MEĐUNARODNI ZNANSTVENO-STRUČNI SKUP
"ŽIVOT I DJELO NIKOLE TESLE"

KONCERTNA DVORANA "VATROSLAV LISINSKI"
i
KINO DVORANA MINISTARSTVA GOSPODARSTVA,
RADA I PODUZETNIŠTVA REPUBLIKE HRVATSKE

28 - 29. LIPANJ 2006.

Skup se održava pod pokroviteljstvom Hrvatskog sabora
i u suorganizaciji
Akademije tehničkih znanosti Hrvatske (HATZ) i
Ministarstva znanosti, obrazovanja i športa Republike Hrvatske

ZBORNIK SAŽETAKA
PROCEEDINGS

INTERNATIONAL SCIENTIFIC AND PROFESSIONAL MEETING
"THE LIFE AND WORK OF NIKOLA TESLA"

CONCERT HALL "VATROSLAV LISINSKI"
and
THE MOVIE HALL OF THE MINISTRY OF ECONOMY, LABOUR
AND ENTREPRENEURSHIP OF THE REPUBLIC OF CROATIA

JUNE 28 - 29, 2006

This Meeting is under Auspices of the Croatian Parliament
and in cooperation with
Croatian Academy of Engineering (HATZ) and
Ministry of Science, Education and Sports of the Republic of Croatia

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Poštovani,

Iznimna mi je čast i zadovoljstvo, pozdraviti vas u ime Ministarstva znanosti, obrazovanja i športa i u svoje osobno ime, na Međunarodnom znanstveno-stručnom skupu "Život i djelo Nikole Tesle".

S obzirom da se upravo ove godine navršava 150. godina od rođenja Nikole Tesle, Hrvatski sabor je na prijedlog Vlade RH 2006. godinu proglasio Godinom Nikole Tesle i na taj način odao priznanje našem znanstveniku svjetskog glasa. Niz plani-ranih aktivnosti i događanja, od stručnih i znanstvenih, preko kulturnih i onih gospodarskih, a povezanih sa onime što je stvarao i za što se zalagao Tesla, naše su skromno "hvala" velikanu Nikoli Tesli.

Kad govorimo o Nikoli Tesli, govorimo o znanstveniku ispred svog vremena, o vizionaru čijih stotine priznatih i mnoštvo još uvijek nepoznatih izuma, su tek dio ideja o kojima je razmišljao, a koje nije stigao ostvariti. Cijeli svoj život Nikola Tesla posvetio je istraživanjima koja bi olakšala život ljudi i unaprijedila ljudsku civilizaciju. Bio je izumitelj čiji su rezultati ostali epohalna ostavština čovječanstvu.

Danas je znanost u daleko povoljnijem položaju nego u doba Nikole Tesle. Ministarstvo kojem sam na čelu, svjesno značaja znanosti i znanstvenog rada, konkretnim mjerama i programima, nastoji osigurati što primjerenije uvjete za rad znanstvenika i istraživača. Za znanstvenu zajednicu važne pretpostavke za razvoj ovog sustava predstavljaju pokrenuti projekti povratka hrvatskih znanstvenika iz inozemstva i umrežavanje sa znanstvenom dijasporom, kao i poticanje izvrsnosti u suradnji s Nacionalnom zakladom za znanost, visoko školstvo i tehnologijski razvoj RH i Svjetskom bankom te stvaranje Hrvatskog znanstvenog portala kao sveobuhvatnog mrežnog poslužitelja. Naš je cilj osigurati znanstvenicima uvjete za rad u domovini, kao i mogućnost razmjene znanja i ideja s njihovim kolegama u inozemstvu. U ožujku 2006. godine osnovan je Hrvatski institut za tehnologiju - HIT, koji će imati ključnu ulogu u objedinjavanju znanstvenih, obrazovnih i tehnologijskih rezultata u RH, budućći da znanstvene ideje i projekti u potpunosti mogu biti ostvareni samo primjenom u praksi.

Međunarodni znanstveno-stručni skup "Život i djelo Nikole Tesle" te radovi vas, uglednih znanstvenika iz čitavoga svijeta, sabrani u ovom zborniku značajan su doprinos obilježavanju Godine Nikole Tesle. Želim vam stoga uspješan rad na skupu, ponajprije razmjenu znanstvenih i stručćnih ideja i mišljenja, čime ćete zasigurno dati doprinos daljnjem izučavanju djela Nikole Tesle.

S poštovanjem,

doc. dr. sc. Dragan Primorac,
ministar znanosti, obrazovanja i športa

Dear participants,

It is a great honor and pleasure to greet you on behalf of the Ministry of Science, Education and Sports as well as on my own at the International Scientific and Professional Meeting "The Life and Work of Nikola Tesla".

Because this year is the 150th anniversary of birth of Nikola Tesla, the Croatian Parliament, according to the proposal of the Croatian Government, proclaimed the year 2006 to be "The Year of Nikola Tesla", and gave great acknowledgement to our scientist with worldwide reputation. Planned activities and events, from professional to scientific, from cultural to economic, all related with Nikola Tesla's creations and work, are our humble expression of gratefulness to the great man Nikola Tesla was.

When we speak about Nikola Tesla, we speak about a scientist before his time, about a visionary whose hundreds of recognized and variety of still unrecognized inventions are only a part of the ideas he reflected upon, but had never been able to achieve. Nikola Tesla dedicated his life to the research which would facilitate the human living and improve the human civilization. He was an inventor whose results remained an epochal heritage to the entire mankind.

Today the science is in far more favorable position than it had been in Nikola Tesla's time. The Ministry that I govern, aware of the significance of the science and the scientific work, is trying to ensure as adequate conditions for work of scientists and researchers as can be, using concrete measures and programmes. For the scientific comunity, the important preconditions for the development of this system are the started projects of return of the Croatian scientists from abroad and their networking with the scientific diaspora as well as the encouraging of excellence in cooperation with the Scientific Foundation for Science, Higher Education and Technological Development of the Republic of Croatia and the Word Bank, together with creation of the Croatian Scientific Gateway as an all-encompassing network server. Our aim is to ensure the working conditions in Croatia for the scientists as well as the possibility of exchange of knowledge and ideas with their colleagues abroad. In March 2006 we founded the Croatian Technological Institute (HIT), which is about to have a key role in consolidation of the scientific, educational and technological results in the Republic of Croatia, having in mind that the scientific ideas and projects may be realized by practical application only.

The International Scientific and Professional Meeting "The Life and Work of Nikola Tesla" as well as the papers that you, as distinguished scientists from all over the word, have prepared, and which are collected in this Proceedings, are a significant contribution to celebration of the Year of Nikola Tesla. Therefore I wish you a successful work at the Meeting, and before all else, the exchange of the scientific and expert ideas and opinions by which you will certainly contribute to further studying of the work of Nikola Tesla.

Sincerely,

Dragan Primorac, M.D., Ph.D.
Minister of Science, Education and Sports of the Republic of Croatia

NIKOLA TESLA - ŽIVOT I DJELA

Današnji svijet teško je zamisliti bez Tesle i njegovih patenata. S Teslom se susrećemo u našem domu, na radnom mjestu, u našem društvenom životu ili trenucima odmora i opuštanja. Njegovi patenti toliko su integrirani u naš život da se to smatra civilizacijskim dostignućem i općim dobrom.

Promatrajući s tog kuta gledanja, Tesla je opća vrijednost i svatko može s jednakim pravom obilježavati njegov život i djelo. Naravno, to se i događa. U formalnom i neformalnom smislu, Tesla je čovjek koji je više nego bilo tko pridonio da se moderno gospodarstvo i moderan način života ostvaruju na ovoj razini tehnološkog razvoja.

Njegovo nadnacionalno djelo ili djelo za iskorak u razvoju civilizacije, nameće i potrebu određivanja našeg odnosa prema svima onima koji ga po bilo kojoj osnovi žele slaviti. Republika Hrvatska, na čijem je prostoru prije 150 godina u obitelji srpske nacionalnosti rođen Nikola Tesla, raduje se svakom doprinosu podsjećanja na njegovo djelo i podupire sve takve ideje i projekte koji građane širom svijeta podsjećaju na velikog izumitelja i vizionara.

Teslini patenti počeli su se vrlo brzo primjenjivati na području naše države. S primjenom patenata u hrvatske domove i tvrtke ušla je nova energija i kvaliteta života. S time se razvijala industrija, obrazovne institucije, a mnogima su njegovi patenti i njihova primjena postali životnom i profesionalnom preokupacijom.

Što znači obilježavanje 150 godina od rođenja Nikole Tesle za Akademiju tehničkih znanosti Hrvatske? Za instituciju koja je nastala u pretposljednjoj dekadi te obljetnice, iskustva "življenja" njegova djela i odnosa prema njemu znače sljedeće:

- nitko nema privilegij na talentiranost i Teslin primjer da se takav genij pojavljuje u maloj, siromašnoj i nerazvijenoj sredini, ukazuje da u dijelu svoje aktivnosti Akademija treba podupirati talentiranost i otvarati vrata novim „Teslama";
- trajno treba afirmirati univerzalne vrijednosti i doprinos civilizaciji, odbacujući bilo kakvu diskriminaciju, a prihvaćajući vrijednosno jednako svakoga tko želi s nama podijeliti radost za rezultate kao i doprinos svakog iznimnog pojedinca;
- Teslina ostavština kao i doprinos mnogih generacija inženjera treba biti trajni poticaj razvoju te struke i gospodarstva;
- njegovo stvaranje treba zaustaviti ograničen ljudski život, jer je Tesla ostavio nedovršenog posla za generacije koje dolaze i za sve nas.

U Teslinu životu i djelu Akademija tehničkih znanosti u Hrvatskoj može naći svoju ideju djelovanja u godinama koje dolaze. Afirmirati tehničke znanosti, poticati nadarenost, otvoriti se prema znanju i primjeni znanja i nastaviti izgrađivati suradnju u Europi i na svjetskoj razini.

Obilježavanjem 150 godina od rođenja Nikole Tesle želimo vratiti Nikolu Teslu u naš svakidašnji život na način kako to on i zaslužuje. Biti građaninom njegove domovine velika je obveza svakoga, a ujedno i veliki izazov da se svi mi kroz znanje snažno integriramo u globalom znanju i gospodarstvu.

Uvodnik
TEHNIČKE ZNANOSTI
GLASNIK AKADEMIJE TEHNIČKE ZNANOSTI HRVATSKE
Vol. 13 (1) 2006.

doc. dr. sc. Goran Granić
glavni tajnik HATZ

NIKOLA TESLA - THE LIFE AND WORK

It is hard to imagine the contemporary world without Tesla and his patents. We encounter Tesla in our home, at our working place, in our social life or in the moments of repose and relaxation. The degree of integration of his patents into our life is considered a civilizational achievement and a common good.

From this point of view, Tesla is a common value and everyone has the equal right to celebrate his life and work. Of course, this happens. In formal and informal sense, Tesla is a man who has, more than anyone else, contributed to the present technological level of realization of modern economy and modern way of life.

His supranational work, which is also a work for a step forward in the development of civilization, also brings forth an urge to determine our relation to all those that wish to celebrate Tesla on any basis. The Republic of Croatia, on the territory of which Nikola Tesla was born 150 years ago in a family of Serbian nationality, is rejoicing to every contribution that reminds us of his work, and is supporting all such ideas and projects that remind the citizens of the entire world to this great inventor and visionary.

The application of Tesla's patents started very soon in Croatia. With the application of these patents, new energy and quality of life entered the Croatian homes and companies. Likewise, the industry developed as well as educational institutions, while Tesla's patents and their application have become a life and professional preoccupation of many people.

What does the celebration of 150th anniversary of Nikola Tesla's birth mean for the Croatian Academy of Engineering? For an institution founded in the 14the decade of Tesla's anniversary, the experiences of „living" his work and relation to him means the following:

- No one is entitled to a privilege of talent, and thus Tesla's example of a genius born in such a small, poor and undeveloped environment, points that the Academy, as a part of its activity, should support the talent and open door to new „Teslas",
- The universal values and contribution to the civilization require permanent affirmation and discarding any type of discrimination, with valutatively equal acceptance of everyone who wishes to share with us the joy for the results as well as contribution of every excep0tional individual,
- Tesla's legacy as well as the contribution of many generations of engineers should become a permanent encouragement to the development of this profession and the economy,
- His opus should suspend the limitations of the human life, because Tesla has left much of his work unfinished, which is a challenge to the forthcoming generations as well as for all of us.

In Tesla's life and work the Croatian Academy of Engineering may find the idea inspiring its activities in the future years. It should affirm the engineering sciences, encourage the talents, open itself towards knowledge and its application and continue to build cooperation both in Europe and worldwide.

By celebration of the 150th anniversary of Nikola Tesla's birth, we wish to bring Tesla back into our everyday life in a way he deserves. To be a citizen of his homeland is a great obligation for everyone, but also a great challenge for all of us to integrate strongly through knowledge into the global knowledge and economy.

Assoc. Prof. Goran Granić, Ph. D.,
Secretary-General of the Croatian Academy of Engineering

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HEP HEP-HRVATSKA ELEKTROPRIVREDA, Inc.

KONČAR KONČAR - Group, Inc.

elektroprojekt ELEKTROPROJEKT, Inc.

Zahvalni smo svima koji su pomogli u organizaciji ovog Skupa posvećenog "Životu i djelu Nikole Tesle"

We express our gratitude to all those that have helped to organize this Meeting dedicated to the Life and Work of Nikola Tesla

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Melanija Strika, Prof.Soc., Buisiness Secretary

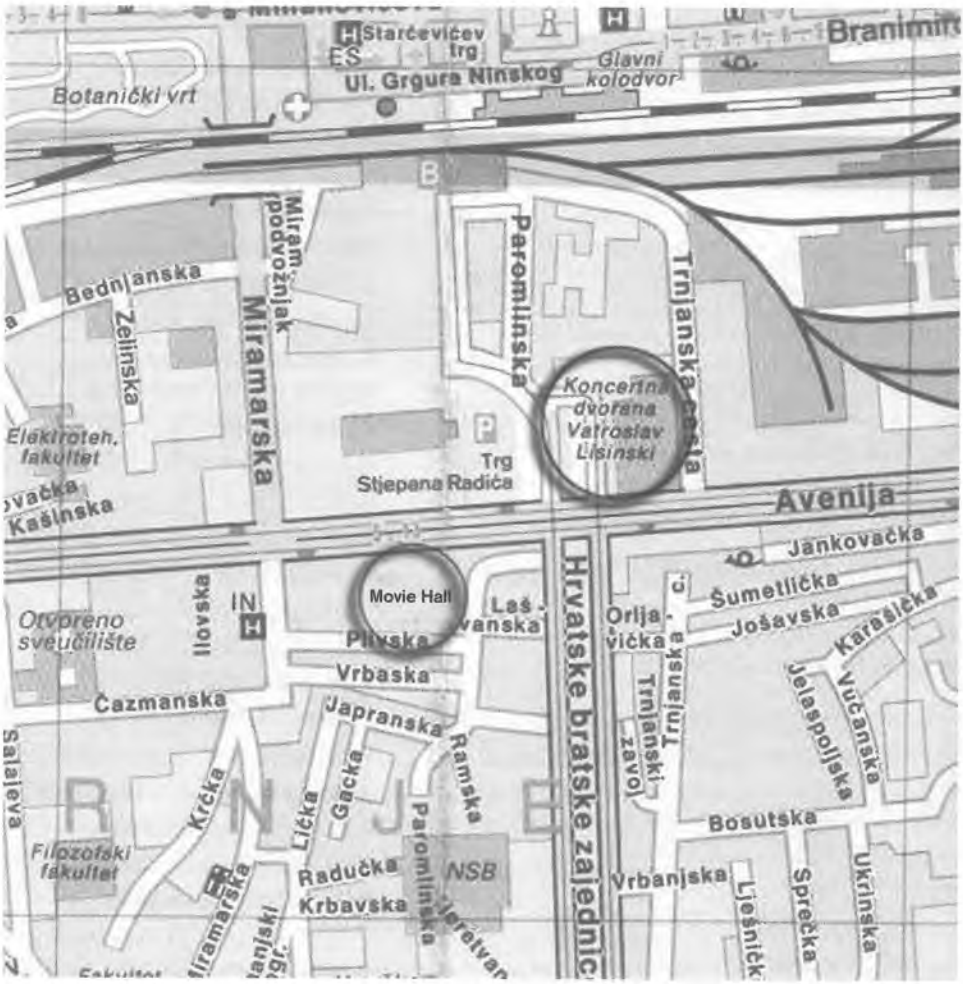
CROATIAN ACADEMY OF ENGINEERING
Kačićeva 28, P.O.Box 59, HR-10001 Zagreb

Location of the Meeting

The Meeting will be held at the Concert Hall "Vatroslav Lisinski",
Stjepan Radić Square 4, 10000 Zagreb, Croatia

and

Movie Hall of the Ministry of Economy, Labour and Entrepreneurship of the Republic of Croatia, Vukovar Street 78, 10000 Zagreb, Croatia (eastern entrance)



Program | Programme

27. lipnja 2006., utorak / *June 27, 2006, Tuesday*

14:00 - 19:00 Registracija - (Akademija tehničkih znanosti Hrvatske - HATZ, Kačićeva 28, Zagreb)
Registration - (Croatian Academy of Engineering - HATZ, 28 Kačić St.)

