assessment, Wi-Fi data storage

References

1. Buda, A.; and Sarbu, A. (2021). Development of an Android application for user exposure assessment to electromagnetic fields emitted by an IEEE 802.11ax client. IEEE International Black Sea Conference on Communications and Networking, 24–28 May 2021.

10. DEFECTOSCOPY TOOLS FOR THE EVALUTION OF NEAR FIELD RADIATED EMISSIONS

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Abstract

Two methods are proposed for the rapid assessment of near-field electromagnetic leakage areas [1] using two different tools. One is for assess RF leakage using an electric field probe, and the other is based on a magnetic field probe. Using auxiliary devices, the two methods can also provide visualization of amplitude variations provided at the output of the tools. In the case of the tool based on the electric field probe, the appropriate visualization device was considered to be the oscilloscope, laboratory or portable, and in the case of the one based on the magnetic field probe, the use of a specialized visualization software was chosen, with the role of processing the received data from a RTL-SDR, connected directly to the probe.

The electric field probe tool is based on the operating principle of the voltage-frequency converter. As a detector, a Ge detection diode was used (with an opening voltage of 180 mV). The diode was placed in the high-impedance input circuit of a comparator. When the voltage at the diode terminals reaches a certain value, the comparator triggers an astable circuit that provides output pulses with a frequency proportional to the electric component intensity of the electromagnetic field received by the device's probe. In order to create reflected waves through the cable, for testing the tool sensitivity, an impedance mismatching [2] was intentionally produced by using a cable with an impedance of 75 Ω and a terminal power load of 50 Ω. Fig. 1 (a) shows the operating principle of the tool and Fig. 1 (b) shows the oscillogram of its output signal, as it is moved along the 75 Ω coaxial cable. In Fig. 2 (a) the complete tool can be seen, ready for testing.

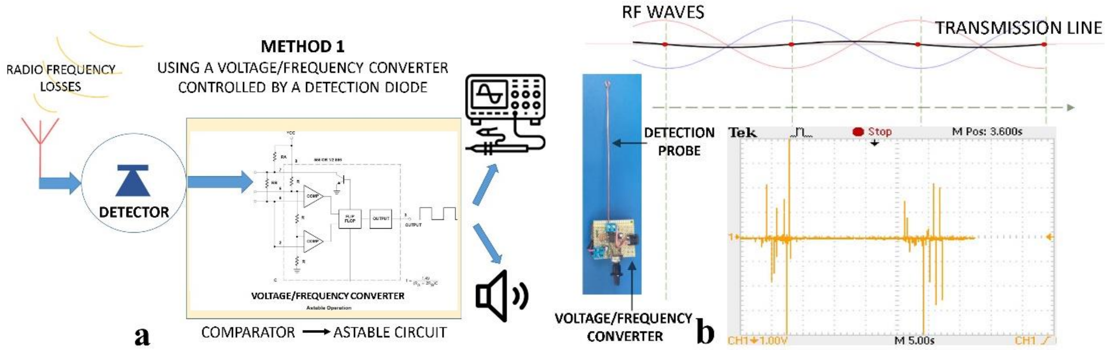

Fig 1. Operating principle (a) and results obtained (b) with the electrical field probe tool

The magnetic field probe tool is directly coupled to an RTL-SDR via SMA connector and is made of low loss RG402 semi-rigid coaxial cable. After bending the cable into a loop, the center conductor and ground braid were joined at the same point on the cable by soldering (Fig. 2 (b)). To simulate a cable failure, a 3 cm longitudinal incision was made in it (Fig. 3 (a)). In Fig. 3 (b) it can be seen the complete tool, with the probe connected to the RTL-SDR. The “rtl-sdr dongle panorama " software was used to process the data generated by RTL-SDR.

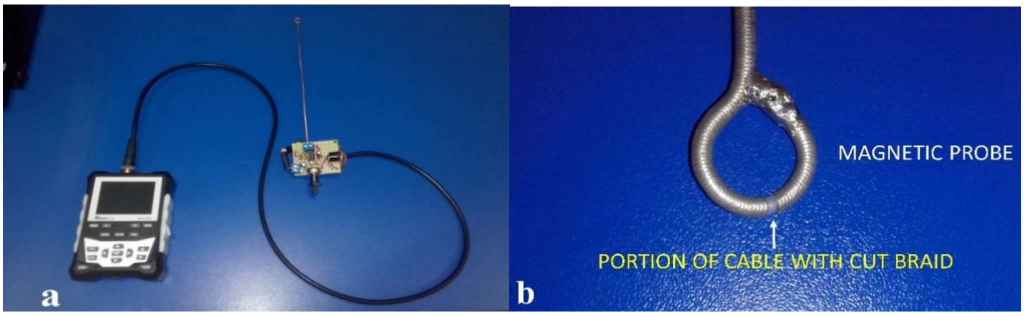

Fig. 2. Complete tool with electric field probe prepared for evaluation (a). Magnetic field probe loop (b).

Fig. 3. Cable caused failure (a) and the complete tool prepared for evaluation (b).

It can be seen in Fig. 4 (a) the test results on the cable before caused failure. Fig. 4 (b) reveals the cable radiated emissions, after making the incision. From these it is found that the emission of the defective cable is 7 dB higher than the emission of the cable before the incision was made.

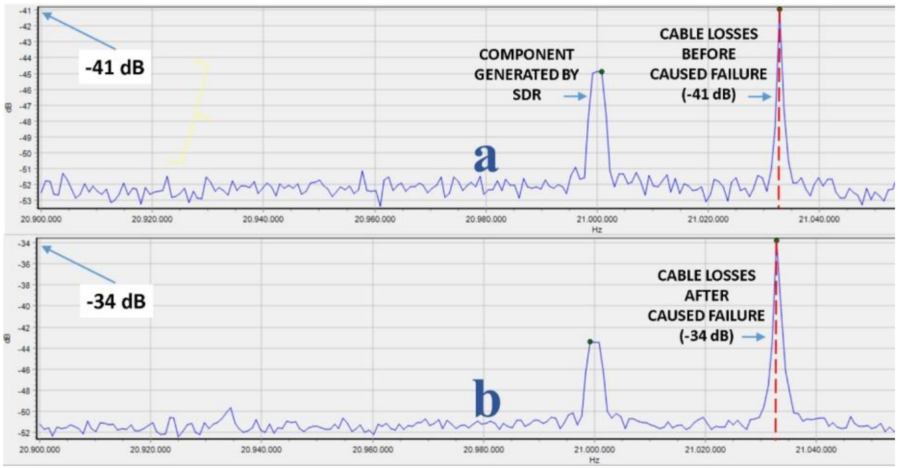

Fig. 4. Results on the cable tests before caused failure (a) and after making the incision (b).

Keywords: EMI defectoscopy, radiated emission

References

[1] Electromagnetics Explained, A Handbook for Wireless/RF, EMC, and High-Speed Electronics, Ron Schmitt, ©2002 Elsevier Science, ISBN 0-07506-7403-2.

[2] K.T. McDonald, "Waves on a Mismatched Transmission Line" (Oct. 4, 2014), http://kirkmcd.princeton.edu/examples/mismatch.pdf

11. ABOUT THE ELECTROMAGNETIC COMPATIBILITY OF RADIO COMMUNICATION SYSTEMS

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Abstract

This article is dedicated to the comparative analysis of two methods for estimating electromagnetic compatibility for radio communication systems. The first method makes it possible to determine the permissible noise power in relation to the average signal strength, and in the case of the second method, the period of time for which the radio communications are interrupted is determined on the basis of the convolution of the signal and the noise.

The first method leads to erroneous results in estimating the electromagnetic compatibility of radio communication systems and to the insufficient use of the radio frequency spectrum, as statistics for signal and noise are not taken into account. In order to increase the certainty of the evaluation of the electromagnetic compatibility of radio communication systems, it is proposed to perform a comparative analysis of the first method with the method in which the period of radio communications inactivity is evaluated based on the convolution of statistics for signal and noise.