19:00 - 21:00 Koktel dobrodošlice - (Tehnički muzej, Savska cesta 18, Zagreb)
Welcome Party - (Technical Museum Zagreb, 18 Savska St.)

28. lipnja 2006., srijeda / *June 28, 2006, Wednesday*

(Koncertna dvorana "Vatroslav Lisinski", Trg Stjepana Radića 4, Zagreb)
(Concert Hall "Vatroslav Lisinski", 4 Stjepan Radić Sq., Zagreb)

08:00 - 09:00 Registracija / *Registration*

09:00 - 09:45 Svečano otvaranje Skupa / *Opening Ceremony*

09:45 - 10:30 Harold.K. Forsen, Ph.D.: **"Nikola Tesla: scientist, engineer, inventor"**
PL1 National Academy of Engineering, USA

10:30 - 10:45 Carl-Henric Svanberg: **"Tesla vision lives on in Ericsson**
PL2 President and CEO Ericsson, Sweden

10:45 - 11:15 Kurt R. Richter, Ph.D., Prof. Emer: **"Tesla's time and application of his achievements in the future"**
PL3 Technical University of Graz, Austria, Hon. Mem. of the HATZ

11:15 - 11:45 Aleksandar Marinčić, Ph.D.: **"Some recent recognition of pioneering role of Nikola Tesla in the development of Radio"**
PL4 Serbian Academy of Sciences and Arts, Republic of Serbia

11:45 - 12:00 Pauza za kavu / *Coffee break*

12:00 - 12:15 Stjepan Car, Ph.D.: **"Nikola Tesla and KONČAR Group"**
PL5 KONČAR - Electrical Engineering Institute, Inc.

12:15 - 12:30 Ivica Toljan, M.Sc.: **"European power systems interconnection"**
PL6 HEP, Inc. - CIGRÉ

12:30 - 12:45 **MOVIE produced by HEP, Inc.** "Development of the Electric Power System in Croatia"

12:45 - 13:45 PRIJAM / *RECEPTION*

VIZIJE I DJELO NIKOLE TESLE: DANAS I SUTRA
THE VISIONS AND WORK OF NIKOLA TESLA: TODAY AND TOMORROW

28. lipnja 2006., srijeda / *June 28, 2006, Wednesday*
(Ministarstvo gospodarstva, rada i poduzetništva RH, Ulica grada Vukovara 78, Zagreb)
(Ministry of Economy, Labour and Entrepreneurship of the Republic of Croatia, 78 Vukovar St., Zagreb)

PATENTI / *PATENTS*

Moderatori / *Moderators:* **S. Tonković (Croatia), J. Moser (Croatia)**

14:30 Milović, T., Sučić, T., Topić, Ž., Kuterovac, Lj.: **PATENTI NIKOLE TESLE / BIT PATENTNE ZAŠTITE NA PRIMJERU PATENATA NIKOLE TESLE**

L1 ***NIKOLA TESLA'S PATENTS - ESSENCE OF PATENT PROTECTION SHOWN IN THE EXAMPLE OF NIKOLA TESLA'S PATENTS***

15:00 Moser, J.: **TESLINI PATENTI IZ PODRUČJA ELEKTROENERGETIKE**

L2 ***TESLA'S PATENTS IN THE FIELD OF ELECTRIC POWER***

15:20 Sekso Telento, A.: **HRVATSKI POGLED NA SPOR TESLA - FERRARIS I ULOGU PATENATA U NJEMU**

L3 ***CROATIAN VIEW ON QUARREL TESLA - FERRARIS AND ROLE OF PATENTS IN IT***

15:40 Petković, T.: **TESLINI IZUMI U FIZICI I ELEKTOTEHNICI I NJEGOVE INŽENJERSKE INTUICIJE**

L4 ***TESLA'S INVENTIONS IN THE FIELDS OF PHYSICS AND ELECTROTECHNICS AND HIS ENGINEER INTUITIONS***

16:00 Valenta, A.: **TESLINA DJELA I DJELA O NJEMU U HRVATSKIM KNJIŽNICAMA PRETRAŽIVA PUTEM ONLINE KATALOGA**

L5 ***TESLA'S WORKS AND WORKS ABOUT TESLA IN CROATIAN LIBRARIES, SEARCHABLE VIA ONLINE CATALOGUE***

16:20 Rasprava / *Discussion*

16:30 **PAUZA UZ OSVJEŽENJE / *COFFEE BREAK***

ELEKTROSTROJARSTVO I ENERGETIKA / *ELECTRIC MACHINES AND DRIVES AND POWER SYSTEMS AND TRANSMISSION*

Moderatori / *Moderators:* **A. Sekso Telento (Croatia), S. Jeszenszky (Hungary)**

16:45 Jeszenszky, S.: **PRVI KORACI BLISTAVE ZNANSTVENE KARIJERE - TESLA U BUDIMPEŠTI**

L6 ***FIRST STEPS OF A GLORIOUS SCIENTIFIC CAREER - TESLA IN BUDAPEST***

17:00 Mrvoš, D., Mucko, D., Aviani, I.: **TERMOMAGNETSKI MOTOR**

L7 ***THERMO-MAGNETIC MOTOR***

17:15 Sekso Telento, A.: **BORBA STRUJA OD EDISONA I TESLE DO DANAS**

L8 ***THE "BATTLE OF CURRENTS" FROM EDISON AND TESLA TILL NOW***

17:30 Majstrović, M., Majstrović, G., Bajs, D., Sarajčev, P.: **NAPONSKE I STRUJNE PRILIKE NA ISKLJUČENOJ TROJKI DVOSISTEMSKOG DALEKOVODA**

L9 ***VOLTAGE AND CURRENT ANALYSIS OF PHASE DISCONNECTION OF DOUBLE CIRCUIT OVERHEAD LINE***

17:45 Kuzmanović, B., Ferković, L.: **TOPLJENJE I ZAGRIJAVANJE METALA U ELEKTROMAGNETSKOM POLJU**

L10 ***MELTING AND HEATING OF METALS IN ELECTROMAGNETIC FIELD***

18:00 Meyl, K.: **REPRODUKCIJA EFEKTA SKALARNOG VALA TESLINOG WARDENCLYFFE TORNJA**

L11 ***REPRODUCTION OF THE SCALAR WAVE EFFECTS OF TESLA'S WARDENCLYFFE TOWER***

18:15 Rasprava / *Discussion*

29. lipnja 2006., četvrtak / *June 29, 2006, Thursday*
(Ministarstvo gospodarstva, rada i poduzetništva RH, Ulica grada Vukovara 78, Zagreb)
(Ministry of Economy, Labour and Entrepreneurship of the Republic of Croatia, 78 Vukovar St., Zagreb)

KOMUNIKACIJE / *COMMUNICATIONS*

Moderatori / *Moderators:* **B. Zovko-Cihlar (Croatia), P. Podhradsky (Slovakia)**

09:00 Huljenić, D., Dešić, S.: **TESLA KROZ VIZIJU KOMUNIKACIJA**

L12 **NIKOLA TESLA FROM THE ASPECT OF COMMUNICATION**

09:15 Dešić, S., Huljenić, D., Vrlika, V.: **UPRAVLJANJE INOVACIJAMA - OSNOVA USPJEŠNOG RAZVOJA**

L13 **INNOVATION MANAGEMENT AS A BASE FOR SUCCESSFUL DEVELOPMENT**

09:30 Podhradsky, P.: **SMJERNICE RAZVOJA KONVERGENTNIH MREŽA I BUDUĆE GENERACIJE MREŽA**

L14 **EVOLUTION TRENDS OF THE CONVERGED NETWORKS AND NEXT GENERATION NETWORKS**

09:45 Poljak, D., Dorić, V., Blažević, Z.: **MODELIRANJE TESLINOG ODAŠILJAČA PRISTUPOM PREKO TEORIJE ANTENA**

L15 **MODELING OF TESLA'S TRANSMITTER USING THE ANTENNA THEORY APPROACH**

10:00 Miličić, P.: **OSNOVNI SUSTAV RADIOKOMUNIKACIJA - IZUM RADIJA**

L16 **THE FUNDAMENTAL SYSTEM OF RADIO COMMUNICATION - INVENTION OF RADIO**

10:15 Zovko Cihlar, B.: **OD TESLINIH IZUMA U PODRUČJU RADIOKOMUNIKACIJA DO DIGITALNOG RADIODIFUZNOG ODAŠILJANJA ZA MULTIMEDIJSKE USLUGE**

L17 **FROM TESLA'S INVENTIONS IN THE FIELD OF RADIOCOMMUNICATIONS TO DIGITAL BROADCASTING FOR MULTIMEDIA SERVICES**

10:30 Blažević, Z., Poljak, D., Cvetković, M.: **O MODELIRANJU TESLINIH ODAŠILJAČA PRIJENOSNOM LINIJOM**

L18 ***SOME NOTES ON TRANSMISSION LINE REPRESENTATIONS OF TESLA'S TRANSMITTERS***

10:45 Hadžialić, M., Hadžiahmetović, N., Ahić-Đokić, M.: **JEDAN ASPEKT MODELIRANJA RADIO KANALA POGODAN ZA ESTIMACIJU PARAMETARA FEDINGA**

L19 ***AN ASPECT OF RADIO CHANNEL MODELING SUITABLE FOR ESTIMATION OF FADING PARAMETERS***

11:00 Mustafić, A., Behlilović, N., Hadžialić, M., Vučinić A.: **PRIMJENA NAPREDNOG ENKRIPCIJSKOG STANDARDA U IMPLEMENTACIJI VIRTUELNIH PRIVATNIH MREŽA**

L20 ***APPLICATION OF ADVANCED ENCRYPTION STANDARD IN VIRTUAL PRIVATE NETWORKS IMPLEMENTATION***

11:15 Hadžialić, M., Behlilović, A., Sarajlić, A., Begović, P.:**UTJECAJ RAZLIČITIH MODELA SLABLJENJA NA VJEROVATNOĆU GREŠKE U KANALU POD UTJECAJEM SPOROG FADINGA I PROMJENJIVOG NAKAGAMI-M FADINGA**

L21 ***INFLUENCE OF PATH LOSS MODELS ON ERROR PROBABILITY IN GAMMA SHADOWED NAKAGAMI-M FADING CHANNEL***

11:30 Rasprava / *Discussion*

11:45 **PAUZA UZ OSVJEŽENJE / *COFFEE BREAK***

SLOBODNE TEME / *FREE TOPICS*

Moderatori / *Moderators:* **Z. Jakobović (Croatia), M. Martinis (Croatia)**

12:00 Jakobović, Z:: **TESLINE VF STRUJE U ELEKTROTERAPIJI**

L22 ***TESLA'S HF CURRENTS IN ELECTROTHERAPY***

12:15 Martinis, M.: **TESLA I MEDICINA**

L23 ***TESLA AND MEDICINE***

12:30 Musić, M., Ahić - Đokić, M., Mušić, O.: **MODULACIJA ULTRAZVUČNOG SIGNALA U VRTLOŽNOM TOKU FLUIDA**

L24 ***MODULATION OF ULTRASONIC SIGNAL IN VORTEX STREET OF FLUID***

12:45 Moser, J.: **TESLINI ZAPISI IZ COLORADO SPRINGSA**

L25 ***COLORADO SPRINGS NOTES OF NIKOLA TESLA***

13:00 Filipi, M.: **NIKOLA TESLA I DRUŠTVENO OKRUŽJE U KOJEM JE ŽIVIO**

L26 ***NIKOLA TESLA AND THE SOCIAL ENVIRONMENT IN WHICH HE LIVED***

13:15 Rasprava / *Discussion*

15:00 **Odlazak autobusima za Smiljan i posjet rodnoj kući Nikole Tesle (povratak u Zagreb oko 22:00)**

Departure for Smiljan by bus, visit to the birth house of Nikola Tesla (arrival to Zagreb around 22:00)

Plenarna predavanja

Plenary lectures

PL 1

Nikola Tesla: scientist, engineer, inventor

Harold K. Forsen, Foreign Secretary - Retired
National Academy of Engineering, USA

On this 150th anniversary of the birth of Nikola Tesla it is most appropriate that we honor him and in doing this we thank the Croatian Academy of Engineering and their President Zlatko Kniewald for planning and organizing this symposium.

Tesla was born of Serbian parents in the small town of Smiljan, Croatia. He was educated and worked for a while in Europe but this part of his story begins with his move to the United States in 1884 at the young age of 28. To put into perspective the early life of this brilliant contributor to our modern way of life, we should consider where the technical world stood at the time - in this case electricity.

The wide scale use of electricity has been considered the single most important engineering benefit to our society in the 20th century and Nikola Tesla's inventions can be argued as the fundamental technical achievement which made this possible. During the middle to late 19th century the world was just beginning to understand the field of electricity and its potential uses even though it was not clear exactly what electric currents were. Electronic carriers in metals, or electrons, had yet to be discovered but the drivers, electric potentials or volts, were understood. It was also known that electric currents in conductors produced magnetic fields. Magnetic fields in turn produced forces on these current carrying conductors and all electric motors work because of the interaction of magnetic forces. Similarly, generators rotated by power sources such as steam, produced currents, but the currents within the rotating coils alternated in a sinusoidal manner - reversing direction over a cycle or produced an alternating current (AC). This AC was converted to direct current (DC) through segmented commutators. These commutators have electrical connections to the rotating coils and current flows through them by brush contacts which are fixed within the generator or motor. Their use produced undesirable arcs and sparks. City and home lighting was carried out by gas lamps. These were being converted to electric arc lamps and eventually to incandescent lamps as electrical distribution was installed. Tesla had worked on all of these things while in Europe and had brilliantly devised a way to use directly the alternating current produced by generators to drive motors and thus eliminate the commutators. That is, he invented an AC motor and methods to better use this form of electricity.

While this may seem like a small breakthrough, it was really a very fundamental one because motors are what drive industry. Further, AC electricity has much greater flexibility than does DC. Electricity from a DC source has to be delivered to the user at the voltage specifically required for the equipment and this means that the losses during transmission can be very large - growing as the square of the current. The only way to overcome this is to use large

copper conductors or have the power source close to the user, both of which are expensive and impracticable. AC can use a transformer to increase the voltage at the source, reducing the current, then step the voltage back down at the user to deliver the same power. Thus transmission losses are reduced and the power can be carried many miles, not the one or two miles typical of a DC system.

Now to get back to our Nikola Tesla story. While Tesla was still in Europe he had worked for the European Edison company and after his arrival in New York, it was natural for him to seek out Thomas Edison to apply for a position in his company and Tesla was hired into the Edison Machine Works. The parent Edison company was rapidly expanding its operation in DC. They were building local generating stations, wiring the city and selling its now mass produced incandescent lamps. Edison's company was heavily financed by the great business tycoon, J. Pierpont Morgan, a person of immense wealth and power and one who would ultimately drive Tesla to despair.

During the course of his employment, Tesla would attempt to interest Edison in his AC system but could not. Edison, a fierce business competitor, was totally disinterested in anything that might slow up the expansion of his DC installations. Meanwhile Tesla undertook several assignments to improve and repair the company's hardware - motors, generators and electric distribution. In this effort he proved to be an extremely hard working and exceedingly bright employee. This attracted Edison's attention and allowed Tesla to gain his confidence but even this was insufficient to permit any real discussion of his inventions. However, Tesla continued the conceptual development of his ideas, both for DC and AC, and ultimately filed patents on several of them - including an improved arc light. While there may have been other reasons Edison would not discuss AC with Tesla, a strong one was that his competitors, Westinghouse and Thompson-Houston among others, were selling DC systems, but were also working on AC developments. Edison was under extreme financial pressure to fund his expansion of his systems and stay ahead of the competition.

Tesla understood early that while Edison was a great inventor, he was also mostly involved in developing the ideas made by himself and his people. His real talent was in implementing and commercializing their new technologies. Further, Edison had little formal education and was not skilled in the theoretical aspects of electricity so that discussions without drawings and hardware were not easy. Since Tesla carried essentially all of what he had developed in his head, there was little common ground in which to communicate. In frustration, including a difference over a possible unpaid bonus for improvements in Edison's direct current systems, Tesla left the Edison company in early 1885 after less than a year.