Thus, for each of the two methods was obtained the dependence of the time difference of radio communications inactivity depending on the signal-to-noise ratio. Estimation of statistics for signal and noise within the radio communications was performed based on ITU-R Recommendations P. 525, P. 526 and P. 452 [1-3].

Keywords: Radio communication systems, electromagnetic compatibility

References

[1] ITU-R Recommendations P. 525: Calculation of free-space attenuation. Approved in 2019-08.

[2] ITU-R Recommendations P. 526: Propagation by diffraction. Approved in 2019-10.

[3] ITU-R Recommendations P. 452: Prediction procedure for the evaluation of interference between stations on the surface of the Earth at frequencies about 0,1 and 0,7 GHz. Approved in 2015-07.

12. OPTIMIZATION OF ENERGY CONSUMPTION IN EDUCATIONAL INSTITUTIONS

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Abstract

The paper presents a complex approach in solving the energy consumption optimization problem used for artificial lighting in educational institutions. The objectives of the paper are realized by identifying the educational process based on a Multi-Agent distributed system that operates based on a genetic algorithm and collective intelligence, and it is defined in a multi-objective optimization space. Agents are a set of computer systems interconnected in a network, to realize data exchange, acquire data from human presence sensors and the intensity of the light flux in the controlled space. The algorithmic functionality of the Agents is defined by mathematical models presented in the paper.

Keywords: Multi-Agent System, Multi-objective Optimization, Genetic Algorithms, Swarm Intelligence, Sensor Network, Distributed Control.

Introduction

The educational process is one of the most dynamic processes involving a lot of humans, technical, logistical and technological resources. Planning these processes is complicated because each component of the system induces a lot of global or individual objectives that influence the educational process.

In this paper it is proposed to identify the control system of the educational process based on a Multi-Agent system [1] defined in a multi-objective optimization space [2] in order to optimize the energy consumption for artificial lighting. To solve the energy consumption optimization objectives, it is proposed to use distributed control models [3] integrated in a sensor network [4] based on genetic algorithms [5] and collective intelligence [6].

Method of Solving the Energy Consumption Optimization Problem

In the space $S \subset R^{2N}$ is defined the educational process $P = F\left(t, X^M(t), X^L(t), U(t)\right)$ with artificial lighting, where: N - the number of Agents for the control of the lighting process; t - the time variable, or the evolution of the process over time; $X^M(t) = \left(x_i^M(t), \forall i = \overline{1,N}\right)$ - the set of motion sensors that identify the human presence in the controlled space by the Agent; $X^L(t) = \left(x_i^L(t), \forall i = \overline{1,N}\right)$ - the set of motion sensors that identify the intensity of the light flux in the space controlled by the Agent; $U(t) = \left(u_i(t), \forall i = \overline{1,N}\right)$ - the set of control signals with the artificial lighting process; $F = \left(f_i, \forall i = \overline{1,N}\right)$ - the set of operators for the data generated processing by the set of sensors $X(t) = \bigcup\left(X^M(t), X^L(t)\right)$ and the calculation of control signals $U(t)$:

$$F : X(t) \rightarrow U(t). \quad (1)$$

The energy consumed by a lighting device $W_i(t)$ in the time interval $t \in [0:T]$ is calculated based on (2) formula. The 24-hour interval is recommended for synchronization:

$$W_i(t) = \int_{t=0}^{T} \left(w_i(t), u_i(t), k_i\right) dt, \tag{2}$$

where: $w_i(t)$ - the consumption power of the lighting device per time unit; $u_i(t)$ - the control signal value generated by the Agent; k_i - the coordination coefficient.

For the energy consumption optimization, the multi-criteria optimization problem is defined (3):

$$\begin{cases} \min h\left(W_i(t), \forall i = \overline{1,N}\right); \\ g_j\left(X(T), U(t)\right) = 0, \forall j = \overline{1,N}; \\ X^L(t) \geq X^{L*} : \exists\, X^M(t) \neq 0; \\ X(t) \in S, U(t) \in U^*. \end{cases} \tag{3}$$

where: h - is the multi-criteria function for energy consumption optimization. Genetic algorithms are used to find optimal values. The process of solving this function is distributed among all Agents; $W_i(t)$ - energy consumption of each lighting device; g_j - the set of functions for processing the signals obtained from the set of sensors $X(t)$; X^{L*} - the set of minimum values for artificial lighting in case of human presence in the space controlled by the Agent; U^* - the range of variation of control signals.

Results

Functional verification of the Multi-Agent system for multi-criteria optimization of the energy consumption used for artificial lighting in educational institutions was carried out based on ESP32-WROOM-32E devices (Technical characteristics: 32-bit MCU, 2.4GHz Wi-Fi, 4 MB Flash). Sensors were used for data acquisition: PIR Sensor - identification of human presence in the control area and a light sensor. The action element is made in the form of a relay connecting the 220V power supply to the artificial lighting device.

Conclusion

The use of the Multi-Agent system for the efficiency of energy consumption for artificial lighting in educational institutions, will allow reducing energy consumption by 15-20%, while also ensuring the quality of the lighting process.

References

1. B. Firme, G. Lopes, M.S. Martins, T. Coito, J. Viegas, J.M. Sousa, J.C. Reis, J. Figueired, S. Vieira, Multi-Agent System for Dynamic Scheduling. *In Proceedings of the International Joint Conference on Neural Networks IJCNN-2020, 19-24 July 2020, Glasgow, UK*, pp. 1-8, DOI: *10.1109/IJCNN48605.2020.9207055.*

2. E.-Gh. Talbi, S. Mostaghim, T. Okabe, H. Ishibuchi, G. Rudolph, and C.A. Coello, Parallel Approaches for Multiobjective Optimization, *Multiobjective Optimization, LNCS 5252,* pp. 349-372, Springer-Verlag, 2008.

3. G. Weies, *Multiagent Systems: A Modern Approach to Distributed Artificial Intelligence*, January 1999, MIT Press, Cambridge, US, 547p. ISBN: 978-0-262-23203-6.

4. M. Islam, A. Kumar, A. Hossain, Study of Wireless Sensor Network. *International Journal of Sensors and Sensor Networks. Vol. 7, No. 1, 2019*, pp. 9-15. doi: 10.11648/j.ijssn.20190701.12.

5. E. Mbunge, S.G. Fashoto, E.J. Mnisi, Enhanced Heuristic Teaching Timetabling Algorithm Using Genetic Algorithm. *International Journal of Scientific & Technology Research, Vol. 9, Issue 04, April 2020,* pp. 3804-3814, ISSN: 2277-8616.

6. K. Kaur, Y. Kumar, Swarm Intelligence and its Applications Towards Various Computing: A Systematic Review. *In Proceedings of the 2020 International Conference on Intelligent Engineering and Management (ICIEM), London, UK,* pp. 17–19, June 2020.

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13. USING THE SPECTRAL FINGERPRINT OF MOBILE TACTICAL PLATFORM TO ENSURE EMISSIONS CONTROL AND PERSONNEL SAFETY

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[2]National Institute for Research and Development in Electrical Engineering ICPE-CA Bucharest, Romania

Abstract

For a mobile tactical platform, the assessment of the control of RF emissions and the exposure of personnel to non-ionizing radiation can be performed based on the related spectral fingerprint. In this paper, the method of exploiting the spectral fingerprint is presented in order to ensure the of the emissions security and the safety personnel.

Keywords: Emission Control, EMCON, Radiation Hazards, RADHAZ

In today's technology environment, it is not enough to simply know whether systems are exceeding appropriate levels. To support the daily operation of tactical platforms, to ensure the security emissions and safety of personnel, it is more important than ever to be able to discover, locate, classify, record signals of interest through a combination of EM radiations survey and frequency spectrum monitoring.

In this paper, we will discuss electromagnetic radiation, Emission Control (EMCON) and of Radiation Hazards (RADHAZ). We will cover development of a paradigm for the evaluation and monitoring EMCON security or EMF exposure of personnel, on board the platform. A real-time spectrum analysis sensor (e.g. RF analyzer on USB) can be used to identify EMCON violations and mitigate RADHAZ risks. An RF sensor network can improve RFR situational awareness.

Radiofrequency electromagnetic radiation (RFR)

Excessive levels of exposure to radio frequency radiation (RFR), generated by radar, communications, command and control equipment installed on the mobile tactical platform, can result in adverse effects on personnel, respectively, can cause premature activation of electronic devices -explosives (EED) or interference with other electronic equipment on board the platform. For military emission security operations such as EMCON and RADHAZ, awareness of the existence of non-ionizing RFR from electronic communications terminal devices to radar is essential to protect personnel, equipment and missions.

Emissions Control (EMCON)

During military operations, EMCON measures are recommended to prevent an enemy from detecting, identifying, and locating friendly forces. For EMCON management, the need to ensure that operations comply with the appropriate regulated EMCON security level is of utmost importance.

EMCON management consists of four main levels (Delta - used during normal operations, Charlie - allows RFR from mission-essential equipments, Bravo - limits what is authorized to be radiated and transmitted, Alpha - the most restrictive form of emissions control when an operation requires absolute silence). Each level requires different levels of situational awareness.

Given the ubiquity of mobile and RF-using electronic devices in today's world, managing EMCON operations can be challenging.

Radiation Hazard (RADHAZ)

RADHAZ procedures aim to establish the fundamental measures to mitigate the risks associated with RFR. For mobile tactical platforms, RADHAZ risks can be particularly high when two radio-emitting vehicles or ships interact with each other.

The dangers of electromagnetic radiation generated by the radar and communications systems operating on the platform can affect the health of the personnel on board.

The use of high-frequency transmitters and high-gain antennas, as well as the complicated structure and rigging on board ships, increased the likelihood of electrical voltages on linear metal objects on board the ship. Radiation from nearby transmitting antennas can lead to voltage levels that are sufficient to cause problems, which can occur from direct contact with a conductive object or from a spark discharge.

Another form of electromagnetic radiation hazards occurs when RFR enters sensitive electrically initiated devices (EIDs) or electro-explosive devices (EEDs) and can cause an unexpected explosion. RFR energy can enter a munition element through a hole or slot in its casing, or through cables and firing wires.

The RF spectral footprint in the evaluation of EMCON and RADHAZ

To respond to these EMCON and RADHAZ concerns, improved emission security and EMF exposure assessment methods and monitoring concepts that generate valid RF data must be developed and implemented. The RF spectral footprint of the platform is unique, but the feature extraction methods differ for the two analyses, EMCON and RADHAZ.

From this general perspective, the following scientific challenges must be overcome: collecting systematic RF data and establishing a paradigm for the evaluation and monitoring of EMCON and RADHAZ; development of feasible EMCON and RADHAZ evaluation methods, based on the spectral fingerprint and adapted to the emissions risks related to the latest RF technologies; development of appropriate equipment for RFR monitoring.

The process of monitoring the RF environment for EMCON compliance or RADHAZ risks involves basically similar steps:

- determination of the spectral fingerprint related to the mobile tactical platform;
- characterization of the risk of RF emissions from the point of view of ensuring emission control and personnel safety;
- defining the spectral mask for radio monitoring, in accordance with EMCON and RADHAZ regulations;
- discovery of the offending signal that has a level above the spectral mask of normality;
- locating the origin of the signal;
- signal identification, classification and recording for further analysis.

Conclusion

For mobile tactical platforms, the advancements and ubiquity of RF technology have required a shift in how threats to personnel, equipment, and operations are viewed, identified, and responded to. Going forward, we expect the RF innovation landscape to continue to expand, accelerate, and become more complex and difficult to assess and monitor.

References

[1] Electronic Warfare and Radar Systems Engineering Handbook. 4th Edition, Naval Air Warfare Center Weapons Division Point Mugu CA, Sept. 2013, www.dtic.mil/dtic/tr/fulltext/u2/a617071.pdf.

[2] Global Security, Chapter 3, Emissions Control, www.globalsecurity.org/military/library/policy/navy/nrtc/14226_ch3.pdf.

[3] Global Security, EMCON Keeps Ships Out of Sight, JOSN David Beyea, November 5, 2002, www.globalsecurity.org/military/library/news/2002/11/mil-021105-usn01b.htm.

14. ELECTROMAGNETIC FIELD LEVEL ANALYSIS IN DENSELY POPULATED AREAS

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Abstract

With the growing popularity of mobile phones and the expansion of network infrastructure, the presence of radio frequency electromagnetic fields (RF-EMF) is becoming more intense. One of the main sources of radio frequency emissions found today, both in the public and private domain, are the mobile communications (2G, 3G, 4G etc.). These offers, in addition to the benefits of this modern technology to transfer information packets at high speed, the likelihood of potential negative effects on health or on sensitive groups, such as children, on long-term exposure to RF-EMF. [1][2]

The main objective of the research was to selectively assess the levels of RF-EMF exposure in the 200 MHz - 2.7 GHz frequency range in a densely populated area. This work reflected the public exposure to electromagnetic field by determining the highest value in each frequency range.

The measurements were performed with the Rohde & Schwarz FSP 13 spectrum analyzer using an isotropic antenna with a frequency range of 30 MHz – 3 GHz within the Polytechnic University of Bucharest. This place was chosen for the high activity in the field of radio frequency due to existing antennas on the Rector’s Office Building and on the other hand, it is a place with a high density of people daily (students, teachers, administrative staff etc.).

The results indicated that the recorded levels do not exceed the limits proposed by ICNIRP (*International Commission for the Protection of Non-Ionizing Radiation*).

Keywords: radiofrequency electromagnetic fields, exposure levels, spectrum analyzer, isotropic antenna, urban environment

References

[1] Yiannis Kiouvrekis, Georgios Manios, Vasiliki Tsitsia, Georgios Gourzoulidis, Constantin Kappas, *A statistical analysis for RF-EMF exposure levels in sensitive land use: A novel study in Greek primary and secondary education schools*, Environmental Research, Volume 191 ,2020, 109940, ISSN 0013-9351, https://doi.org/10.1016/j.envres.2020.109940.

[2] Urbinello D, Joseph W, Huss A, Verloock L, Beekhuizen J, Vermeulen R, Martens L, Röösli M., *Radio-frequency electromagnetic field (RF-EMF) exposure levels in different European outdoor urban environments in comparison with regulatory limits*, Environ Int. 2014 Jul; 68:49-54. doi: 10.1016/j.envint.2014.03.007. Epub 2014 Apr 3. PMID: 24704639.

15. MEASUREMENT METHODS IN 5G MOBILE COMMUNICATIONS

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Abstract

This paper presents the difference between the wideband measuring method and frequency selective measurements in 5G mobile communication. Wideband measuring methods determine the total value of immissions in a large frequency range. It is possible by using the other method, the frequency selective measurements to determine the components of immissions being able to determine the source of immissions too.

The usual measurement configuration for frequency selective methods is built with a receiving antenna, RF cables and spectrum analyzers. The preset for measurement of spectrum analyzer is the RMS detector, trace Average, a low-resolution bandwidth and a maximum hold-function and a span of 2.5 – 10 ms.

The 5th generation requires a MIMO (Multiple Input Multiple Output) technique because the wavelengths are shorter and can use up to 128 to 256 integrated antennas and more than 64 integrated transceivers in just one system. The technique if is combined with beamforming and beamsteering capabilities can create an active antenna system that can emit beams for specific users.

In wireless systems, the real communication signals consist of electrical voltages and currents or electromagnetic waves. The downside is distorsion being created at signal generation, transmission and reception because these signals pass through real components. Signal characterization in this case is hard to accomplish because of errors in microwave circuits which scale with frequency.