Because of his excellent work with Edison, Tesla was approached by a few investors to start a company to compete in this new era of electrification and the Tesla Electric Light & Manufacturing Co. was formed. After about a year of work, a complete DC arc lighting installation was made in a small town where one of his partners lived. Tesla had anticipated that the new company would support his AC system development but such was not the case. He ended up being removed from the company with no more to show for his efforts

than an engraved stock certificate of dubious value - more disappointment and frustration. To make ends meet in a period of desperation, he took on odd jobs and ironically worked as a ditch digger installing Edison's power lines.

Happily, within a year his luck began to change. Through his foreman to whom he had described his ideas, he was introduced to another group of people with financial connections and an interest in using AC power. In April of 1887, the Tesla Electric Company was established with a laboratory in New York. Tesla contributed all the rights to his patents but only owned four ninths, or less than half, of the company.

During the next months, Tesla developed images his encyclopedic mind had stored in detail into real hardware. Within a short period he constructed a two phase motor, making improvements over an earlier model he had put together while still in Europe. He took the motor to a colleague at Cornell for testing and in October 1887 he filed for patents covering the system. The records indicate that he previously had been granted seven patents. The new patents, which were quickly issued, included three for an electromagnetic motor, two covering electric transmission of power and two covering methods for the distribution of AC electricity.

Within the following year Tesla had developed and filed additional patents on single, two and three phase systems. These included the generators, motors, transformers using three and four wire, three phase and their associated controllers. In May 1888 he presented a paper to the American Institute of Electrical Engineers (AIEE) on only the motor elements of his research. It was a shocking revelation to many that by using multiple phases, the use of AC could be so versatile. Professor Elihu Thomson was in the audience and apparently challenged Tesla that his own work had preceded Tesla's but as Tesla pointed out, Thomson's motor still had commutators. Tesla's discoveries, and his patents, accelerated his launch to fame but not to fortune. Unfortunately, Tesla was never able to fully understand the difference between great ideas and the difficult process of getting them developed and to commercialization. As it turned out, Tesla was more interested in concepts and humanitarian deeds than profits.

As mentioned earlier, Westinghouse had been dabbling in AC and had been working with a single phase system (motor with commutator, transformer and transmission system) licensed from Lucien Gaulard and George Gibbs. They also had licensed a generator developed by Werner von Siemens of Germany. On the other hand, after hearing what Tesla was now doing with multiple phases, his work could not be overlooked. George Westinghouse met with Nikola Tesla and his associates and immediately tried to bring Tesla and his inventions into Westinghouse. An offer of cash for the patents and additional royalties of $2.50 per horsepower sold were acceptable to Tesla. He also agreed to join Westinghouse for a time in Pittsburgh to oversee the development of the system and, in particular, his motors.

Once again Tesla was to become discouraged. The Westinghouse engineers were stuck on a single phase AC frequency of 133 cycles per second (or Hertz - Hz) based on work they were doing with their Gaulard-Gibbs system, Siemen's generator and power plants they had

already sold. Tesla's system and motors had been designed for 60 cycles. Considerable friction arose in trying to solve the conflicting problems relating to costs, existing hardware and ability to manufacture. Here again, Tesla decided to leave Pittsburg and moved back to a new laboratory in New York

In the early years of major competition for the electrification of the country, many small companies failed and considerable consolidation took place. In the final analysis, only the General Electric Co, with J P Morgan's financial help, and the Westinghouse Electric Co. survived. General Electric was promoting and selling DC systems and Westinghouse was developing and selling both kinds of systems. Elihu Thomson, with his partner Edwin Houston, were to survive for some time, also marketing both systems. Thomson-Huston eventually would become part of General Electric. As a result of this polarization of approaches, the so called "war of the currents" began. Edison was fully convinced that AC was wrong and that it was dangerous and should not be used in homes. He went so far as to support the killing of stray animals by electrocution with AC to make his point.

The large amount of capital necessary for expansion of electric installations while the country was facing a depression, resulted in Westinghouse's financial backers demanded a reduction in the costly development still being invested in Tesla's system. As a result, the work was stopped. Further, they objected to the excessive royalties that would have to be paid to Tesla in the event his system was commercialized. George Westinghouse, trying to stand by his bargain but with control out of his hands, had to inform Tesla. Tesla was obviously discouraged but made an agreement that if Westinghouse would continue the development of his inventions, he would give up the royalty element of their agreement. This done, the work eventually resumed and multiphase 60 cycle motors, generators and the accompanying systems were developed. Tesla, as a result, saw his dream fulfilled, but he had given up literally millions of dollars of future royalties. Again, his humanitarian goals were his first priority.

Tesla continued working on new ideas in his laboratory. He could produce higher frequencies by adding poles to his generators and rotating them faster, but the limit seemed to be about 10,000 Hz. He had designed an oscillating system driven by steam or compressed air that could move a coil very rapidly through a magnetic field to produce high frequencies, but this too was limited because of the mechanical nature of the apparatus. Tesla clearly understood the earlier work of Michael Faraday with oscillators and the frequency limits of iron core transformers, so that he began to work with air core transformers. By using capacitors as drivers, with the self inductance of the transformer, he could generate resonant, very high frequencies and voltages in the transformer secondary. Repeatable discharges from these resonant transformers were estimated to be over 100,000 volts and 100,000 Hz. Because of the transformer effect, these very high voltages had correspondingly very low currents. Tesla also found that very high frequency currents traveled over the surface of the skin and thus caused no real harm to a person when holding on to a terminal of the discharge. As a result, his body could act as the carrier of this form of electricity and he was able

to create discharges in evacuated glass bulbs held in his hands. Similarly, isolated glass bulbs throughout the lab could be illuminated by the resulting fields. He could also detect a warming effect on his body with discharges of the appropriate frequency. Patents were filed on the apparatus and applications for these devices. Today this process is known as "Diathermy."

While Tesla would forever be proud of his Croatian birth and his Serbian parentage, in 1891 he became a citizen of the United States.

Tesla's new and exciting discoveries on AC systems resulted in his being asked to give lectures in 1892 at the Institute of Electrical Engineers and, subsequently, the Royal Society in London, and the Physical Society and International Society of Engineers in Paris. In his lectures Tesla described the broad series of inventions and developments he had made and the talks were well received by his audiences. In London, Tesla presented Lord Kelvin with one of his "Tesla Coils" - a useful and clever device which was to become famous for probably centuries to come. One interesting outcome of the London presentation was that Lord Rayleigh advised Tesla that, with his great talent, he should concentrate his research on one great idea. As we know, this would be impossible for Tesla.

On returning to his laboratory in New York, he refocused his efforts on resonances and produced multiple wavelength electromagnetic (EM) signals that he could pick up at various places around town. To do this he had to ground one side of his secondary transmitter to the piped-in water supply. This grounding issue was to become very important in the future as it became fundamental in wave polarization and propagation. Tesla's research into the ability of different frequencies, or wavelengths, to propagate along the earth's surface or in the air, set him far apart from other researchers of the time

Tesla's work on high frequency, resonance produced radiation should not to be confused with the tests of Heinrich Hertz. In 1888 Professor Hertz had sought to show that EM waves traveled at the speed of light and behaved like light waves in order to further establish the viability of the mathematical equations developed by James Maxwell. Hertz's apparatus was simply two oppositely charged condensers linearly connected through rods to a spark gap that discharged when the condenser voltages were sufficiently high. This produced a propagating wave that could be detected by a similar apparatus nearby. However, there was no real concept of controlling the frequency. The use of EM waves by Hertz was thought by him at the time to be of "no use whatsoever." However, Guglielmo Marconi, an Italian, on reading about the experiment, visited Hertz and his apparatus. Initially, using these ideas, Marconi was to go on and eventually develop the concept and hardware for wireless telegraphy.

The development and deployment of various AC power systems continued at a rapid pace. In Europe, systems were being implemented in the UK by Sebastian Ziani de Ferranti and by 1891 in Germany; power from a hydroelectric plant at Lauffen had been carried over a hundred miles away to Frankfurt via a 30,000 volt three phase system. This was designed and constructed by Swiss and German firms represented by inventors Charles

Brown and Michael von Dolivo-Dobrowlsky, respectively. Brown subsequently published articles acknowledging that the systems used in the Lauffen-Frankfurt project were indeed covered by patents issued to Tesla. Over time, Westinghouse would sue various patent infringers and in some cases would win, but heated arguments over creative priority would plague Tesla for the rest of his life and greatly confuse some of the written history. Only rarely would significant royalties for the commercial licensing of Tesla's patents be paid to Westinghouse, and even more rarely to Tesla.

In 1892 the US planned to celebrate the 400th anniversary of Christopher Columbus' discover of America. A major lighting exposition was planned for Chicago, the Columbian Exposition. Westinghouse won the contract to provide the power and lighting for the exhibition but George Westinghouse himself had to be convinced by his staff that the benefits that Tesla's system offered made it the one that should be used. General Electric, for competitive reasons, decided it would not issue a license to Westinghouse to produce Edison's incandescent lamps for use at the exhibit. Consequently Westinghouse had to manufacture hundreds of thousands of less efficient, "different" lamps.

The exhibit opened with much fanfare in 1893 with a most impressive display of lights. There were demonstrations by several electric companies from the US and Europe and many of these devices and systems could be tied back to inventions made by Tesla. Tesla was given his own space to demonstrate his various inventions including motors, generators, lighting tubes, a display of his rotating magnetic field and, of course, his high frequency, high voltage system. Using this, he permitted discharges from his body to illuminate lamps held in space - a most spectacular show. A large monument was erected at the site by Westinghouse which advertised that the "Tesla Polyphase System" was being used to produced the exhibitions power and distribute it.

At about this time the harnessing of the energy from the great water falls at Niagara, New York was being revisited and General Electric and Westinghouse were the main competitors for the installation - AC versus DC and Tesla versus Edison. Important personalities, such as Lord Kelvin took sides on these two options. Tesla as a boy had envisioned the harnessing of this great energy source and here it was about to happen. Westinghouse ultimately won the contract for the power plant which was to produce two phase AC electricity. General Electric, having licensed the Tesla patents from Westinghouse, was awarded the three phase AC conversion and transmission lines to carry power some 22 miles to Buffalo and eventually, New York City. The initial installation was over 11,000,000 watts and later expanded to more than three times this - all using the Tesla patented multiphase systems at 60 cycles. It is not known how much General Electric ultimately paid for their license and royalties for the multiphase Tesla system but Tesla never received a cent.

By this time General Electric had acquired the services of Charles Steinmetz through a corporate acquisition. Steinmetz was an outstanding mathematician and electrical engineer who would complement with theory, the empirical approaches of Edison. The General Electric Co. had by this time essentially switched over to Tesla's multiphase AC. Steinmetz

was to contribute significantly to the understanding of this part of Tesla's work and do significant original work of his own. However, he never acknowledges Tesla's seminal accomplishments in any of his writings.

In 1895 Tesla's New York laboratory was totally consumed by fire which started in the floors below his. Destroyed in the fire were his notes, records, most of the equipment that had been constructed or purchased over the past several years and what remained of the Tesla Electric Co. This was to be a terrible loss since the lab was uninsured and Tesla still owed Westinghouse for much of the equipment. Prior to the fire, Tesla had been working towards an EM signal transmission demonstration from his laboratory to a distant receiver, thus proving his technique of tuned wireless communications.

Complicating all of Tesla's money problems was the fact that the country had been in the throws of financial turmoil as investors demanded gold to back their paper money. Enter J P Morgan again, or at least one of his people, with offers of support for Tesla and his work. While no formal agreement appears to have been reached, some funds were furnished and another new laboratory was set up in New York. After about a year, Tesla was in operation again and he resumed transmission testing. At the time, the principal application was to replace the wired telegraphic data transmission with wireless telegraphy. That is, the making and breaking of the signal would produce the dots and dashes of Morse code. Tesla had been issued patents on the tuned wireless transmission process in 1897.

Through the course of his research during the past several years, Tesla had used his resonant air core transformer apparatus to explore many things. Among them was the use of evacuated glass bulbs that contained electrodes and, at times, various gases - similar to that of his friend Sir William Crooks. In this work he discovered that phosphorescent and fluorescent coated tubes produced brilliant light. He could also bend gas filled glass tubes which could be illuminated by excitation to write out names - neon signs. These things were all demonstrated at the Columbus Exposition. One interesting phenomenon that was not demonstrated there was that when using his so called metallic button lamps, where brush discharges occurred, the button would vaporize - depositing the metal on the glass tube walls. Ultimately he would discover that the radiation emitted from similar lamps produced an exposure on photographic paper and that this radiation would penetrate solids, including the human body - x-rays. Because of Tesla's unwillingness to publish or discuss the details of his work before he had fully developed the idea and/or the hardware, it is not clear when his "shadowgraphs" were first produced. However, Wilhelm Roentgen, in Germany, would make a similar discovery in 1895 and in 1901 receive the Nobel Prize for his contributions to the discovery of x-rays.

At the Electric Exposition of 1898 in New York, Tesla demonstrated a robotic boat controlled by multi-channel or frequency EM waves. The boat had multiple small motors or servos that produced its propulsion and steerage and would flash its lights in response to questions. It was remotely controlled by Tesla using a telegraph key. The US was involved with the Spanish-American war at the time and Tesla offered to support the development of a remotely

controlled torpedo but he was turned down. Throughout Tesla's life he was against war but continued to work on devices that could be used for defensive purposes. Remote control would become a major use of EM waves.

In 1899 Tesla was made an offer to move to Colorado where he was to receive free electricity to power his experiments. A facility was constructed with space for the installation of a very large oscillator/transformer and a 200 foot tall, adjustable length (tunable) antenna with a dome. Here he also understood the importance of a grounding system and took considerable pain to provide a suitable coupling to the ground. With his transmitter he could generate million volt lightening bolts, ones that would rattle the mountains with their noise. Tesla wanted to measure the electric potential and resonant frequency of the earth and find ways to couple to it with his system - perhaps deriving power. This may be where he began to feel that the energy of the earth could be made available for public use, free energy, and again exhibiting his humanitarian goals. One evening when he and his equipment were ready for a particularly strong test, the switches were thrown and extremely high voltage lightening bolts of several millions volts emanated from his domed tower, producing discharges over a hundred feet long. Before long this power demand destroyed the generator at the local power company and the town went dark - not the result he had hoped for.

Tesla returned to New York, again a bit discouraged and again, essentially out of funds but still hoping someday to return to Colorado to continue his work. On arriving in the city it was made known that Marconi was in town lecturing and seeking funding for his wireless development. The two met. It seems clear that Tesla did not think much of Marconi's untuned Hertz oscillator for producing EM waves. Since only very crude tuning was possible, by varying the length of the rods between the capacitor energy sources. and Tesla saw this as impractical for private communications.

Meanwhile a publisher friend of Tesla's had encouraged him to write an article on some of his wireless research. Tesla worked long on this but ended up writing a very different summary of some of his work and his ideas for the future. The article was published in the "Century" magazine and titled "The Problem of Increasing Human Energy." Some of the sections describe his theory and accomplishments in wireless, together with pictures of the Colorado apparatus, but most of his topics were much more philosophical, conjectural and metaphysical. The controversial article attracted the attention of many - one of whom was J. P. Morgan who saw some commercial opportunities in it. A number of other readers critically challenged the article, undermining Tesla's credibility and fundamental reasoning - similar to what had occurred earlier in the development of multiphase AC. Many published responses were slanderous, unprofessional and personal attacks on Tesla and these were widely distributed by the media. Unfortunately this became part of the story of his life and contributed to his lack of recognition by many contemporary scientists and consequently on recorded history.

In subsequent meetings with Morgan, Tesla sought funding for a transmitter that could carry wireless messages across the Atlantic, claiming his system far superior to Marconi's. Morgan, ever the business man, had extensive holdings in railroads, banks, iron and

steel, and General Electric and could see wireless business communications as a future opportunity. On the other hand Morgan knew of Tesla's controversies, his dealings with Westinghouse and otherwise his inability to commercialize his inventions. Finally in early 1901 they agreed to proceed with $150,000 from Morgan and a 51/49 stock split for the new company - the ownership ratio was suggested by Tesla. However, Morgan apparently wanted to be a silent partner which would bring no external support or business credibility to Tesla. The initial facility was to include a 95 foot tall transatlantic transmitter at a site chosen by Tesla. However, in the final agreement submitted by Morgan, and reluctantly signed by Tesla, Morgan would also control all of Tesla's lighting patents.