Using the frequency selective measurement to estimate the maximum 5G EMF is not a straightforward task or easy due to need of apply a proper extrapolation factor to the pilot signal and the need for taking into account a number of 5G feature as sweep beam in the measured level of the signal and Time Division Duplexing (TDD).

Keywords: wideband, frequency selective, 5G, mobile communication, electromagnetic measurements

References:

[1] Matthias Wuschek,” Measurements in the vicinity of fixed wireless transmitters”, Narda Safety Test Solutions GmbH, 2012.

[2] Federal Institute of Metrology METAS, Technical Report: Measurement Method for 5G NR Base Station up to 6 Ghz, 18 Febr 2020.

[3] R. Pawlak, P. Krawiec and J. Żurek, "On Measuring Electromagnetic Fields in 5G Technology," *IEEE Access*, vol. 7, pp. 29826-29835, 2019.

[4] K. A. Remley *et al*., "Measurement Challenges for 5G and Beyond: An Update from the National Institute of Standards and Technology," in *IEEE Microwave Magazine*, vol. 18, no. 5, pp. 41-56, July-Aug. 2017.

[5] Djuric, N., Kavecan, N., Radosavljevic, N., Djuric, S. (2021). The Wideband Approach of 5G EMF Monitoring. In: Zitouni, R., Phokeer, A., Chavula, J., Elmokashfi, A., Gueye, A., Benamar, N. (eds) Towards new e-Infrastructure and e-Services for Developing Countries. AFRICOMM 2020. Lecture Notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering, vol 361. Springer, Cham.

POSTER PRESENTATIONS

1. MATLAB ALGORITHMS FOR CHARACTERIZATION OF DETECTED FREQUENCIES AS STRATEGIES TO DETECT PATHOLOGICAL AGENTS OF TROPICAL DISEASES IN THE DIGITAL AMPRENT FROM THE BREATH TESTS

Alexandru TOPOR[1], Dumitru ULIERU[2], Cristian RAVARIU[3], Florin BABARADA[3]

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2. EVALUATION OF INDOOR EXPOSURE TO RADIOFREQUENCY ELECTROMAGNETIC RADIATION FROM RADIOCOMMUNICATION PUBLIC SERVICES BY OUTDOOR MONITORING IN URBAN ENVIRONMENT OF WARSZAWA

Jolanta KARPOWICZ[1], Krzysztof GRYZ[1], Szymon CYGAN[2], Alicja ŁYJAK[2], Piotr TULIK[2]

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[2]Warsaw University of Technology, Faculty of Mechatronics, Institute of Metrology and Biomedical Engineering, Warszawa, Poland

3. MEASUREMENTS AND NUMERICAL MODELLING OF ELECTROMAGNETIC HAZARDS RELATED TO THE USE OF SURGICAL DIATHERMY DEVICES

Jolanta KARPOWICZ, Patryk ZRADZIŃSKI, Krzysztof GRYZ

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4. ELECTROMAGNETIC COMPATIBILITY ISSUES IN NANOPORE BIOSENSING TECHNOLOGIES

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[3]Department of Biomedical Sciences, ”Ștefan cel Mare” University of Suceava, Suceava County, Romania

5. EFFECTIVE SCREEN BASED ON COPPER – MAGNETIC COMPOSITION OF FLUOROSILOXANE RUBBER

Lilia SAVA, Ana NISTIRIUC, Andrei CHIHAI, Pavel NISTIRIUC, Serghei ANDRONIC

Technical University of Moldova, Chisinau, Republic of Moldova

6. AN OVERVIEW OF THE "STUDY ON THE EVALUATION OF THE ELECTROMAGNETIC COMPATIBILITY DIRECTIVE 2014/30/EU (EMCD)"

Jana PINTEA

National Institute for Research and Development in Electrical Engineering ICPE-CA Bucharest, Romania

7. ON THE ELECTROMAGNETIC COMPATIBILITY OF A SHIELDED ROOM IN PRESENCE OF PENETRATING WALL POWER AND DATA/SIGNAL CABLES

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8. EMC AND TEMPEST - COMMON OBJECTIVES

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9. LOOP ANTENNA FOR PROXIMITY IMMUNITY TEST

Adrian CONSTANTINESCU, Alexandru STĂNESCU, Mihai DIMITRIU

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1. MATLAB ALGORITHMS FOR CHARACTERIZATION OF DETECTED FREQUENCIES AS STRATEGIES TO DETECT PATHOLOGICAL AGENTS OF TROPICAL DISEASES IN THE DIGITAL AMPRENT FROM THE BREATH TESTS

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Abstract

This work has the aim to demonstrate the feasibility of a non-invasive, safe and patient-friendly methodology for the accurate diagnosis of tropical diseases on the spot. The proposed approach is based on breath tests, which are easy to obtain and do not present discomfort or risk to patients' health. This study enrolls patients with three different types of tropical diseases (hydatidosis, leishmaniasis and dengue) from different geographical locations. Respiration sampling follows a standardized procedure. To maximize the success of our methodology, the medium infrared effect of various advanced and complementary chemical detection techniques is investigated: cascade laser spectroscopy with mice and different types of devices for chemical gas sensors. A prototype point of care is proposed based on the results obtained and is validated on the spot. The system is also applied to digitalized samples from real measurements from breathing samples from healthy patients and patients / diagnosed with tropical diseases, as part of the clinical experiment.

Keywords: respiratory biomarkers, power spectral density, nanomaterial-based devices.

References

[1] World Health Organization, "The 17 neglected tropical diseases", http://www.who.int/neglected_diseases/diseases/en/ (2014).

[2] World Health Organization, "Echinococcosis", http://www.who.int/echinococcosis/en/ (2014).

[3] K. Aoun, A. Bouratbine, "Epidemiological data concerning hydatidosis in Tunisia", Médecine et Maladies Infectieuses, 37 (2007) S40-S42.

[4] G. Grosso, S. Gruttadauria, A. Biondi, S. Marventano, A. Mistretta, "Worldwide epidemiology of liver hydatidosis including the Mediterranean area", World journal of gastroenterology, 18 (2012) 1425.

2. EVALUATION OF INDOOR EXPOSURE TO RADIOFREQUENCY ELECTROMAGNETIC RADIATION FROM RADIOCOMMUNICATION PUBLIC SERVICES BY OUTDOOR MONITORING IN URBAN ENVIRONMENT OF WARSZAWA

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Abstract

The use of electromagnetic way of radiocommunication data transfer by various public services (such as radio-television broadcasting, mobile internet access and mobile phone networks) is the most intensive in the urban environment – where usually the highest density of antennas emitting electromagnetic radiation (EMR) and users of services are observed [1,2]. Fast developing of new radiocommunication systems (such as 4/5G mobile networks) continuously increasing the number (or density) of EMR antennas, rising the need to monitor parameters of exposure to EMR (to ensure undisturbed coexistence of radiocommunication networks and electronic devices and humans). In practice, significant percentage of measurement campaigns and available reports regarding the parameters of EMR in the environment accessible by public, are based on EMR measurements in the outdoor locations – when the majority of humans activities in urban environment is indoor located.

This ongoing study is experimentally searching relations between the relevant parameters of EMR in easily available outdoor locations (at ground level in public space of urban environment) and EMR inside various buildings accessible by public. The aim is to test hypothesis that monitoring or evaluation of EMR indoor exposure for various practical purposes may be possible without entering buildings (what was found to be especially important when sanitary restrictions related to COVID pandemic made nearly impossible monitoring of EMR indoor exposure).

The study is covering measurements and analysis of EMR exposure in Warszawa (capital city of Poland) – with respect to its frequency spectrum in order to determine dominating components of exposure which need to be evaluated because of indoor exposure, and variability over time of the level of EMR emitted by particular radiocommunication systems (using multi frequency-narrow-bands electric field data recorders – collecting characteristics of exposure to EMR split into the frequencies of: (1) typical urban mobile radiocommunication systems: LTE 800, GSM 900, DCS/LTE 1800, UMTS/LTE 2100, LTE 2600; (2) radio and television transmitters (FM, TV VHF and UHF); (3) local networks of communication between devices and access to the Internet (Wi-Fi 2.4 GHz and 5 GHz).

The preliminary results showed that in outdoor environment, as well in indoor one, EMR exposure in space accessible for public caused by the use of mobile radiocommunication networks may be considered to be caused by downlink signal transmission only (from the base station to the terminal – what is opposite to the situation of individual user of such systems, who may receive the majority of EMR exposure from the own terminal – such as smartphone or tablet with wireless access

to internet and voice communication). Local communication networks (Wi-Fi) were found to be EMR exposure sources which are usually negligible in the public environment (what may be not a case of individual user of such devices).

It has been found that the level of indoor EMR exposure near the city center is varying daily, even more than twice – it needs special attention in further work with our hypothesis. Interesting results were obtained from the analysis of outdoor/indoor ratio for EMF emitted by particular radiocommunication services (Figure 1). When total EMR exposure and exposure to EMR emitted by mobile networks were found lower inside buildings comparing to the outdoor EMR at ground level, the level of exposure to EMR emitted by RTV services were found higher in some cases (especially at upper floors). It may need attention when EMR exposure is evaluated in the vicinity of RTV broadcasting towers located sometimes in urban environment. In majority of locations, it is probably negligible effect because outdoor RTV EMR signal is already very weak.

The collection of exposure samples and analysis of outdoor/indoor ratio in various exposure situations and various components of exposure is ongoing.

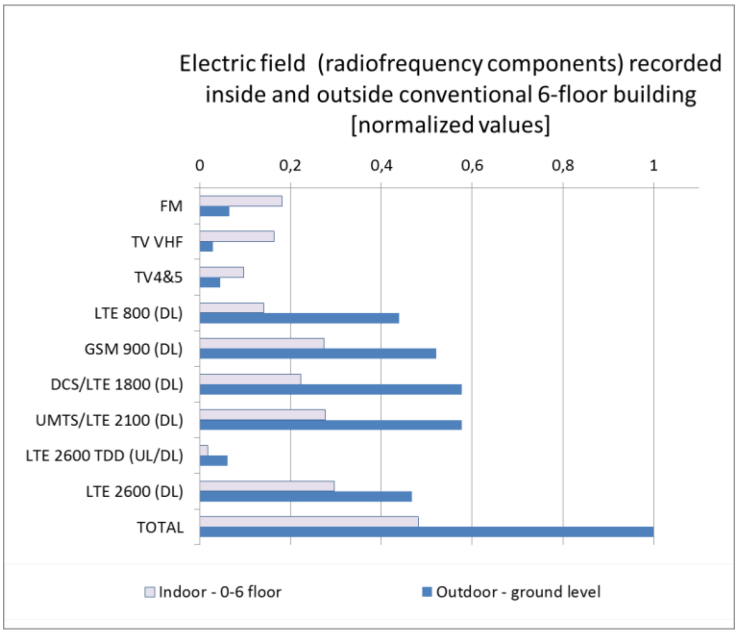

Fig. 1. The example of parameters of EMR exposure recorded in the vicinity of multi-floor building (Outdoor – ground level) and in rooms at various floors (Indoor – 0-6 floor): EMR components and total RMS value of E-field emitted by various radiocommunication networks, normalized to the wideband RMS value of E-field (TOTAL) recorded in the vicinity of building; analyzed data from 2-hours monitoring of EMR in various locations (by simultaneous 3-locations measurements).

Keywords: electromagnetic exposure, radiocommunication networks, exposure evaluation

References

[1] Gryz, K., Karpowicz, J., Zradziński, P. – Electromagnetic field emitted by radiocommunications systems – changes in Warsaw in the 21st century. Bezpieczeństwo Pracy, 2021, 7(598), 5-9 (in Polish).

[2] Gryz, K., Karpowicz, J., Zradziński, P. – Empirical assessment of the electromagnetic effects of the development of urban radiocommunication networks from the perspective of a clinical hospital (2014-2021). Inżynier i Fizyk Medyczny, 2021, 5(10), 363-367 (in Polish).

Acknowledgement - Funding: The National Programme “Improvement of safety and working conditions” (the scientific research and development funded by the National Center for Research and Development - project II.PB.16).

3. MEASUREMENTS AND NUMERICAL MODELLING OF ELECTROMAGNETIC HAZARDS RELATED TO THE USE OF SURGICAL DIATHERMY DEVICES

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Abstract

The transposition of binding European Directive 2013/35/EU into provisions of labour legal systems in European Union countries has raised attention to the electromagnetic safety in the work environment. The highest levels of exposure to magnetic field may be found in the vicinity of electro thermic industrial devices, but the highest levels of exposure to electric field is more probable near the medical devices, such as physiotherapeutic and surgical diathermias [1-3]. Thanks to the growing use of robots and other types of automatic industrial processes – the use of many sources of strong electromagnetic field (EMF) may be possible without significant influence of EMF on workers. The most difficult management of electromagnetic hazards is in general related to the use of devices which emit strong EMF and need to be manually operated. Indisputable example of such conditions is typically observed in case of the use of surgical diathermy units (SDU) for various kind of medical treatment.

Our studies aimed at characterization of EMF exposure experienced by treatment team using SDU devices (typically used in hospitals worldwide).

Our studies covers various complementary methods: (i) questionnaires-based investigations in hospitals in Poland to find typical electrical parameters and settings of SDU, and spatial configurations of the health care personnel activities during the use of SDU; (ii) laboratory and in-situ measurements to find the characteristics of wave forms and levels of EMF emitted by SDU during various treatment; (iii) advanced computer simulations to find SAR and induced electric field (E-ind) distribution in the workers exposed to EMF emitted during the use of SDU.

The results of our studies showed significant differences in the profiles of exposure of health care personnel involve in various treatments – the profile of exposure is determined in principle by the technical conditions difficult to be modified (i.e. patient's health, SDU equipment type available in the hospital and spatial organization of the treatment room), but also by more flexible organization of the work of the treatment team (including e.g. the number of personnel assisting simultaneously to the patient and the location of them and other nearby objects, such as lamps or tables, the location of cables connecting SDU electrodes with the generator, the way of grasping the handle of active electrode or cable, and even the electrical grounding of particular devices and objects in the treatment room).

The questionnaire-based studies showed various composition and organization of activities of multi-worker treatment teams usually exposed near SDU (up to 10 health care workers involved in the treatment in hospitals, when also one or two workers only - surgeon and nurse - in ambulatory treatment, may be considered, taking also into account that during complex treatment they may changed).

In the SDU manuals, the basic frequency of emitted EMF is usually reported in the 300-500 kHz range. But our EMF measurements [4] showed that frequencies of several MHz may be also emitted by some SDU in the cut mode of operation (which may be considered to be quasi-sinusoidal emission). Additionally, EMF is usually

deeply modulated, when is emitted by SDU in coagulation mode of operation (including at least several harmonics of significant level - from at least 0.3-3 MHz frequency band). Spatial distribution of unperturbed electric field: (i) the level exceeding 1000 V/m was measured at 10 cm distance from the cables connecting SDU electrodes and generator, (ii) the level evaluated in direct vicinity of cables (extrapolated) may be several times higher, (iii) at 100 cm distance from cables the level up to approximately 10 V/m was measured. Monitoring of the real duration of SDU activation during the treatment showed that only during the first minutes of treatment it may reach 50%, varying at the range of approximately 10-20% during later course of treatment [5].

Concluding our observations – such measurements may be challenging for the EMF measurement devices and protocol used to evaluate unperturbed EMF near SDU cables or other nearby objects: (i) the measurement frequency range of at least 0.3-10 MHz is needed, (ii) the dynamic range up to at least 1000 V/m is highly welcome and protection of device (or the protocol of its use) against damages by over load of sensors in the strong EMF, (iii) the fast sampling is welcome to minimize the reduction of sensitivity of device during measurements of highly modulated EMF.