A site was chosen in Long Island, New York named Wardenclyffe but as the design proceeded, the stock market crashed - partially as a result of Morgan and his railroad competitors. This resulted in prices going up, and so did the cost of Tesla's laboratory and its transmitting antenna. On approaching Morgan for additional funds, and trying to sell him on an even larger antenna, Morgan essentially threw Tesla out of his office, claiming he had not completed the original antenna or commercialized the lighting opportunities. This approach and attitude was to continue throughout Tesla's interface with Morgan. He had many turndowns and received no additional funds. Tesla had apparently told Morgan of his idea to use the transmitter to propagate free energy from the earth. Such an idea would be totally contrary to Morgan's thinking as a businessman. In any event, the laboratories were built and work on the antenna begun - a cone shaped structure now rising to over 150 feet with copper sheeting to be added around its spherical top. Tesla was careful to include a deep complex tunnel for the grounding side of his system and it would become evident that he had anticipated using the facility for more than just wireless communication across the Atlantic. As might be expected, the cost of the facility, equipment and staff became more than was affordable even with Tesla contributing some of his own modest financial resources. While some work continued for a year or so at Wardenclyffe, the facility was eventually closed and sold for scrap by a creditor. Tesla had moved earlier to a small office back in New York. In March of 1913, J P Morgan would die but in spite of Tesla's frustration with him, Tesla would maintain over the years that Morgan was a great man.

During all this, Marconi was developing a system, on which he had filed a patent in 1900, to explore wireless telegraphic communications - not telephonic. In 1901 he built stations in the northwestern US and in England to demonstrate its long range capability. Unfortunately, both stations were destroyed in storms before they could be used. However, within a short time he sent up a weather balloon in Newfoundland, Canada, using a dangling wire for an antenna and was able to receive a Morse coded "s" on December 13, 1901 from a transmitter in England some 2100 miles away. The resulting publicity insured Marconi as the wireless creator as recorded in much of history. Guglielmo Marconi would receive the Nobel Prize in 1909 for his contributions to wireless telegraphy. Tesla would sue for patent infringement but his resources to carry this through were minor compared to Marconi's company and he dropped the action.

All was not over, however, as others doubted the authenticity of the Marconi reporting. Many still clung to the idea that all EM waves traveled in a straight line and the earth's curvature would prevent such long distance transmission - certainly Thomas Edison believed this. About the same time, Steinmetz had become president of the AIEE and at an annual dinner, without Tesla but with many of Tesla's adversaries in attendance, they had a fine time congratulating Marconi and degrading Tesla. As indicated earlier, frequently such discussions were to be the norm among many engineers, scientists and historians throughout the first half of the 20th century. A few, less biased writers would attempt to get the record corrected concerning the invention of wireless telegraphy but it would not be easy. Finally a decision by the US Supreme Court in 1943, after Tesla had passed away, would overturn the Marconi U.S. patents as being preempted by the earlier Tesla patents. This part of the legal record was finally set straight if, only in the U.S.

There is much more that could be added to this story but let me conclude here on a positive note. Nikola Tesla was creative throughout his lifetime - having being issued hundreds of patents. Like many truly gifted persons, he had his own quirks and idiosyncrasies but he was a proud gentleman and was loved by his colleagues and friends who truly knew him. Through much discouragement, he was strong, resourceful and able to come back with great ideas through great persistence. He lived in the U.S. to the age of 87 before he died in 1943, still living in New York.

His contributions to our society and our profession are truly great and without his developments and inventions, we would not have realized for many years the comforts we enjoy today. For this, he would be pleased. Gifts to society in a humanitarian and intellectual sense were more important to him than the financial benefits he was unable to enjoy himself -- but certainly were enjoyed by many others. He has been honored in many ways: by awards during his lifetime, medals, honorary degrees, published articles, academy membership, stamps and monetary notes in his name; by his name being used as the international unit of magnetic flux density, the Tesla; by his statues in many major universities and other important places, with new ones added as recently as this year; by the several dedicated museums displaying his works; and, by the gratitude exhibited by his countrymen, his fellow scientists, engineers and inventors. We honor him with this symposium and hope the publication of the proceedings of this conference will help to continue to set the historical record straight - even 150 years later.

The material for this summary was taken from numerous resources found on the Internet and essentially two books: John J. O'Neill, who knew and interviewed Tesla, "Prodigal Genius: the Life of Nikola Tesla" 1944, and the very detailed and scholarly work by Marc J. Seifer, "Wizard: the Life and Times of Nikola Tesla" 1998. Dr. Seifer was also kind enough to review this paper and for this, I am most grateful.

PL 2

Tesla vision lives on in Ericsson

Carl-Henric Svanberg, President and CEO, Ericsson

From the time our first cry announces our arrival into the world, our need to communicate starts to grow. Interacting with our parents and friends, and sharing ideas, we develop our social skills; communication becomes a fundamental part of our lives. We soon want to communicate over longer distances and while on the move.

Mobile communication is now a part of the everyday lives of more than 2 billion people, and it will reach 3 billion during 2007. New ways to enjoy media are constantly emerging, with news, music, gaming, television and other experiences conveniently available any time and any place via fixed and mobile broadband.

Communication is also improving our professional lives, with greater working efficiency, smarter business processes and increased flexibility in blending private and professional life. These are all vital elements of our vision that motivates us as we lead the way into the all-communicating world of the future.

However, two-thirds of the world's population still do not benefit from communication services. Making communication available and affordable for everybody is an equally important dimension of our vision.

Putting appealing, easy-to-use communication services in the hands of billions of users is a great challenge. It requires not only innovation and technology leadership but also a deep understanding of consumer requirements, market conditions and the ability to undertake large-scale assignments. Only a few companies can make this work end-to-end, all the way from one person to another, regardless of which devices and networks they are using.

Ericsson thrives on such technical challenges, but being the prime driver also requires people working together to create new services, new solutions, new ways of communicating for the benefit of all people. At Ericsson we have all of this, and that's one reason why operators choose to partner with us more than with any other supplier. That's also why we can confidently say that we are uniquely positioned to be the prime driver in an all-communicating world.

However, we owe the communication possibilities of today to great visionaries and scientists of the past, because radio, the telegraph and the telephone are closely related. Nikola Tesla (1856-1943), one of the fathers of radio, paved the way for many of the technological developments of modern times.

From vision to technology leadership

Ericsson has a long history of innovation and in pioneering new technologies for more efficient and better quality communication. We invest around 16 percent of our sales into Research & Development each year and we look for positive, long-term contributions to the communities in which we work and the world in which we live.

Bringing faster, more reliable and more cost-efficient networks to the world is what we do best. When operators choose their equipment suppliers they are often selecting a partner for the next 10-15 years. It is important for us to be able to show that we have been in the business a long time.

In fact, we have never left a country or let down our customers. We have lived with them through troublesome times of war, revolution or natural disaster. In addition, our early involvement with, and substantial contributions toward, creating the world's leading technology standards enable us to be first-to-market with many of these solutions.

With nearly one-third of our employees working in R&D and one of the industry's largest mobile-system R&D programs, we are a technology leader.

We hold more than 20,000 patents worldwide and registered as many as 4000 new patents in the past year alone. We are a leading contributor to the standards for GSM and WCDMA technologies, as well as a significant holder of Intellectual Property Rights (IPRs) in many other technologies. While our ability to license IPRs to other vendors generates additional revenues for Ericsson, our deep commitment to developing technology based on open standards is key to our success.
In addition to both mobile and fixed networks, we also develop and license technology platforms, including the chip design and software that are inside many of the world's most advanced GPRS and WCDMA handsets.
With the latest developments such as "turbo 3G" or HSPA, next-generation networks and all-IP technologies, we are at the forefront of technology. But it is not enough to be the leading innovator. It is also important to understand what our customers, and their customers want, in order to succeed in this tough market.

Global vision, global presence
We are able to contribute to an all-communicating world and share the vision of the great thinkers, such as Nikola Tesla, thanks to our global presence in more than 140 countries, and with more local resources than any of our competitors.
Our operations are spread evenly across the globe, with a quarter of our revenue coming from each of our four regions. The founder of the company, Lars-Magnus Ericsson, was an insightful person who understood the importance of expanding abroad. Just five years after establishing the business in Stockholm in 1876, he had already started foreign activities.

Ericsson Nikola Tesla in Croatia
Ericsson Nikola Tesla is based in Zagreb and has Research & Development activities both in Zagreb and Split. Nikola Tesla, the predecessor of the present company, became one of the first Ericsson's licensing partners in 1953 and became an integral part of Ericsson in 1995. The Croatian company has contributed to Ericsson's technology leadership over the years. It was behind the idea of implementing SIP (session initiation protocol) into the AXE platform. The solution has been since implemented in the networks of about 10 leading global operators.
Ericsson Nikola Tesla has helped establish a national grid computing project in Croatia, concentrating on the goal of developing a large-scale, worldwide middleware system. It has also been cooperating with the EU DataGrid project conducted by the CERN research center in Geneva. Experts from Ericsson Nikola Tesla have globally acknowledged competence, expertise and creativity, supported by their enthusiasm and customer orientation.
The company incorporates the entrepreneurship of Lars-Magnus Ericsson and the innovative spirit of Nikola Tesla. Its name and actions remind the community of two great men who contributed to the foundations of the new communications era.

Conclusion
The spirit and visions of great thinkers such as Nikola Tesla, Guglielmo Marconi[1] and Lars-Magnus Ericsson live on within Ericsson. This powerful combination has brought value to us and benefit to our customers - and we are rightfully proud of that.

Notes: [1] Ericsson acquired Marconi's telecom business in January 2006.

PL 3

Tesla's time and application of his achievements in the future

Kurt R. Richter, LF IEEE

In 2006 we celebrate the 250th respectively the 150th anniversary of two outstanding personalities. On the 17th January 1756 Mozart was born and 100 years later, on the 10th July 1856 Tesla, two geniuses who were so different and yet very similar in their ingenuity. I believe it is no sacrilege to compare these two outstanding personalities even their achievements were totally different. Both were untiring in their creative power. It can be realized looking at the catalogue, called in German "Köchelverzeichnis", which contains more than 600 compositions of Mozart on the other hand more than 700 patents had been assigned for Tesla's inventions. Both had the ability to develop and design their ideas in their heads so completely that no corrections were necessary to be made at the later stage of realisation. At the moment there is an exhibition in the Albertina, the graphic collection in Vienna, showing Mozart's compositions in which you find almost no corrections on the handwritten sheets of music. It was the same with Tesla who said about himself, that he had developed all his inventions and experiments in his head ready for realization. Tesla once wrote "The images I saw were to me perfectly real and tangible".

Tesla was a marvellous inventor, an "Ingenieur" in the very meaning of the word ingenious and not an engineer the roots of which are the engine. In my presentation I will try to cover the time Tesla lived, studied and worked in Europe before he left for the United States of America in 1884 to work as an employee of Thomas Alva Edison.

Fig. 1 The k.k. Austro-Hungarian Monarchy (1914 and after World War I)

Nikola Tesla was born in Smiljan in the province of Lika, as one of 5 children. At this time this was part of the KK Austro-Hungarian Monarchy which was in those times one of the strong powers in Europe. The map in Fig. 1 shows Austria Hungary before and after World War I, when it fell apart into several states of various nationalities.

Tesla was born after the Crimean War and died during the most disastrous World War II.

No wonder he became a pacifist as so many others.

As a young boy he very soon became passionate about reading first in the library of his father who was a Serbian-Orthodox clergyman. However, after he had met Edison in USA Tesla believed he "... had studied a dozen languages, delved in literature and art, and had spent all my best years in libraries reading all sorts of stuff that fell in my hands". Later he became extremely self-disciplined and accurate. He learned to memorize whole books with poems which seems that he had trained his brain so much that he could imagine complicated structures and coherences.

Tesla's education started in primary schools of Smiljan and Gospic followed by 4 years at the middle school there. He finished middleschool in 1874 in Karlovac. Only after a critical Cholera disease his parents agreed that he might study physics, and so, in 1855, Tesla became a student at the "Kaiserlich-königliche Technische Hochschule in Graz" which is today the University of Technology in Graz. Only one year before Tesla registered the Polytechnic Institute, financed by the province of Styria, it was transferred to a Technical Hochschule which would be called nowadays a federal school. From 1878 on the "Kaiserlich-königliche Technische Hochschule in Graz" final examinations became "Staatprüfungen" (stately examinations). However, doctoral degrees could not be awarded before 1901.

But all this did not bother young Tesla. He left Graz without any degree after the Education Department of the *"K.K. Generalkommando in Agram* (Zagreb)", which administrated the Borderland, stopped the continuation of the stipend. The last recording in the registration reads: *"Wegen Nichtbezahlung der Unterrichtsgelder fuer das I. Semester 1877/78 gestrichen"*.

Tesla was an excellent student and in his annual report he had the best marks available even he had an interesting discussion with his professor in Experimental Physics. Prof. Poeschl was a well known professor of high reputation. In a lecture he demonstrated a Gramme machine which he had recently received when Tesla meant that a brushless motor would have much less spark generation and therefore less losses and noise. Poeschl answered that Tesla might be a very clever man, however, his ideas could never become reality because it would be equivalent to a *perpetuum mobile*.

Fig. 2 shows a photograph taken in those years either in Graz or Maribor.

Fig. 2 Nikola Tesla

Much later, Tesla received the Honorary Doctorate from the *Technische und Montanistische Hochschule Graz* in 1937. That of the University in Vienna he had received already in 1908. In the same year he was nominated for the Nobel Prize in Physics by the Viennese professor of Physics at the University of Vienna Felix Ehrenhaft (1879 - 1952).

Because of the lack of financial support Tesla left Graz without graduation and went for a short time to Maribor where he stayed from autumn of 1878 to March 1879. After almost one year in Gospic he went to Prague in 1880 following the request of his father to graduate

from a university. He never graduated from the university there either and some biographers mention that he could not even register at the university because he did not speak Czech
When he felt that his parents had to make too great sacrifices for him he decided to be no longer a burden for them. He accepted a position at a Hungarian telephone company in Budapest. There, in February 1882, as a 25 years old man he had the innovative idea of the principles of rotating fields. 37 years later Tesla himself described it that the idea had enlightened him like a flash. It happened during a walk in the City Park of Budapest when the age of alternating current machines began. In this moment his further fate determined him to become an "engineer" and inventor whose genius even today seems to be an inexhaustible source for science and technology. Nevertheless, again and again his name became forgotten, however, popping up brilliantly periodically. This Symposium and all the events in connection with his 150th birthday are perfect opportunities to let Tesla's name shine as brilliant as it deserves.
In the same year of this important walk, in Budapest by recommendation of a friend he was offered a position at Continental Edison in Paris. There he experimented with rotary current field motors and built first models whenever he had the opportunity. In Summer of 1983, in Strasbourg he was successfully building the first operable motor without sliding contacts (brushes) and without commutator.
Encouraged by the director of Continental Edison and American friends in Paris he left Europe in June 1884 and joined Edison Machine Works in the United States. In 1891, when Tesla was 35 years old, he received the Citizenship of the United States of America. Until then all his inventions and all patents granted to him are achievements of a European living and working in the United States of America. At this time he was still a citizen of the Austro-Hungarian monarchy, and in particular a citizen of the Kingdom of Hungary.
His inventions and discoveries were pioneering in many areas. But already during his life time his personality was disputed and he was involved in many quarrels as far as his patents were concerned which all seemed to have been solved in his favour.
Already during the turn of the last century in many textbooks his name did not exist. Nowadays his name is remembered only by the Tesla transformer to generate high voltages at high frequency and by the measuring unit of the magnetic field. Also many of his patents are so much forgotten that today sometimes patents are issued which can be seen near those of Tesla's. Maybe Tesla himself contributed unconsciously to the loss of his high reputation by his patents applications and publications of his later years. Mostly the clarity of engineering thinking seems to be missing or are his ideas not understood yet? I do not dare to answer this question. Who knows what will be in the future and how many thoughts will be thought which Nikola Tesla had already thought.
No doubt, his contributions changed the world and still are not out of date. They will help to keep on developing civilisation and the wellbeing of humanity.
What the application of his achievements in the future is concerned I would like to refer to what a famous physicist once said: *"Predictions are very difficult to be made, in particular when they deal with the future"*.

There are many open questions and open for speculations, like what Tesla meant by the *Death Rays*. Did he mean by it a corpuscular radiation? He was talking about these rays as a weapon, which will banish wars for ever? Unfortunately, however, in this case I believe he was absolutely wrong. Because with weapons wars are never avoided as soon as the other side possesses the same or equivalent weapons. I believe in Mahadma Ghandi's words: *"There is no way to peace, peace is the way"*.

Another example is the *Free Energy* of Tesla which would help to solve the energy problem of the world. Is it just an illusion or had he already heard about the dark energy in space which plays an important role in cosmology nowadays?