Because of the near field exposure conditions, the evaluation of workers' exposure caused by SDU use needs also to be evaluated using parameters characterizing metrics of EMF impact on humans - the SAR coefficient and the strength of electric field induced in the body E-ind (because of the frequency of considered EMF) – usually with respect to the results of numerical modeling using spatially-relevant and anatomically-relevant models of exposure scenarios (where SDU, nearby objects, treatment team and patient are modeled). The computer simulations were performed for example with single block, homogeneous models of the human body (patient and 1-10 nearby workers from the treatment team) in the models of exposure scenarios. The results showed significant (up to at least 10-times) influence of the dielectric properties and electrical insulation of models on levels and spatial distribution of SAR (relevant to evaluate exposure caused by emission during the cut mode of SDU operation) and E-ind (relevant for exposure during the coagulation mode) in exposed models of humans, as well as of spatial distribution of surrounding EMF – what may be used in validation if the numerical model has relevant parameters.

Results of our numerical modeling showed significant differences in SAR and E-ind levels and distribution, when different number of workers were considered in multi-worker treatment team: (i) others than the SDU operator may be exposed comparable or even stronger to the operator (when staying next to the operator or on the opposite side of the patient), (ii) the surgeon's EMF exposure seems to be stronger when larger team is assisting to a patient [6].

Because of technical difficulties of discussed computer modeling required in evaluation of the EMF exposure of the surgical treatment team - (i) the complex spatial and electrical configuration of patient's and workers' bodies, and accessories used near SDU, (ii) the need to use of relevant dielectric properties of modeled objects and boundary conditions in the model of large space of treatment room, (iii) the need of experimental validation of analyzed numerical models - till now this problem in occupational electromagnetic safety is insufficiently analyzed to fully meet the requirements of labour law. More detailed simulation studies of the EMF exposure of surgical treatment teams are still ongoing using anatomically-relevant models of workers' body.

Keywords: electromagnetic exposure, Specific Absorption Rate (SAR), exposure evaluation, Directive 2013/35/EU

References

[1] Zradziński P, Karpowicz J, Gryz K, Leszko W - Evaluation of the safety of users of active implantable medical devices (AIMD) in the working environment in terms of exposure to electromagnetic fields – Practical approach to the requirements of European Directive 2013/35/EU. International Journal of Occupational Medicine and Environmental Health, 2018, 31(6), 795-808.

[2] Karpowicz J, Gryz K - An assessment of hazards caused by electromagnetic interaction on humans present near short-wave physiotherapeutic devices of various types, including hazards for users of electronic active implantable medical devices (AIMD), BioMed Research International, 2013, Article ID 150143, 8 pages, http://dx.doi.org /10.1155/2013/150143.

[3] Karpowicz J - Environmental and Safety Aspects of the use of EMF in Medical Environment, [in:] Electromagnetic Fields in Biology and Medicine, ed. M. Markov, CRC Press - Taylor & Francis Group; 2015, 341-362. http://dx.doi.org /10.1201/b18148-22.

[4] Karpowicz J., Zradziński P., Gryz K., *Surgical diathermy – primary source of health care workers' exposure to electromagnetic fields*. Inżynier i Fizyk Medyczny 3/2021 vol. 10: 253-260. (in Polish)

[5] Karpowicz J, Gryz K, Leszko W, Zradziński P - *Objectivized evaluation of surgeons exposure to radiofrequency electromagnetic fields – In the context of exposure duration and Polish and new international requirements regarding workers protection*, Medycyna Pracy, 2013, 64(4), 487–501, https://doi.org/10.13075/mp.5893.2013.0044. (in Polish)

[6] Karpowicz J., Zradziński P., Gryz K., *Electromagnetic aspects of the use of surgical diathermy - pilot model studies of workers' exposure*. Inżynier i Fizyk Medyczny 6/2020 vol. 9: 445-455. (in Polish)

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4. ELECTROMAGNETIC COMPATIBILITY ISSUES IN NANOPORE BIOSENSING TECHNOLOGIES

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Abstract

Studies at the molecular level are of particular importance for the rapid and accurate identification of different diseases and thus for the administration of specific treatments. From the identification of common molecules such as glucose, cholesterol, insulin to the analysis of pathogens involved in infections or cancer biomarkers, all nanopore analysis methods come with significant challenges in improving signal-to-noise ratio (SNR) and lowering the effective time resolution of the experiment. Various types of noise manifested in biological and solid-state nanopore biosensing technologies are discussed in this paper, along with their physical origins and potential mechanisms of noise mitigation.

From biological nanopores that are formed from various proteins (hemolysin, aerolysin, *Mycobacterium smegmatis* porin A, etc.) that self-assemble in pore form in lipid solutions, to synthetic nanopores that are artificially fabricated by various methods (controlled decomposition, electrochemical reactions, laser etching, controlled laser decomposition) and from different materials (SiN_x, SiO_2, graphene, etc.) nanopore techniques are in continuous development. The shape given to biological nanopores is consistent with the chemical bonds formed in the self-assembly process. The diameter of the most used nanopores varies from 1 nm to 4 nm depending on the protein used, but there are also nanopores with larger diameters. Due to interactions with analytes, biological nanopores have high selectivity. On the other hand, synthetic nanopores have a geometry that can be tuned by different fabrication methods and can be over 20 nm in diameter. Moreover, synthetic nanopores are resistant to working conditions (temperature, pH, ion concentration), having superior robustness. synthetic nanopores offer material robustness and large-scale integrity with chip electronics, they have the potential to overcome the limitations of their biological counterparts. Biological nanopores stand out for their precise reproducibility at the atomic level, but also for their surface adaptation and selectivity. In terms of synthetic nanopores, they are much easier to mass-produce and have higher durability than biological ones. In contrast, for synthetic nanopores selectivity is not a specific property, as point modifications on the nanopore surface are difficult to achieve. Last but not least, synthetic nanopores have higher background noise.

Because the ionic current in the nanopore experiment is often very small (pA), noise is a significant challenge that would severely limit the sensitivity and reliability of the nanopore sensor. Theoretically, biological and glass nanopores exhibit less noise than SiN_x or 2D nanopores. In fact, changing the pH increasing the electrolyte concentration reduces the noise spectrum. On the other hand, in nanopores, in addition to the measured current, there is always a leakage current, thermal

fluctuations of this leakage current contribute to the dielectric noise. Thus, understanding the translocation process of molecules through nanopores is essential for solving problems with the ultimate goal of developing precise methods of analysis using nanopores.

A potential solution to overcome the limitations of two classes of nanopore biosensing technologies is to integrate a biological nanopore into a solid sensing device, detection being achieved through the biological one to reduce spatial resolution. However, this requires a relatively large thickness of the solid-state membrane which increases the capacitive noise that generates a low signal-to-noise ratio. Various electromagnetic compatibility issues related to nanopore biosensing technologies will be discussed in details in the presentation.

Keywords: nanopore biosensing technologies, rapid diagnosis, noise, ionic current

References

[1] W. Shi, A. K. Friedman, and L. A. Baker, “Nanopore Sensing,” *Analytical Chemistry*, vol. 89, no. 1, pp. 157–188, Jan. 2017, doi: 10.1021/acs.analchem.6b04260.

[2] S. Liang et al., “Noise in nanopore sensors: Sources, models, reduction, and benchmarking,” *Nami Jishu yu Jingmi Gongcheng / Nanotechnology and Precision Engineering*, vol. 3, no. 1, pp. 9–17, Mar. 2020, doi: 10.1016/j.npe.2019.12.008.

[3] A. R. Hall, A. Scott, D. Rotem, K. K. Mehta, H. Bayley, and C. Dekker, “Hybrid pore formation by directed insertion of α-haemolysin into solid-state nanopores,” *Nature Nanotechnology*, vol. 5, no. 12, pp. 874–877, Dec. 2010, doi: 10.1038/nnano.2010.237.

[4] A. Fragasso, S. Schmid, and C. Dekker, „Comparing Current Noise in Biological and Solid-State Nanopores”, *ACS Nano*, vol. 14, pag. 1338 – 1349, 2020

[5] C. Wen, „Solid-State Nanopore for Sensing – From Theory to Applications”, *Digital Comprehensive Summaries of Uppsala Dissertations from the Faculty of Science and Technology* 1825. 107 pp. Uppsala: Acta Universitatis Upsaliensis. ISBN 978-91-513-0689-6.

5. EFFECTIVE SCREEN BASED ON COPPER – MAGNETIC COMPOSITION OF FLUOROSILOXANE RUBBER

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Abstract

Currently, the issues of creating effective screens for the laboratory of electromagnetic compatibility, protection of electronic equipment and people from external electromagnetic radiation in the entire frequency range are becoming more and more urgent. It is well known that according to the skin effect, the depth of penetration of the alternating current δ in the conductive materials is determined by the relation [1] :

$$\delta = 503\sqrt{\rho/\mu_r f},$$

where: ρ is the resistivity of the conductive material, in $\Omega \cdot m$;

μ_r – relative magnetic permeability of the material; f – frequency of the current, in Hertz.

We have developed and manufactured a composite screen based on fluorosiloxane rubber (35%) [2] with the addition of copper powder (26%) ($\rho = 0.0172 \cdot 10^{-6}\Omega \cdot m$; $\mu_r = 1$) [3] and Mu Metal powder (39%) ($\rho = 0.55 \cdot 10^{-6}\Omega \cdot m$; $\mu_r = 80000 - 100000$) [4], which at a thickness of 0.25 mm proved to be effective in the spectrum of frequencies from 50 Hz to 28 GHz. This composite screen is flexible and represents an analogue of textile fabric, which can be rolled up, and also has a wide operating temperature range (from -90 to + 250 ℃).

Keywords: Screen, fluorosiloxane rubber, copper, Mu Metal.

References

[1] Micu, Emil, Electrotechnics from A to Z. Bucharest, Scientific and Encyclopedic Publishing House, 1985.

[2] Composition based on fluorosiloxane rubber and the formation of products from it. Patent 2013194113, Japan, published 09.30.2013.

[3] Petrescu M. Treatise on the science and engineering of metallic materials. Vol. 3. Metale. Alloys. Special materials. Composite materials. Bucharest, Agir Publishing House, 2009.

[4] Akash Y. Ferromagnetic Material for Strong Magnetic Shielding. International Journal of Advancements in Technology, 2016, Volume 7, Issue 4, DOI: 10.4172/0976-4860.1000166.

6. AN OVERVIEW OF THE "STUDY ON THE EVALUATION OF THE ELECTROMAGNETIC COMPATIBILITY DIRECTIVE 2014/30/EU (EMCD)"

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Abstract

The final report in respect of the Study on the Evaluation of the Electromagnetic Compatibility Directive 2014/30/EU (EMCD) was one study led by the Centre for Strategy & Evaluation Services ("CSES"), supported by CSIL and Trilateral Research.

The study's main objective was to support an evaluation of the Electromagnetic Compatibility Directive (Directive 2014/30/EU) ("the EMCD") by the European Commission's DG GROW. The study has assessed five key evaluation criteria, namely the Directive's effectiveness, efficiency, relevance (including fitness for purpose), coherence and EU added value.

The study's time scope covered the 1989-2020 period, during which there have been three different Electromagnetic Compatibility Directive (EMCD): Council Directive 89/336/EEC, Directive 2004/108/EC and the current version of the Directive 2014/30/EU.

The current Directive was updated in 2014 as part of the alignment process with the New Legislative Framework (NLF), a horizontal piece of legislation, which includes common requirements in respect of placing goods (equipment) on the market, common arrangements for market surveillance and common accreditation rules to ensure the quality of the services of conformity assessment bodies.

As of July 16, 2021, the EMCD shall be applied in conjunction with the market surveillance provisions of new Regulation (EU) 2019/1020.

Keywords: Electromagnetic compatibility, interference, EU directive, standards

References

[1] Study on the evaluation of the electromagnetic compatibility directive 2014/30/EU (EMCD) Final report – Centre for Strategy &Evaluation Services- June 2021.

[2] Regulation (EU) 2018/1139 of the European Parliament and of the Council of 4 July 2018 on common rules in the field of civil aviation and establishing a European Union Aviation Safety Agency, and amending Regulations (EC) No 2111/2005, (EC) No 1008/2008, (EU) No 996/2010, (EU) No 376/2014 and Directives 2014/30/EU and 2014/53/EU of the European Parliament and of the Council, and repealing Regulations (EC) No 552/2004 and (EC) No 216/2008 of the European Parliament and of the Council and Council Regulation (EEC) No 3922/91 (OJ L 212, 22.8.2018, p. 1).

[3] Radio Equipment Directive 2014/53/EU.

7. ON THE ELECTROMAGNETIC COMPATIBILITY OF A SHIELDED ROOM IN PRESENCE OF PENETRATING WALL POWER AND DATA/SIGNAL CABLES

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Abstract

The influence of the penetrating accesses of power and data cables through the walls of a shielded room on the electromagnetic compatibility and the solutions to minimize it was analyzed in a research contract as a collaboration between Beia Consult International and ICPE-CA. The accesses of power and data cables through the walls of shielded room diminishes the shielding of the room and the interior of it is under influence of the conducted perturbations through the cables which generates the galvanic and radiative effects. The analysis of the subject was focused on the ways of coupling of these perturbations, shielding efficiency without and with the access cables, solutions for mitigation of galvanic and radiative couplings, tests and measurements in 100 kHz – 18 GHz frequency range.

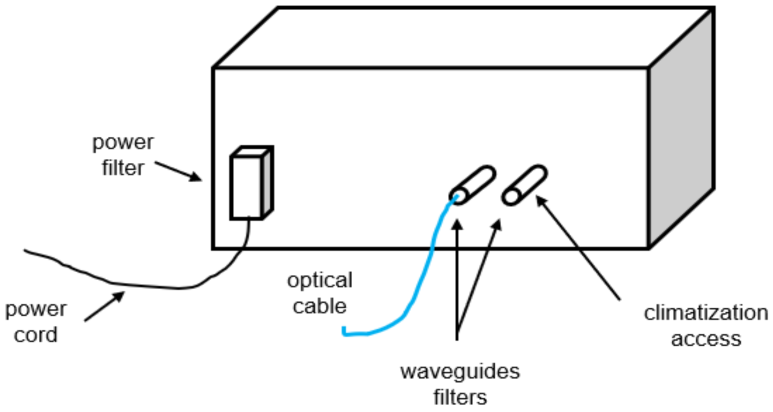

Fig. 1. An equipped accesses shielded room

In figure 1 is presented a drawing of a complete accesses equipped shielded room using solutions to enhance the shielding efficiency such as optical cable for data transmission, waveguides for walls penetrating and special power filter to minimize the conducted perturbations from mains. The measured shielding efficiency with the access cables is presented in figure 2 as two curves 0.1 – 1000 MHz and 1 – 18 GHz.