After all the scientific community continues to be interested and mankind still benefits and will also benefit in the future from the numerous contributions to modern technology of this genius - to the "Man who Invented the 20th Century" as an Austrian newspaper entitled an article in 1992.

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PL 4

Some recent recognition of pioneering role of Nikola Tesla in the development of radio

Aleksandar Marinčić, SASA, Belgrade, Serbia and Montenegro

Summary. *After completing fundamental work in the low frequency polyphase alternating current field, Nikola Tesla continued to work in the field of alternating currents, but of higher frequencies. He developed sophisticated mechanical alternators but after generating about 20 kHz currents, he turned his attention to condenser discharge through an induction coil. At that time it was known that discharging of a condenser through an inductance produces a pulse of damped sinusoidal current. Tesla invented several methods of a condenser quick spark extinction and soon he discovered "Tesla coil", spark discharge generator of almost continuous high frequency currents. Tesla coil is in fact a system of two tuned resonance circuits. In his research, Tesla investigated the uses of high frequency currents for efficient light production in various types of vacuum tubes. Later, he investigated uses in wireless energy transmission starting with one wire conductor and the use of resonant receiving devices. After returning from Europe in 1892, in the following year he presented the basic scheme of radio with monopole antennas at the transmitter and receiver sides, both tuned to the same frequency, which has been essential to the operation of a radio ever since. Tesla submitted basic radio patents in 1897, a year after Marconi submitted the patent in England based on the Hertz spark generator connected to an elevated body and ground as proposed by Tesla in 1893. Marconi's system patented in 1896 did not include tuning; he added it several years later based on Tesla's patent from 1897. In the early days of radio, many incorrectly considered Tesla's and Marconi's systems as different, although in essence they were electrically identical. As time passed, Tesla's interest in radio faded, especially after failing to complete his World Center in Long Island. Tesla's contribution to the invention of radio faded over time, to the extent that the European Broadcasting Union, in spite of many complaints, did not mention his name among the pioneers of radio celebrating the 100 years anniversary of radio in 1996. Over the past decade, a growing number of researchers have attempted to correct this omission and recognize Tesla's role in the development of radio.*

INTRODUCTION

Humanity must build its hopes for the future on waterpower and a perfect system of wireless transmission of energy to any distance so that man will be able to solve all the problems of material existence. Distance, which is the chief impediment to human progress, will be completely annihilated in thought, word and action. Humanity will be united, wars will be made impossible and peace will reign supreme."

Nikola Tesla

Nikola Tesla belongs to rare human beings who devoted all his long life to searching secrets of nature whose disclosure would help mankind to cope in everlasting fight with unmerciful powers of Nature. There were so many things that Tesla attempted to take into consideration: he succeeded in inventing polyphase alternating current system of generation, transmission

and utilization which we still use today, he succeeded in generation of high frequency currents and opened numerous field of their uses in radio, for light production, industry, medicine, etc. He also fulfilled his child's dream of making bladeless turbine and pumps. With his writing and speeches he intrigued mind of many people who knew something about his life and his finished and unfinished research into secrets of electricity.

Nikola Tesla was not great theoretician who developed new frontier of science, or to a great practitioner who invented many useful things for our lives. He belongs to pioneers who in their original way open and trace new fields of technology. He produced his own theories based on experimental observations about a number of electrical phenomena that helped him to develop his polyphase system, and later when he entered even more complicated new field of high frequency currents. From the very first steps into the a.c. field, he was concentrated on efficient transmission phenomena based on step-up and step-down transformers. Others developed low frequency single-phase a.c. transformers, but he had to invent polyphase, more complex, transformer. When entering the field of high frequency a.c. he was in a completely new field. In these cases the iron core was disadvantage and he disposed of the iron and produced air-core transformer, known since as the Tesla coil. This was the key element in all his high frequency devices that led him to develop the basis of modern radio.

HIGH FREQUENCY ALTERNATORS

Nikola Tesla had begun work on high frequency alternators in 1888 in his laboratory at 89 Liberty Street. He had just completed his system of power transmission except several problems that had to be solved. One was to run his induction motors at very high speed; another one was to adapt them to the existing 133 Hz alternating currents used in Westinghouse's electric lighting system. In dealing with these problems, Tesla constructed quite a number of laminated structures with a great many poles which gave over ten cycles per revolution. By running such alternators at high speed he obtained alternating currents of 2000 Hz! Then he had to go for a year to Pittsburgh to attend the manufacture of the motors and upon return to New York he resumed work in new laboratory at 175 Grand Street.

In the transcript for pre-hearing interview with Nikola Tesla and his legal counsel in 1916 Tesla among other things said [1]:

"I had at that time already perceived enough to get the idea that energy could be transmitted without wires. It was of no consequence to me at that time whether it was to be used for telegraphy, or telephony, or power transmission. It was on the problem of transmitting energy without wires; and as it is my custom always to analyze scientifically every problem that I undertook to solve, I devoted a great deal of thought to how to attack the problem, and the following crystallized out.

It was evident to me that wireless transmission of energy, if it could ever be accomplished, is not an invention; it is an art...that requires a great many inventions in combination.

We are living on a planet that is rushing through space; this planet is partly conducting and party insulating. If it were all conducting, or if it were all insulating, we could not transmit

energy without wire. It is only because it is partly conducting and partly insulating that a glorious future for man is reserved through the application of this art."

To explain his opinion about wireless transmission Tesla stated that five steps to be taken are:

- Production of electric oscillations of the required character;
- Transformation of these oscillations into such form of energy as could go to a distance;
- Developing methods and apparatus for reception;
- Isolation the energy - not let it go in all directions;
- Discover the laws according to which this energy flows through the planet.

The first step towards the evolution of a generator, which he considered, that may be used "to flash energy to a distance under practical and economical conditions" was described in his U.S. patent 447,920, of March 10, 1891. This high frequency alternator Tesla used in his lectures and it could produce between ten to twenty kHz "perfectly sinusoidal" alternating current. He used it in various experiments with resonant circuits and was satisfied with its operation, but it was destroyed later in the fire that annihilated his laboratory in the spring of 1895. This machine was used in experiments with wireless telephony, telegraphy and many other experiments until it was destroyed.

TRANSMISSION THROUGH SINGLE WIRE OR NO WIRE

In his Columbia College lecture in 1891 Tesla demonstrated single wire and no wire illumination of vacuum bulbs [2]. Fig.1 shows how energy goes through space without wire. In describing this experiment Tesla said: "That was an experiment which carried the whole world by storm; but to me it was the first evidence that I was conveying energy to a distance, and it was a tremendous spur to my imagination and to my energy to develop what I had stated."

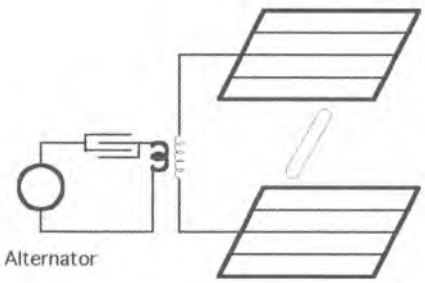

Fig.1. Experiment with wireless light

In Grand Street laboratory Tesla used direct connection of his high frequency alternator and two plates forming a condenser (Diag.1 in Fig.2).

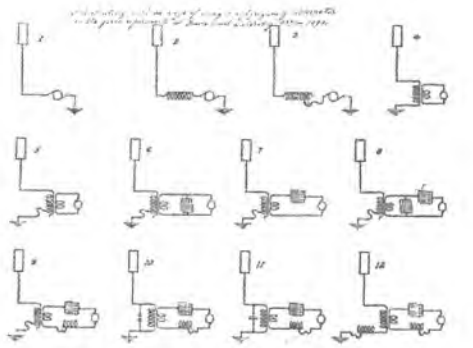

Fig.2. Illustrating various ways of using a high frequency alternator in the first experiments at the Grand Street Laboratory: 1891-1892.

Prior to going to England to lecture before the Institution of Electrical Engineers and the Royal Institution [3], Tesla made experiments with wireless transmission of signal by connecting at the roof "sorts of devices to constitute capacity" by wire to one terminal of the alternator and the other terminal to the water pipe. His idea at that time was that he could disturb the electrical equilibrium in the nearby portion of the earth and that some instrument could detect it. Since that time the term "antenna" was used to describe the elevated terminal with capacitive plate. By adding a series inductance (Diag.2 in Fig.2) he increased current in the antenna, making generator - loading circuit closer to resonance. Diag.4 in Fig:2 is further improvements that increased voltage fed to the antenna circuit, and with secondary coil tuning (Diag.5 in Fig.2) still better results were obtained. The best results were obtained with Diag.12 in Fig.11 where tuning was done in the primary and secondary circuits.

In his laboratory on Grand Street Tesla employed several skilled technician and performed many experiments with his transmission apparatus. Explaining his work at this time he said: "At the time I made this experiments, there were very few of the electrician, that since made a success with wireless in some way or another, who would have known much about these things anyway. They had seen me to run the wire up the building,

they had seen me operate continuously with these machines. I had shown them wonderful results, and had told them all the time that I was going to transmit energy without wire - telephone, telegraph, run cars and lights at any distance - and that these were the primary steps towards this end. How much these men could tell, in the light of present knowledge, that, of course, I am unable to say; but, certainly, I had plenty of witnesses to follow my work, and to know what I had been doing."

As in his transmission experiments Tesla, in fact, used devices to detect presence of high frequency carrier. He "would run one of the machines, tune a circuit, then go around the city and get the hum of the alternator in my tuned receiving circuit, and from this note and the intensity of the sound I could judge the quality of the devices that I was using...I operated mostly between the laboratory on South Fifth Avenue and the Hotel Gerlach on 27th Street, near Sixth Avenue, where I was stopping." Listening "hum" he tried to avoid problem of detecting carrier when it was out of the hearing range by generating, at the receiving station, oscillation of a certain frequency, and then combine them with an incoming oscillation to obtain beat. He did not succeed in persuading U.S. Navy to fund the idea and further develop this principle, as everybody was ridiculing his efforts: "Everybody said it is impracticable, and after my patent expired only a few months ago, Congress appropriated this sum [$750,000] and I have no the pleasure of simply looking on when others are using my inventions, which I could not persuade people to adopt. This is usually so" [1]. Needles to say that this was the basic principle of later invented homodyne receiver.

Tesla also constructed, patented and used another machine that had "a disk-shaped armature that anticipated later General Electric design and reached a frequency of 15 kHz, the highest frequency attained by any alternator before 1900" [4].

In the Columbia College lecture Tesla described a new method of producing light with a single electrode bulb and novel apparatus for producing high frequency and high voltage (see Fig.3), to be known later as "the Tesla coil" [5]. In a book [6] , W.H.Eccles remarked about this coil that "it was invented not for wireless but for making vacuum lamps glow without external electrodes, and it later played a principal part in other hands in the operation of big spark station".

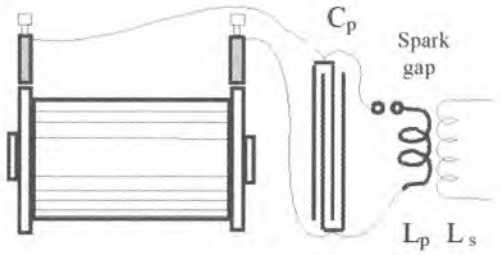

Fig.3. First drawing of Tesla Coil driven by an induction coil Presented in his 1891 lecture.

Simple Tesla coil shown in Fig. 3 is a high frequency, high voltage generator. It consists of high voltage source (can be low frequency a.c. or d.c.), spark gap, primary capacitance and air core transformer. High voltage source charges C_p until voltage across the spark gap reaches breakdown voltage and then discharging starts producing damped sinusoidal current of frequency determined by the transformer parameters. There are two basic types of operation of Tesla coil depending on the spark duration. For a long spark, the voltages in the primary and secondary circuits are as shown in Fig.4a. After several oscillations in the primary circuit, energy is transferred to the secondary, then again returned to primary, repeating these transfers until the spark is extinguished.

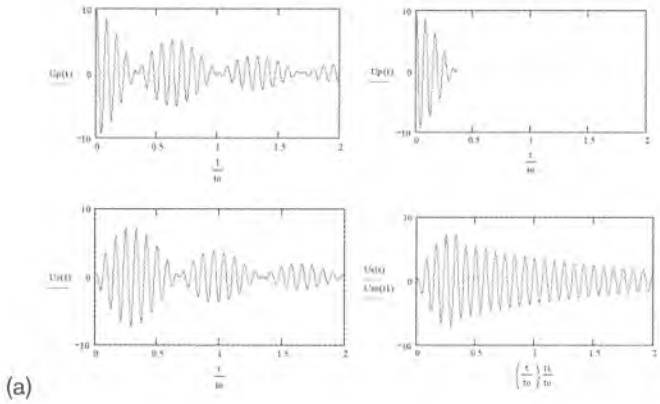

Fig.4. Primary $U_p(t)$, and secondary $U_s(t)$ voltages for: (a) long spark; (b) short spark.

More economical mode of operation is achieved when the spark lasts until all energy of the primary circuit is transferred to the secondary (see Fig.4b). In that case, after the spark in the primary is extinguished, the energy transferred to the secondary causes free oscillation in the secondary circuit shown as $U_{s0}(t_1)$ in Fig.4b.
Spectrum of voltages shown in Fig.4, in the interval of time when transfer of energy is active, even when the free oscillations of the primary and secondary are the same, consists of two damped sinusoidal frequencies, one above and one below the common free resonant frequency of the two circuits. After the spark in the primary is extinguished, free oscillation in the secondary are determined by L_s and parasitic capacitance of the secondary coil.
Tesla could not known in 1891 or about, complex operation of Tesla coil. Theory of Tesla coil, to our knowledge, appeared in 1895. Tesla experimentally adjusted his coil to produce the highest voltage; he guessed that the length of wire in the secondary should be close to the quarter wavelength at the operating wavelength, made studies of the effect of coupling between the primary and secondary circuits. In order to diminish the effect of rapidly decaying currents, he spent a long time in developing fast switching apparatus - circuit controllers and managed to produce almost sinusoidal oscillations in the secondary. After the introduction of electronic tubes, interest in circuit controllers vanished, although for high power transmitters, sparks were used for nearly twenty years.

In his 1891 lecture Tesla also proposed, that "the ideal way of lighting a hall or room would, however, be to produce such a condition that an illuminating device could be moved and put anywhere, and that it is lighted, no matter were it is put and without being electrically connected to anything". The system was composed of high frequency alternator connected in series with a condenser and a primary of high frequency transformer. The secondary of transformer was connected to an insulated metal plate suspended on the ceiling and to the ground, "their sizes being carefully determined". According to his explanation, an illuminating device could be moved and put anywhere, even beyond the plates (see Fig.1). He also mentioned that by making use of resonance we might obtain the required electromotive force at a distance.
In 1891 Tesla published more than ten papers, most of them in connection with his research in high frequency current field, in addition to ten patent applications, accepted later in USA and abroad. In his 1892 European lectures [3] he disclosed new achievements in obtaining better operation of his spark high frequency generator by producing rapid succession of sparks, either by employment of a magnet, air current, simple or multiple air gaps or various design of mechanical interrupters. Many of these inventions were later 'reinvented' by others without even mentioning Tesla's name.

CONTINUOUS WAVE RADIO

In 1893 he described a system with a monopole antenna at the transmitting and receiving sides (see Fig.5) and suggested the use of continuous high-frequency currents and tuned

receiver [7]. His system generated guided wave along the earth, and in contrast to Hertz's system it operated at long wavelength. Preoccupied with the idea to develop system that could transmit large amount of energy with negligible loss, Tesla fundamental radio patents, filed in 1897, on Apparatus for Transmission of Electrical Energy and System of Transmission of Electrical Energy [8,9], only mentioned possible use of Tesla's system and apparatus for message transmission.

Fig.5. Tesla's proposition from 1893: S - h.f. generator; B- ground plate; P-elevated plate (antenna). Receiver is tuned to the transmitter frequency

In the early development of Radio one can distinguish two phases: one based on Hertz's apparatus disclosed in 1887 with a spark-gap generator producing pulses of highly damped, high frequency currents. The operating frequency of such system depended on the dipole antenna attached to the high voltage coil, it was unstable and its spectrum was wide. As a receiver Hertz used a wire loop with small balls separated at short distance. The received signal was detected by observing a tiny spark between the balls. Nikola Tesla began his radio research from the low frequency side of the spectrum. Hence, he worked with the continuous high frequency currents and that was the beginning of the second phase of radio development - so called "the continuous wave radio"[4]. However, in spite of mentioning Tesla's contribution to the development of early phase of radio by some of his contemporaries [6], Tesla has not been recently mentioned between "Six great pioneers of wireless"[10].