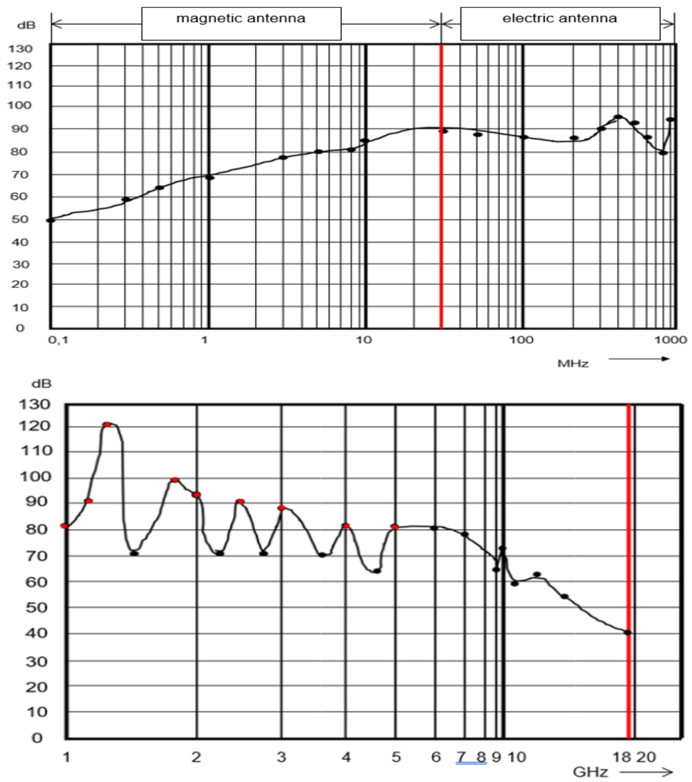

Fig. 2. Shielding efficiency graphics

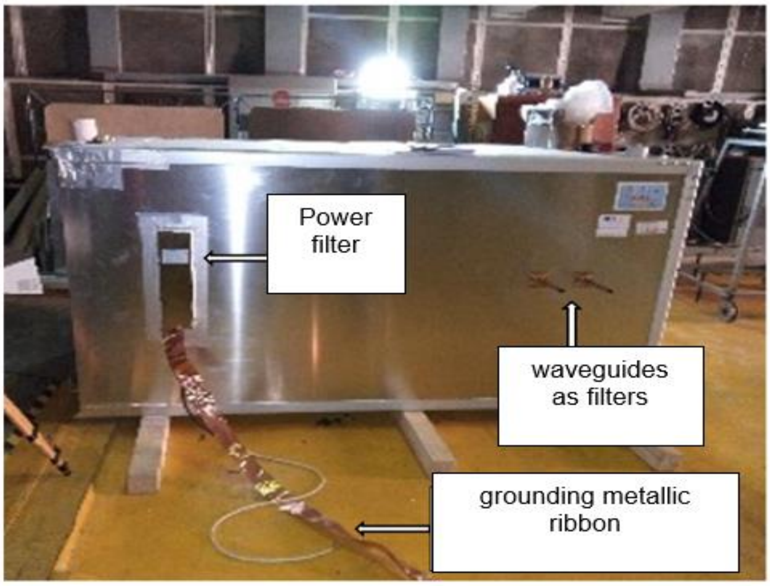

Fig.3. Shielded room photo on the measurements process

Keywords: electromagnetic compatibility, shielding, frequency, waveguides

References

1. Electromagnetic Comptatibility Engineering – Henry Ott – 2009.
2. Lectures waveguide – Nassiri A. – uspas.fnal.gov.
3. EN 5016.
4. EN 55022.

8. EMC AND TEMPEST - COMMON OBJECTIVES

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Abstract

As integrated circuits (IC) manufacturing technology has evolved, ICs have continued to grow in complexity and capacity. Integrated circuits can now process enormous amounts of information and by combining the capabilities of many integrated circuits, the electronic equipment and systems have been made which play important roles in medicine, finance, manufacturing and national defense. These roles must not be jeopardized either by disruption of the functions which they are intended to perform or by damage/corruption of the electrical signals that support their correct operation, damage/corruption that would be due to natural and/or man-made phenomena.

Unfortunately, these ICs tend to have increased sensitivities to electromagnetic disturbances. Consequently, there are many situations where electronic equipment/systems need to be electromagnetically protected from environmental disturbances and vice versa.

Classified information in the field of state security or related to the economy must be protected against unauthorized interception. Institutions/entities which process classified data/information must comply with TEMPEST requirements, requirements which are met by taking measures to protect against radiated and conducted emissions from the equipment/system which process the information.

EMC and TEMPEST are seen as two domains dealing with electromagnetic emissions, but each is pursuing something different. Thus, while EMC is concerned with both measuring the RF level of emissions generated by equipment and the response of equipment to external electromagnetic emissions, TEMPEST is concerned with compromising the information processed by equipment from electromagnetic emissions. Today without a thorough knowledge of EMC issues and the application of EMC principles in the manufacture of TEMPEST protected electronic equipment/systems, good results cannot be achieved.

The principles of shielding protection of electronic equipment/systems have been known for over 50 years. The need for integrated shielding in electronic equipment/systems means that designers and engineers need to familiarize themselves with the design, specification, construction and testing of electromagnetic shielding materials and electromagnetically sealed enclosures.

The design, construction and testing of shielded facilities/rooms, electronic equipment/systems has traditionally been left to specialists in electromagnetic interference (EMI), electromagnetic pulse (EMP) and TEMPEST. As the need for shielding has expanded to encompass all electromagnetic concerns and to protect much more diverse facilities than military installations and EMI test rooms, other engineering specialties have begun to address electromagnetic shielding. The results have been mixed, ranging from extreme over-design to installations that are said to be shielded, but whose materials and construction break many fundamental shielding principles.

Correct measurement of the shielding efficiency of a material used in electromagnetic shielding, correct choice/use of shielding materials thus to achieve the desired results in attenuation of electromagnetic fields, design and testing of filters on power supply lines and data lines, has made both EMC/EMI and TEMPEST

specialists have common goals in the design, shielding and realization of electromagnetically shielded electronic equipment/systems.

All these mentioned things cannot be achieved without taking into account proper grounding and its proper testing for high performance of design requirements and achievement of the assumed results.

BlueSpace Technology SRL, ORNISS accredited, is the only company in Romania which produces TEMPEST protected equipment.

Within the company it can be performed:

- production of TEMPEST protected equipment;
- production of TEMPEST passive filters for protection against information leakage on power supply lines;
- testing of TEMPEST protected equipment according to NATO/EU TEMPEST standards;
- testing of materials used in electromagnetic shielding of shielded equipment and facilities;
- testing the shielding effectiveness of shielded facilities;
- issuing electromagnetic shielding solutions for computing equipment and facilities.

9. LOOP ANTENNA FOR PROXIMITY IMMUNITY TEST

Adrian CONSTANTINESCU, Alexandru STĂNESCU, Mihai DIMITRIU
OICPE, Bucharest, Romania

Abstract

The technical / scientific poster presents a loop antenna based on a circuit with constant impedance at any frequency. The components used are for radiofrequency, the coil is a short-circuited transmission line and the capacitor is an open-end transmission line. The results of measurements are presented as automated records.

PUBLISHING

- The abstracts will be published in “Book of Abstracts”, indexed ISSN.
- The authors are responsible for language editing.

WORKSHOP VENUE

The Workshop will be held at „Ștefan cel Mare” University of Suceava, Suceava County, Romania.

Suceava - *City in Romania*

Suceava is the largest city and the seat of Suceava County, situated in the historical region of Bukovina, north-eastern Romania, and at the crossroads of Central and Eastern Europe.

Suceava is an excellent starting point for trips to the many historical, cultural and natural attractions travelers can enjoy in the Bucovina region. Suceava is also the gateway to visiting the Painted Monasteries of Bucovina.

The town has some noteworthy attractions of its own, including Saint George's Church, a UNESCO World Heritage site, the Bucovina Ethnographic Museum, with its valuable folk costumes collection and traditional items exhibits, and Suceava's main tourist site, the remains of the Princely Court.

Location of the Workshop – ”***Dimitrie Leonida” Conference Hall*** in building D of the ”Ștefan cel Mare University of Suceava

For accommodation:

Hotel Continental Suceava (3 stars), address: Mihai Viteazul Street no.4, Suceava – 720057, Romania

Hotel Continental Suceava - Phone number: 0040 372 304 904

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