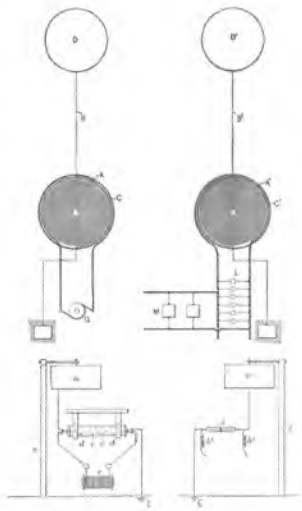

Fig.6. Diagrams showing the salient differences between the apparatus described in Tesla's patents [8,9] and the typical Hertz wave arrangements of that period described in the Re-issue patent of Guglielmo Marconi, No.11,913 of June 4, 1901.

Full explanation of Tesla's radio system, known as the four-tuned circuit he patented in two patents submitted in September 1897 [8,9]. At that time, the only electromagnetic wave transmission explained was that of Heinrich Hertz who in 1888 used the free-space waves. Tesla's proposition was the first syntonic ground-guided system, which soon became the only one used in the early development of radio wave transmission technology.

In explaining the operation of his radio system, Tesla again came with his original theory, explaining that his system is not producing significant free-space radiation but that it makes use of conduction by disturbing the electrostatic charge along the earth surface. In the early days of radio some writers, misled by Tesla's theory, made distinction between the Tesla and Marcony systems! Today we know that this was wrong view. In his first patent Marcony used Hertz apparatus and Tesla's concept of antenna-ground combination from 1893 to produce guided wave but without using resonance, which was essential in Tesla's proposition.

Marconi was the first to send a message across the ocean, and thus, he is partly responsible for 'developing' radio, but he did not invent it. The apparatus and system of four tuned circuits he used was not his invention. The great radio controversy was a landmark decision of The United States Supreme Court in the case "Marconi Wireless Telegraphy Company of America vs. United States" rendering invalid Marconi's basic patent from 1904 as Tesla's patents, issued 1900 and some elements of Stone and Lodge

had priority. It happened after the death of both Marconi and Tesla, and seems that it did not affect much the views of many historians neglecting important Tesla's role in the early development of radio.

ART OF TELEAUTOMATON Đ RADIO EXAMPLE

Many of Tesla's inventions were result of long thinking and careful observation of nature. Remote control of mechanisms is in no way an exception to this rule. In an article, written in 1900, Tesla wrote: *"It was not long before I was aware that also all my movements were prompted in the same way, and so, searching, observing, and verifying continuously, year after year, I have, by every thought and every act of mine, demonstrated, and do so daily, to my absolute satisfaction, that I am an automation endowed with power of movement, which merely responds to external stimuli beating upon my sense organs, and thinks and acts accordingly..."*[11].

Putting this reasoning in practice Tesla conceived the idea of constructing an *"automation"* which would mechanically represent him, but in a more primitive manner. Such automation, in Tesla's words, *"had to have motive power, organs for locomotion, directive organs, and one or more sensitive organs as to be excited by external stimuli."* Tesla worked on the new "Art of Teleautomatics" in the period between 1879-1899. On July 1, 1898 he filed USA patent application and in just over four months the patent on "Method of and Apparatus for Controlling Mechanism of Moving Vessels" was granted to him [12]. In 1898 he was **demonstrating wireless control of model ships in Madison Square Garden and predicting the imminent completion of a system that could transmit both power and intelligence over long distance without wires** [4]. The principle he was developing was applicable to *"any kind of machine that moves*

on land or in the water or in the air", and to show this to an audience he constructed a boat. A storage battery placed within furnished the motive power, the speed and the direction of propeller revolution was controlled from a distance. The rudder was controlled by another motor taking place of the directive organs. As to the sensitive organ Tesla considered radio waves - not the light ray or Hertzian radiation, or any ray-like propagating in straight lines, which would require that the operator continuously see the controlled vessel. In order to avoid "the line of sight" control he used waves that propagate in all directions through space, and used such circuits within the boat, which were exactly tuned to electrical vibrations of the proper kind transmitted to it from the distant transmitter.

The automation boat that Tesla constructed had "borrowed mind" and formed part of the distant operator who transmitted orders to it. But, to quote Tesla *"I purpose to show that, however impossible it may now seem, an automation may be contrived which will have its "own mind", and by this I mean that it will be able, independent of any operator, left entirely to itself, to perform, in response to external influences affecting its sensitive organs, a great variety of acts and operations as if it had intelligence. It will be able to follow a course laid out or to obey orders given far in advance; it will be capable of distinguishing between what it ought and what it ought not to do, and of making experiences or, otherwise stated, of recording impressions which will definitely affect its subsequent actions. In fact, I have already conceived such a plan "* [11].

Following his usual method of presenting new results, Tesla filed application for patent specification on the method and apparatus for controlling moving objects. The patent is full of details about wireless means of transmitting command signals to the moving object. He prefers the use of high frequency currents, which generates electromagnetic waves capable of reaching the moving object although it is not in the line of sight from the operator position. He also suggests the use of tuned circuit at the object to improve sensitivity and selectivity. His transmitting antenna can be an elevated conductor with another terminal of Tesla's coil connected to an earthed metal body, or the two terminals be connected to two remote points with grounded metal plates. The first is a monopole antenna and the second is the loop antenna formed by current spreading between the plates through the ground. He noticed that if the loop type of antenna is used one has to consider relative positions of the transmitting and receiving circuits which shows that he was aware of antenna radiation patterns. At that time Tesla had made many experiments with various antennas but never patented monopole or loop antenna as a separate device. The first appearance of the monopole antenna was in his lecture before Franklin Institute in 1893 [7], and the grounded loop is mentioned in patents applied in 1899.

In the patent specification Tesla gave detailed description of all elements and circuit connections. The pulsed signals from the transmitter are received by a monopole antenna in the middle of the boat and connected to a rotating coherer attached to the clock mechanism. After each pulse, the coherer is shaken and ready to receive another pulse. The effect of received pulse is transmitted to one of the two relays that switch on rudder motor in one of the two possible direction of rotation. Depending on which of the relays is closed the rudder moves right or left. At the same time the main motor is put in operation. To stop the rudder

it is necessary to send another pulse that stops the rudder. In case one needs to change the course, another pulse activates the rudder to move in the opposite direction until the next pulse stops it at a new position. The system is such that one has to know position of the rudder and to be able to "see" its position; Tesla installed two incandescent lamps to indicate the rudder position. Any change of the course is relatively slow with this mechanism, but for a boat the speed is adequate. Tesla's method was classified as independent of time factor (today we would say "asynchronous") and the one, which uses one type of impulse to control a number of different mechanisms as opposed to Walter's method, which depends on synchronous mechanical rotation [13]. Other researchers used Tesla's method later.

Some work on remote control Tesla performed in his laboratory on 35th South Fifth Avenue. When this laboratory burned down in March 1895 it was a terrible blow to him and many experiments were stopped until the end of 1895 when he opened a new laboratory on 46th East Houston Street. In this laboratory he made, in his own words:

"Striking demonstrations, in many instances actually transmitting the whole motive energy to the devices instead of simply controlling the same from distance. In '97 I began the construction of a complete Automaton in the form of a boat, which is described in my original specification #613,809... This application was written during that year but the filing was delayed until July of the following year, long before which date the machine had been often exhibited to visitors who never seized to wonder at the performances... In that year I also constructed a larger boat, which I exhibited, among other things, in Chicago during a lecture before the Commercial Club. In this lecture I treated the whole field broadly, not limiting myself to mechanisms controlled from distance but to machine possessed of their own intelligence. Since that time I have advanced greatly in the evolution of the invention and think that the time is not distant when I shall show an automaton which, left to itself, will act as though possessed of reason and without any willful control from the outside. Whatever be the practical possibilities of such an achievement, it will mark the beginning of a new epoch in mechanics." [14].

After submitting USA patent on the apparatus and system for controlling moving objects, in the following 14 months Tesla submitted patents in 10 other countries.

Tesla's patent claims did not reflect all what he already knew at that time about new technique of remote control. His friends suggested him to omit quite a few things that he thought important in order not to overload the patent claims. In letter to Miessner Tesla wrote:

"I would call your attention to the fact that while my specification, above mentioned, shows the automatic mechanisms as controlled through a simple tuned circuit, I have used individualized control; that is one based on the co-operation of several circuits of different periods of vibration, a principle which I had already developed at that time and which was subsequently described in my patents #723,188 and 723,189 of March, 1903. The machine was in this form when I made demonstrations with it in 1898 before the Chief Examiner, Seeley, prior to grant of my basic patent on Method of and Apparatus for Controlling Mechanisms at a Distance"[14].

In original USA patent specification Tesla omitted to describe his "individualized control" which was a great step forward in providing safe and protected from disturbance control, as compared to simple mechanism control he described in his patent. When at a later date, on July 16, 1900, he submitted patents "Method of signaling"[15] and "System of Signaling"

[16], to protect his method and system of "individualization", prior to obtaining patent he had to clear matter with Fessenden in a patent rights dispute [17]. This document included statements in favors of Tesla by his assistant Fritz Lowenstein and secretary George Scherff. Finally, in March 1903 Tesla obtained patent after more than five years from the moment he had developed and experimentally proved the invention of individualization.

One of recent Tesla's biographers, Marc Seifer [18] writes that Tesla's remote control robotics boat is one of his greatest inventions in terms of shear ingenuity, originality and complexity of design. *"This device"*, Seifer writes, *"was unveiled at the Electrical Exposition held at Madison Square Garden during the height of the Spanish American War in May of 1898, but earliest precursors could be traced to wireless motors which he displayed before the Institute of Electrical Engineers in 1892.... The electrical exhibition was organized by Garden manager Stanford White, who worked with Tesla to fashion a rainbow room of neon lights at the entrance, and it was presided over by Chauncey Depew, another Tesla friend, who was also one of the principals of the Penn Central Railroad and U.S. Senator from New York"*.

Description of Tesla teleautomaton appeared in a number of periodicals and newspapers. It was mentioned in Sewall's book (1903) under the title "Tesla's teleautomata" [19], in Italian book "L'Elettricita" (1909) where Nicola Tesla was presented as the originator of "raditelemechanics ", but was not mentioned in the chapter on alternating current and induction motor, or in connection with radio wave transmission [20]. In Miessner's book "Radio dynamics - The Wireless Control of Torpedoes and Other Mechanisms" (1916) , part of chapter V was devoted to early work of Nikola Tesla, and in chapter XI on "The Advent of Wirelessly Controlled Torpedoes", it is quoted that *"to Tesla, probably more than to any other investigator belongs the credit of first constructing a dirigible vessel which could be controlled from a distance without connecting wires. His experiments were begun in 1892 and from that time on he exhibited a number of wirelessly - directed contrivances in his Laboratory at 35 S.Fifth Avenue, New York city. In 1897 he constructed a complete boat (Figs.40,41 and 42), which would steer itself in obedience to guiding impulses of Hertzian waves sent out from a shore..."*[13].

Ellison Hawks in his book on Pioneers of Wireless [21] gave Tesla's biography and mentions remote control. It is also interesting that Tesla's patent on remote control was listed in "Historical Perspectives of Microwave Technology" in Special Centennial Issue of the IEEE Microwave Theory and Techniques Society as the first among selected patent abstracts which date from 1898 to 1970 [22]. In the same Issue Tesla's contributions were mentioned in several articles dealing with the development of Microwave Communication, with the History of Biological Effects and Medical Application of Microwave Energy, and especially in connection with the History of Power Transmission by Radio Waves.

COLORADO SPRINGS LABORATORY

Continuing his work on high frequency, very high voltages Tesla in 1899 moved to a new laboratory in Colorado Springs. In New York laboratory he reached about four million volts with his transmitter but he needed more to test his theory of the earth electric

charge disturbance that he thought crucial for the energy transmission. Tesla's arrival in Colorado Springs on the May 18, 1899 was reported in the press. In less than eight months he completed his tests, wrote a Diary about his research, and returned to New York on 7th January 1900 [23].

In Colorado Springs Tesla built the largest Tesla transformer with primary and secondary coil of 15 meters diameter, and with "extra" coil that increased voltage to about ten million volts! He performed some experiments of wireless energy transmission but his receiving systems (resonant coils) were not far from the transmitter. Selecting high plateau at about 2000 meters above the sea level, Tesla wanted to be nearer to rarefied air layers that he intended to use for energy transmission. Besides high voltage transmitter he developed methods of individualization and patented it after returning to New York.

At the beginning of twentieth century Tesla believed that he is ahead of all others in developing wireless transmission not only for messages but also of energy in a more significant amount for other uses. He also invented multicarrier transmitter with a special receiver tuned to all carriers. In his own words:

"this invention consists of generating two or more kinds or classes of disturbances or impulses of distinctive character with respect to their effect upon a receiving circuit and operating thereby a distant receiver which comprises two or more circuits, each of which is tuned to respond exclusively to the disturbances or impulses of one kind or class and so arranged that the operation of the receiver is dependent upon these conjoint or resultant action".

Tesla's double circuit system is in a way predecessor of modern spread spectrum system that is intended to protect from message intruders and at the same time decrease disturbing effect of noise in transmission. In Tesla's words this system *"improves individualization and isolation of messages".*

LONG ISLAND PLANT

Immediately after returning to New York in 1900 Tesla tried to get backing for the implementation of a system of "World Telegraphy" [23]. He erected a building and an antenna in Wardenclyffe, Long Island, and started fitting out a new laboratory.

Fig.7 Long Island Plant

From his subsequent notes we learn that he intended to verify his ideas about the resonance of the Earth's globe, referred to in a patent of 1900 [24]. The experiments he wanted to perform were not in fact carried out until the sixtieth of the last century, when it was found that the Earth resonates at 8, 14 and 20 Hz [25]. Tesla predicted that the resonances would be 6, 18 and 30 Hz. His preoccupation with this great idea slowed down construction of his overseas station, and when radio transmission across the Atlantic was finally achieved with a simpler apparatus, he had to admit that his plans included not only the transmission of signals over large distances but also an attempt to transmit power without wires. Commenting on Tesla's undertaking, one of the world's leading experts in this field, Wait has written:..."From an historical standpoint, it is significant that the genius Nikola Tesla envisaged a world wide communication system using a huge spark gap transmitter located in Colorado Springs in 1899. A few years later he built a large facility on Long Island that he hoped would transmit signals to the Cornish coast in England. In addition, he proposed to use a modified version of the system to distribute power to all points of the globe. Unfortunately, his sponsor, J. Pierpont Morgan, terminated his support at about this time. A factor here was Marconi's successful demonstration in 1901 of transatlantic signal transmission using much simpler and far cheaper instrumentation. Nevertheless, many of Tesla's early experiments have an intriguing similarity with later developments in ELF communication" [26].

In a letter to Morgan [27], early in 1902 Tesla explained his research, in which he envisaged three "distinct steps to be made:

1) The transmission of minute amounts of energy and the production of feeble effects, barely perceptible by sensitive devices;
2) The transmission of notable amounts of energy dispensing with the necessity of sensitive devices and enabling the positive operation of any kind of apparatus requiring a small amount of power; and
3) The transmission of power in amounts of industrial significance. With the completion of my present undertaking the first step will be made".

For the experiments with transmission of large power he envisaged the construction of a plant at Niagara to generate about 100 million volts [28].

However, Tesla did not succeed in getting the necessary financial backing, and after three years of abortive effort to finish his Long Island Station he gave up his plans and turned to other fields of interest. He remained convinced to his death that the wireless transmission of energy would one day become reality. Today, when we have proof of the Earth's resonant modes (Schumann's resonance), and it is known that certain waves can propagate with very little attenuation, so little that standing wave can set up in the Earth-ionosphere system, we can judge how right was Tesla when he said that the mechanism of electromagnetic wave propagation in "his system" was not the same as in Hertz's system with collimated radiation. Naturally, Tesla could not have known that the phenomena he was talking about would only become pronounced at very low frequencies, because it seems he was never able to carry out the experiments which he had so brilliantly planned, as early as in 1893 [7]. It is gratifying that after so many years Tesla's name is rightfully reappearing in papers dealing with the

propagation of radio waves and the resonance of the Earth. For example, Jackson [29] in his electromagnetic book stated that: "this remarkable genius clearly outlines the earth as a resonating circuit (he did not know of the ionosphere), estimates the lowest resonant frequency as 6 Hz (close to 6.6 Hz for a perfectly conducting sphere), and describes generation and detection of these waves. I thank V.L. Fitch for this fascinating piece of history".

The last patent in connection with radio transmitters Tesla submitted on Jan. 18, 1902 [30], renewed May 4, 1907 and issued Dec.1, 1914. This patent is extension of patents from 1897 [8,9], with improvements that enable safe operation of apparatus for transmission of electrical energy with antenna charged to a high potential.

In Archives of Nikola Tesla Museum in Belgrade [32] there are a number of various high voltage antenna designs that Tesla prepared in patent drawings form. Some of these were published in 1993 [31].

Chapter 2 of recently published book "History of Wireless" [33], edited by Tapan K. Sarkar et al, published by John Wiley & Sons, Inc, 2006, provides the chronology of the development of wireless up to recent times. Tesla is mentioned several times in connection with high frequency currents:

1890:

- Tesla introduced high frequency currents in therapeutics. He observed that current of high frequency were capable of raising the temperature of living tissues.

1891:

- Tesla patented his Tesla coil in USP 454,622, entitled "System of Electric Lighting" which was used later in every spark gap generator for generation of high frequencies. In Chapter 2 in [32], instead of patent (USP 454,622) a patent from 1890 (USP 433,702) entitled "Electrical Transformer or Induction Device" is quoted.

1893:

- Tesla developed a wireless system for transmitting intelligence;
- Tesla constructed an ac power plant at the World's Fair (Columbian Exposition), Chicago (Fig.2.26).

1896:

- Tesla obtained 8 patents for producing currents of high frequency (Fig.2.30)

1898:

- Tesla demonstrated a radio controlled boat in Madison Square Garden and obtained a patent for it (USP 613,809) (Fig.2.31)

1899:

- Tesla built a gigantic coil resonant at 150 kHz and fed 300 kW to it to demonstrate the transmission of power without wires.

1900:

- Tesla obtained patents USP 645,576 and 649,621 on *System of Transmission of Electrical Energy*, submitted in 1897, which United States of America Supreme Court recognized to be the first patents on *Radio* (Fig.2.32 and upper part of Figure 8.5).

- Tesla patented a security system (ECCM) for remote control, using coincidental transmission (wireless) on two channels, a forerunner of the AND circuit.
- Tesla was the first person to describe a system of determining the location of a moving object using radio waves, i.e., a radar system

Chapter 8 written by A. Marincic in [32] describes "Nikola Tesla and his Contributions to Radio Development".

Chapter 12, written by John S. Berose in [32] presents "A Brief History of the Birth of Wireless", explains how Tesla described wireless system in 1893 in St.Louis and demonstrated sending wireless waves through space, complete with a spark gap transmitter, grounded antenna, tuned circuits, a Morse key, and a receiver with a Geissler tube as an indicator. It also explains Tesla - Marconi court case which ended in favour of Tesla.

CONCLUSIONS

History of radio has been subject of many researchers after historic Hertz's experiments in 1887. The work of Hertz proved the reasoning of Maxwell, who was the first who fully understood what is the nature of electromagnetic radiation. Early historian of science witnessed radio development and followed research of Dolbear, Branly, Lodge, Tesla, Popov, Marconi, Slaby, Fessenden, De Forest, etc. At that time the theory of radio wave propagation was in infancy and that explains why some of them carefully presented Marconi's and Tesla's patents leaving readers to comment on priorities [Sewall, 1904], other thought that Tesla's and Marconi's systems should be presented as different systems [Erskine-Muray, 1913].

Tesla started to think about wireless energy transmission before 1980, and mentioned possibility of wireless in his 1981 and 1892 lectures. In his 1893 lecture before the Franklin Institute in Philadelphia, Tesla described the basic idea of continuous wave radio. It was based on the use of antenna-ground connection to the source of high frequency alternating current at the transmitter side, and antenna-ground connection at the receiving side making use of resonance. What Tesla described in this lecture should be taken to be **the foundation of radio engineering**, since it embodied in essence [34]:

- The principle of adjusting for resonance to get the maximum sensitivity in a selective reception.
- Inductive link between the driver and the tank circuit.
- An antenna circuit in which the antenna appear as a capacitive load.

In developing his 1893 system, Tesla was slowed down because of many other side activities, such as the inauguration of the polyphase system in Chicago World's Exhibition, and burning of his laboratory in March 1895.

In September 1897. Tesla submitted patent application No.650,343, subsequently granted as patent No.645,576 of March 20, 1900 and patent No.649,621 of May 15, 1900. More than a century ago (1898), Nikola Tesla surprised his contemporaries with the invention of remote control applied to a boat exhibited at the Madison Square Gardens in New York.

With this boat Tesla wanted to show another use of radio waves but by a number of others it was considered as pioneering invention in remote control and robotics (as we call it today). In Tesla's explanations, the boat was the first teleautomaton, which is the predecessor of many similar devices in the future, which will have significant role in the peace and war. He tried to apply this invention without success as it was far ahead of the technology of the time when appeared. Remote control, and even more than that, teleautomaton that can have a number of sensors and behave as an intelligent being, had to wait a long time before their introduction in the modern world began. Tesla predicted that a flying teleatomaton could be used as a very precisely guided weapon - not to destroy but more to defend and detract from the war. He had an idealistic view that some future war of teleatomatons will be a "game" without human losses. Tesla's invention is present today in remotely controlled missiles, airplanes, surface and underwater vehicles, satellites and guided exploring vehicles landed by rockets on the Moon and Planets.

The two patents by which Tesla protected his system and apparatus for wireless transmission, known as "system of four tuned circuits", are very important because they were the subject of a long lawsuit brought by the Marconi Wireless Telegraph Company of America against the United States of America, alleging that they have used wireless devices that infringed on Marconi patent No.763,772 of June 28, 1904, on an application filed November 10, 1900, and assigned to Marcony Company on March 6, 1905. After 25 years, the United States Supreme Court on June 21, 1943 invalidated fundamental American radio patent of Marconi No. 763,772 as containing nothing which was not already contained in patents granted to Lodge, Tesla and Stone [35].

In spite of many proofs that Tesla made significant contribution to the radio development in the early phase, his name was not listed among six great radio pioneers as selected by the European Broadcasting Union in 1996 [10].

In this work we presented some old and recent proofs that Tesla's name should be listed among Great radio pioneers. His contribution is fundamental in the development of ground wave propagation system, in applying his high frequency transformer at the transmitting and receiving side, in applying tuning, in proposing double and multiple frequency system in order to individualize transmitted signals, in developing high power high frequency system and remote control of vehicles.

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PL 5

Nikola Tesla and KONČAR Group

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Abstract

It is almost impossible to imagine the world without polyphase alternating currents and rotating magnetic field discovered by the great visionary, scientist and engineer Nikola Tesla. After a brief overview of the state-of-the-art and scientific findings of that time, the patents that are the basis for generation and usage of electricity today are described in more detail. Synchronous and induction machines in which electromechanical energy conversion is performed by rotating magnetic fields have an enormous economic importance both for Croatia and for the world in general. Application of new numerical methods, new materials with specific properties, high-temperature superconductivity and information and communication technologies are new challenges for the future development of rotating machines based on Tesla's inventions.

1. Introduction

Nikola Tesla (1856-1943) was one of those visionaries who pioneered electrical engineering at the end of the 19th and the beginning of 20th centuries. He was an inventor of genius whose creative mind was mostly on alternating currents and transmission of electricity, but who also gave a major contribution to the development of turbines, remote control, illumination, lasers, application of high-frequency currents for therapeutic purposes, development of devices for X-rays, which are described in 112 U.S. patents and numerous confidential documents which the American Government took over after this death and classified.

Today, the annual production of synchronous and induction machines exceeds USD 4.7 b., with tendency to increase for about 8% p.a. On the 150th anniversary of Tesla's birth, it is enough to think back only to several of his inventions to see the contribution of this great genius in electrical engineering.

2. Tesla's rotating magnetic field

The story of epochal invention of the rotating magnetic field began in 1878, when **Nikola Tesla** studied electrical engineering at the Austria Polytechnic in Graz, and when Professor Jakov Poeschl, Tesla's teacher of theoretical and experimental physics, demonstrated the only just invented Gramme's direct current generator with ring winding. When Tesla saw the sparking between the collector and the brushes, he made the bold remark that what should be invented next was a generator without brushes or sparking. The professor answered with a series of arguments and devoted his whole lecture to that problem, and finally concluded: "Mister Tesla will maybe make great things, but it is certain that he will not improve this one".

Nevertheless, Tesla found the answer while walking with mechanical engineer and his friend Antal Szigety in the Budapest City Park one afternoon in February 1882. Reciting Göthe's Faust, which he knew by heart, he suddenly stopped, and started describing his friend in

colourful terms, making drawings in sand, the generation of rotating magnetic field by two alternating currents that flow through two coils shifted in space and a rotating iron rotor. He, in fact, demonstrated the principle of operation of the induction motor, which he patented six years later. Tesla filed the patent application "Electro magnetic motor" on 12 October 1887, and on 1 May 1988 he was granted U.S. Patent 381968. A copy of the drawing from this history-making patent specification and the model of Tesla's two-phase induction motor from the Zagreb Museum of Engineering are shown in figure 1.

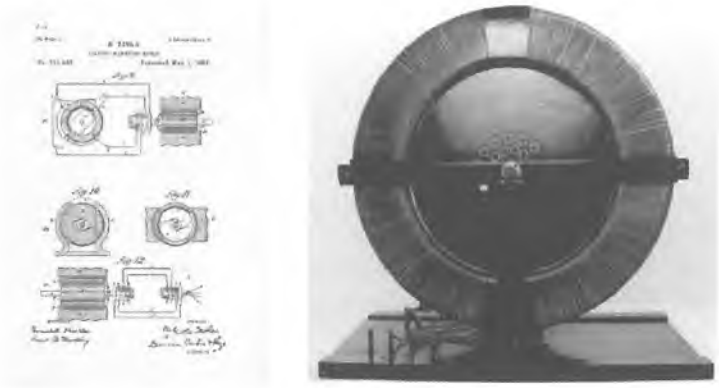

Figure 1 Copy of the printed patent specification for the induction motor of 1 May 1888, which Tesla applied for with the United States Patent Office on 12 October 1887, and the model of Tesla's two-phase induction motor from the Zagreb Museum of Engineering, which Tesla made and demonstrated in Strasbourg on 10 July 1883 - more than four years before the patent application.

U.S. Patent 382280 "Electrical Transmission of Power", whose date of issue is also 1 May 1888, is especially interesting. In it Tesla explained the generation of the rotating magnetic field and the electromechanical conversion of energy, without which we cannot imagine our life today (figure 2).

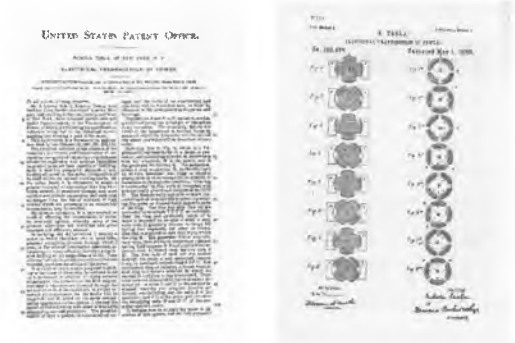

Figure 2 Copy of printed U.S. Patent 382280 "Electrical Transmission of Power" of 1 May 1888 with explanation of generation of the rotating magnetic field (the patent application was filed with the United States Patent Office on 12 October 1887)

In the period from 1888 to 1891 Tesla was granted patents for 36 inventions related to alternating current motors and generators, and 9 related to the electric power transmission and distribution system. Tesla's inventions were very well received, so that he was invited to give a lecture at the American Institute of Electrical Engineering (AIEE) on 16 May 1888 as an AIEE fellow. The title of the lecture was "A New System of Alternate Current Motors and Transformers", and in it Tesla explained his major inventions and the theory

of alternating currents. His public appearance was noticed in Europe as well. German journal Elektrotechnische Zeitschrift (ETZ) of July 1888 published on pages 343 and 344 the article by Du Bois-Reymond titled "Ein neues System von Wechselstrommotoren und Transformotoren von Nikola Tesla", in which he also informed that Tesla gave a lecture at AIEE, and reported in detail about Tesla's explanation and the drawing of the system for electromechanical conversion and transmission of electrical energy (figure 3).

Figure 3 Copy of a part of the article in ETZ, July 1888, pp. 343-344, on Nikola Tesla's new system of alternating motors and transformers presented at the American Institute of Electrical Engineers on 16 May 1888

Tesla's patents and the lecture considerably rose his reputation with electrical engineers. Even before he was granted patents for polyphase systems, the American industrialist George Westinghouse (1846-1914), who was among the few who understood the importance of induction motors and polyphase systems, showed his interest. Since Tesla was not interested in his own industrial production, only in findings and inventions, in May 1888 Westinghouse Electric and Manufacturing Company bought off all of Tesla's patents in the polyphase current area for USD 1 mil. plus USD 1 for each horse power produced by the machines during the term of the patents (15 years). A photograph of synchronous generator and induction motor produced by Westinghouse under Tesla's patent is given in figure 4.

Figure 4 Synchronous generator and induction motor from the time of Nikola Tesla

Perhaps the greatest economic promotion of Tesla's polyphase systems was the construction of generators for Niagara Falls Hydro-electric Power Plant based on Tesla's patents, figure 5, which was completed in November 1896. At that time the first three-phase 35 kilometres long transmission line from the HPP to Buffalo was also put into service.

Figure 5 Interior of the turbine hall of Niagara Falls HPP and the name plate of Westinghouse Co. with the list of applied Tesla's patents

On that occasion professor of electrical engineering at the Yale University and former AIEEE chairman Dr. Charles F. Scott concluded his report with these words: "The evolution of electric power from the discovery of Faraday to the initial great installation of the Tesla polyphase system in 1896 is undoubtedly the most tremendous event in all engineering history".

This was only a brief overview of Tesla's work related to the rotating magnetic field, electromechanical conversion of energy and induction motors, and it has presented only the beginning of Tesla's creative achievements in electrical engineering and energy.

3. The age of Nikola Tesla

To be able to understand at all the ingenuity of Tesla's inventions in the application of laws of nature, it is good to list in chronological order the inventions **in the age of Nikola Tesla (1856-1943)**.

1831 English inventor Michael Faraday discovered the induction law, which says that, when a conductor moves in a magnetic field, current is induced, and thus mechanical work is converted in electrical energy

1859 English natural scientist Charles Darwin presented the theory of evolution of living creatures; the first oil drill

1870 Belgian inventor Gramme designed the direct current generator with ring winding, which Tesla saw during his study in Graz

1873 French engineers Gaulard and Gibbs worked out the transformer, which was the key element in the transmission and distribution of electricity

1876 American physicist of Scottish extraction Alexander Graham Bell invented the telephone

1882 Tesla devised the rotating magnetic field

1883 Tesla designed the two-phase induction motor in Strasbourg, and demonstrated it on 10 July

1887 In October Tesla filed patent applications for the induction motor

1888 In May Tesla gave a lecture at AIEE about the new system of electrical motors and transformers; G. Westinghouse bought off Tesla's patents from the multiphase current area

1891 Tesla filed a series of patent applications from the areas of high-frequency currents and high voltage; Tesla gave a lecture with experiments at Columbia University

1892 In February Tesla gave lectures with experiments on high-frequency and high-voltage currents in London and Paris; **on 24. May a lecture in Zagreb on alternating current**

1893 Promotion of Tesla's polyphase system at the World's Colombian Exhibition in Chicago. On that occasion, 12 two-phase 1000 HP generators and 24 single-phase 500 HP generators were made and connected by twos in a system for driving induction and synchronous motors and for illumination

1896 Tesla performed experiments with X rays. Niagara Falls HPP was completed, and the first three-phase transmission line to Buffalo put in service. **Tesla was appointed honorary member of Yugoslav Academy of Science and Arts (JAZU - today HAZU) in Zagreb**

1897 Tesla's experiments with wireless transmission of electricity
1898 Tesla's remote control patent
1905 American physicist of German extraction Albert Einstein set the formula $E = mc^2$
1914 Tesla granted the patent filed in 1902 for the device for transmission of electricity
1926 Nikola Tesla received doctor honoris causa degree from Zagreb University
1928 English microbiologist Alexander Fleming discovered the penicillin; beginning of the first regular TV broadcast
1960 TESLA was accepted in Paris as the name for the SI unit of magnetic induction.

We must also mention that Nikola Tesla made his invention of the induction motor in Budapest in 1882, implemented it in Strasbourg in 1883, filed the patent application on 12 October 1887, and was granted patent on 1 May 1888. When Tesla made this public, two scientists disputed his claims on the invention: the Italian physicist Galileo Ferraris, who claimed the invention of the rotating magnetic field, and in Germany the engineer Michael von Doliwo-Dobrowolski, who was granted German patent 51083 for the three-phase induction motor with short-circuited rotor in Berlin on 8 March 1889.
The patent litigation between Ferraris and Dobrowolski on the one hand and Nikola Tesla on the other hand continued until 1900, when the judge Towsend of the United States Supreme Court in Washington passed his judgement: "Before Tesla's inventions there were no alternating current motors in use ... Tesla protected his inventions with patents, and thus developed methods and apparatuses what are nowadays widely known under the name of Tesla's polyphase system, and introduced in the engineering new methods, new means and new terminology ...".

4. The beginnings of manufacture and usage of alternating electrical machines in Croatia

The first thermal power plant with three steam-engine driven, single-phase 120 kVA, 2000 V alternating generators was constructed in Rijeka in 1892, while the first hydro-electric power plant on the Krka river was put into operation in Šibenik in 1895. Krka HPP had a two-phase 320 kVA, 3000 V, 42 Hz generator. The first electrical tramway was put into service also in Rijeka in 1899.
Although Dr. Milan Amruš, the mayor of Zagreb, invited Tesla in 1892 to consultations about the introduction of electrical lighting and construction of a hydro or thermal power plant with the alternating system (that was on the occasion of Tesla's public appearance at the Old City Hall), a thermal power plant with a Ganz 865 kVA, 5 kV, 50 Hz alternating generator and a 200 kW, 600/820 V direct generator was completed in Zagorska ulica in Zagreb only in 1907. In 1910, one three-phase 1250 kVA, 5 kV, 50 Hz generator and one 200 kVA, 350 V direct generator were added in the thermal power plant (called "Munjara") for the needs of the electrical tramway, which was installed in Zagreb 11 years after the tramway in Rijeka.
On 24 January 1921, engineers Felix Rottenbücher, Josip Novaković and others founded in Zagreb a joint stock company **ELEKTRA d.d. za elektrotehničku i strojarsku industriju** (electrical and mechanical engineering industries). Not long after its foundation ELEKTRA d.d. took over the representation of Siemens Schneckert Werke AG from Vienna. Several months later Siemens entered with their capital, and ELEKTRA d.d. was reorganised in Jugoslavensko SIEMENS d.d., with sections for low and high-power currents. **That was the beginning of servicing and maintenance of electrical motors in Zagreb - that was also the beginning of KONČAR.**

Since in 1930 the law was passed in Yugoslavia that allowed domestic products to be 10Đ 15% more expensive, SIEMENS organised in Zagreb the production of induction motors and various electromotor parts.
In 1927 Dipl. Ing. Anton Dolenc became one of SIEMENS employees, and in 1932 he was appointed manager of the plant in Trešnjevka, where Siemens had bought land and built a workshop. He was the spiritus movens of the entire development of the company and inventor of many technical solutions. **So, in 1930 the first induction motors with short-circuited rotor and stator winding with lacquered wire instead of cotton-insulated wire were put on the market, what was a novelty on a world scale.** As many as 18,000 electrical motors were produced in that plant in the period from 1930 to 1943.

Figure 6 Series of induction motors produced by Jugoslavenski Siemens, and the tour of Eleanor Roosevelt of the production of induction motors in KONČAR in 1953

In 1941 the name of the company was changed in Hrvatsko Siemens d.d., and on 31 December 1946 the Government of FNRJ changed it in "RADE KONČAR". RADE KONČAR became a company of federal importance, whose production programme included the production of **electrical machines, transformers, switching devices and telephones, with 419 workers**, and from 1 January 1991 it operates as the joint stock company KONČAR - Elektroindustrija d.d. in mixed ownership, with a number of subsidiaries specialised in individual groups of products for electrical power, transport and consumers' consumption. The first induction motor whose diameter of the active part exceeded one meter was delivered to Jesenice Ironworks in 1948, and in the same year the first Končar's 24 MVA synchronous generator was put into operation in the hydro-electric power plant HE Mariborski otok (figure 7).

Figure 7 Manufacture of stator and rotor of 24 MVA, 10 kV, 125 r.p.m. synchronous generator for Mariborski otok HPP (1946)

That traced the way for an independent development of alternating electrical machines in Croatia. The development could not be possible without qualified experts and engineers. In 1848 it was proposed to found the Zagreb Technical University, but it was realised only on 1 October 1919. In 1926 the University became Faculty of Engineering. In 1956 the Faculty of Engineering became the Faculty of Electrical Engineering, and from 1995 it is called the Faculty of Electrical Engineering and Computing. The Faculty was the place where a number of engineers and eminent experts were trained, and many of them worked on the development, design and construction of electrical machines, and at the same time they were professors at the Faculty. Besides the legendary professor Anton Dolenc, a pioneer in the design and technical solutions of induction motors and synchronous generators, who was appointed part-time lecturer at the Zagreb Faculty of Engineering in 1930, there were also other engineers and university professors who made major contributions to the development of alternating machines, of which I shall mention only a few:

- Prof. Dr. Tomo Bosanac, who designed and managed the construction of 2x120 MVA hydrogenerators (the largest at the time) for Zakučac HPP, which was put into operation in 1962.
- Prof. Dr. Božidar Frančić, who patented the self-excited compound synchronous generator, and introduced the theory of dynamic states of alternating machines in the post-graduate studies
- Prof. Dr. Zijad Haznadar, world-renowned theoretician of electromagnetic fields, who was the first to introduce numerical methods for calculation of fields in machines, and studied the expansion and effects of electromagnetic waves
- Prof. Dr. Berislav Jurković, who set the methods for calculation of induction machines, and gave a number of new technical solutions for multi-speed motors for heavy duties
- Prof. Dr. Sc. Zvonko Sirotić, who designed the largest hydrogenerators for Đerdap HPP, and set the principles for building synchronous generators of limit powers
- Prof. Dr. Radenko Wolf, who set the method for calculation of small single-phase motors with an auxiliary phase, and gave an essential contribution to the physical image and theory of various kinds of electrical machines, in particular of small ones.

It should be worth while to point here to some important years for the development of alternating machines and applied technologies, which enabled KONČAR to enter the world market and keep its attained position till today:

1930 Delivery of the first squirrel-cage induction motors of powers from 0.25 to 7,5 kW and with stator made of lacquered wire - a novelty on a world scale - what gave the motors produced in Zagreb a great competitive edge; the applied technology is used even today as conceived by A. Dolenc.

1946 Commencement of construction of the generator for Mariborski otok HPP (24 MVA, 10 kV, 125 r.p.m.), which was put into operation in 1948.

1957 Putting into service the first 16 MVA turbine generator made after KONČAR's own documentation (in Kostolac TPP)

1959 Putting into service the first 5.5 MVA hydrogenerator abroad, Chichoki Mallian HPP in Pakistan; Commencement of the production of induction motors of powers up to 1000 kW under the patent of A. Dolenc, with square-shaped construction of the core called „hedgehog"; Commencement of the construction of Zakučac HPP with four 120 MVA hydrogenerators, two of which were put into service in 1962, and were at the time among the largest generators in the world. Delivery of the first marine generator for the ship Marko Marulić.

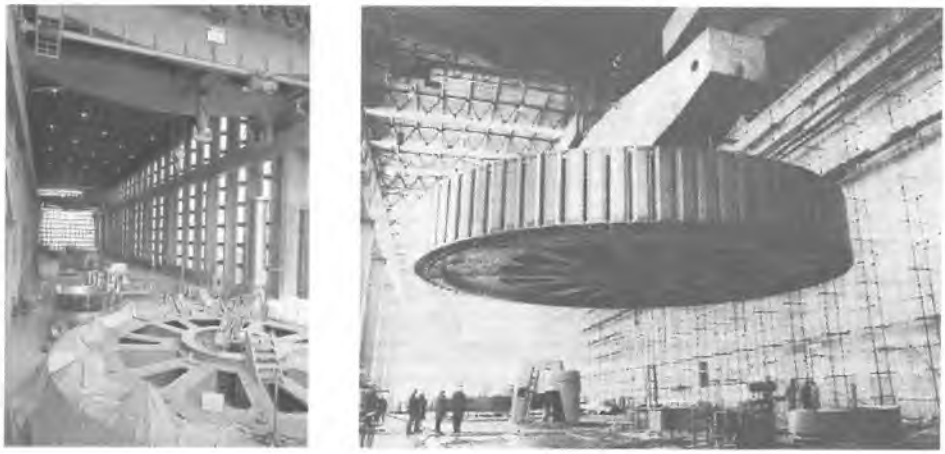

Figure 8 Interior of the turbine hall in Đerdap HPP under construction. KONČAR delivered three 190 MVA hydrogenerators, 1240 tons each, which were put into service in 1972.

1962 First licence for marine motors sold to the Polish company Centromotor, and in 1965to the Italian company Officine electomeccaniche Triestine

1972 Delivery of three largest hydrogenerators (190 MVA each, 16.7 m diameter of the casing, 14.2 m stator bore) for Đerdap HPP

1985 Synchronisation with the network of a 353 MVA turbine generator in Ugljevik TPP (with water-cooled stator winding and hydrogen-cooled rotor)

1991 Commencement of the production of alternating motors with permanent magnets on the rotor for servo drives

2002 Delivery of the largest 7.3 MW induction slip-ring motor to a cement mill in Saudi Arabia

2005 Presentation of the first low-floor tramway with induction squirrel-cage motor and frequency control

Figure 9 Alternating motor with permanent magnets on the rotor for servo drives, and a detail of the current production of low-voltage motors in KONČAR

Figure 10 Induction motor for frequency-controlled electric motor drive of the low-floor tramway, and its first drive in Zagreb in 2005

The development of electrical machines did not only mean the construction of larger and larger units and changes in the construction and technology, but also a constant reduction of weight through the use of better materials and optimisation of design solutions through application of up-to-date numerical procedures. The progress in the construction of 4 kW induction motors can be seen in figure 11.

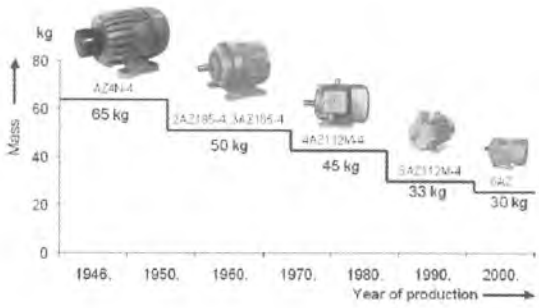

Figure 11 The development of the 4 kW 4-pole closed-type induction motor in KONČAR

In order to speed up the development and become competitive on the world market, KONČAR established within the Electrotechnical Institute, which was founded in 1961, the **Laboratory for Rotating Machines**, which was put into operation in 1971 with all the necessary facilities for research, testing and development of electrical machines and electromotor drives (the testing of electrical materials, electromechanical characteristics, noise and vibrations, temperature rises and cooling, climatic tests, tests of mechanical protection, tests with sinusoidal and non-sinusoidal voltages at various frequencies, and simulations of states in operation), figure 12.

All that contributed to the fact that today KONČAR exports almost 70% of the rotating machines it produces, what makes about EUR 35 mil.

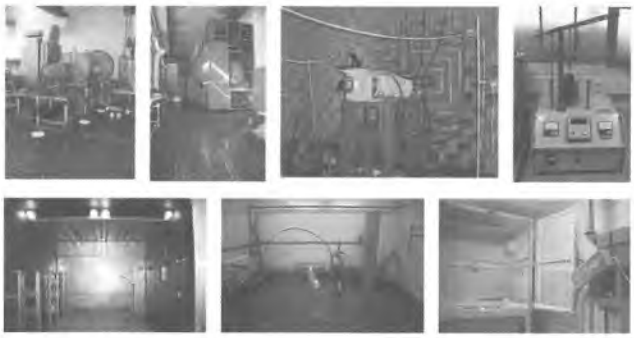

Figure 12 Various testing points at the Laboratory for Rotating Machines in KONČAR - Electrical Engineering Institute, which has been put into operation in 1971.

For their scientific and research work and exceptional contribution to the development of KONČAR, as many as 14 engineers and scientists from the 33 winners of the Nikola Tesla Award so far have been working on rotating machines.

5. A look on further development of rotating machines

2D and 3D calculations based on the finite elements method (FEM) have today the key role in optimisation of various design and technological solutions of alternating machines, both for the calculation of magnetic conditions in individual parts of a machine and for calculations of thermal, ventilation and mechanical conditions, figure 13.

Figure 13 3D representation of the magnetic field in generator core obtained by FEM-based software

The development of electrical machines is greatly influenced by the application of rare-earth (SmCo and NdFeB) permanent magnets both in the cases of servo (figure 9) and traction motors and in the construction of large machines especially for wind-power generators and synchronous motors for strong propulsion. The greatest contribution of permanent magnets to the machine construction is the reduction of losses and consequent increase of efficiency of alternating machines.

The rotational speed of synchronous and induction machines is determined by the speed of revolution of the rotating magnetic field, which depends only on the number of poles and the frequency (which also serve to designate the machines). The application of power electronics converters has enabled a very simple change of the speed of rotation by changing the voltage and the frequency. It is true that higher harmonics of the magnetic field in air gap cause additional losses, pulsating torques, noise and vibrations, but their effects can be considerably reduced by correct dimensioning and appropriate adjustments of the converter and the machine.

Today, the development of alternating machines is largely directed towards their integration in control systems, and also towards their integration in drives, so that it is often hard to tell whether an element belongs to the electric motor, the operating mechanism or the installation.

In the last several years a huge progress has been made in the area of superconductivity, so that high-temperature superconductors (HTS) operating at the liquid helium temperature (-196 °C) or higher temperatures have been developed. Their application can considerably reduce the dimensions of machines, figure 14, what is very important in all places with confined space, and one of such cases are engine rooms on ships. The first induction motor with HTS on the stator was made in 2001, and the application of high-temperature superconductivity is spreading to synchronous generators and transformers, and there are even some ideas to include in a single cryostat all the key elements for electromechanical conversion, storage and transfer of energy: the generator, cables, the transformer, and the current limiter as a new element that should improve the safety of the transmission system in the case of possible short circuit.

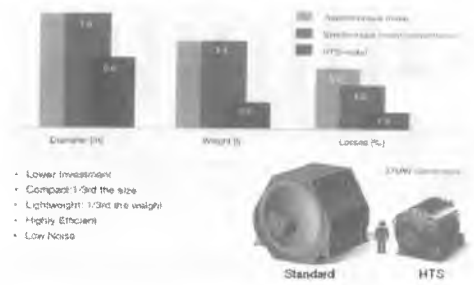

Figure 14 Possible contributions of HTS technology to the construction of alternating machines

Since electrical machines, especially those with higher powers, belong to capital equipment, great attention is paid today to their maintenance in order to make the operation of installations as safe as possible. This is particularly marked in the case of generators, whose availability and reliable operation are of greatest importance, especially after the introduction of free energy market. In this connection, diagnostic tests for the purpose of predictive maintenance and installation of condition monitoring systems, figure 22, are in the focus of investigations and development of the equipment based in information-communication technology. A logical continuation of the development will be the application of artificial intelligence, which will facilitate considerably the usage of such systems, and will be the key element of asset management in near future.

The production of alternating electrical machines and their usage, as well as information-communication technologies that are related to them, have an enormous market potential, what means that they can create an enormous number of jobs. The world market of electrical machines is worth today more than USD 4.7 b., and it is anticipated that its annual increase would be about 8%, in particular in the area of electrical propulsion for ships, figure 15.

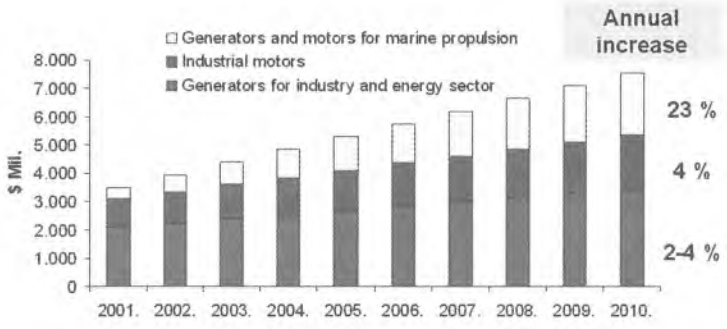

Figure 15 Estimation of the market of rotating machines (Source: AMSC, Arthur D. Little)

So, alternating electrical machines have been not only of great technical and technological, but also of economical importance ever since Tesla had discovered the rotating magnetic field and electromechanical conversion of energy, and they will likely remain so for a long time.

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PL 6

European power systems interconnection

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Summary:
Development of electricity transmission finds an extreme importance in the idea developed by Nikola Tesla on the electric energy transmission, which was patented in 1888. This completes the line: from the revolving magnetic field rotating in the generator operated by a mechanical torque to inducing the voltage by the very same field within the generator windings, transmitting via alternating three-phase remote electric power to the other end where the whole story inverts. Within the induction motor windings the three-phase electric power regenerates the revolving magnetic field which rotates the motor rotor and delivers the torque to the mechanical axle load. If the transformers, providing favourable value of voltage transmission, are placed at the beginning and end of the transmission process, good transmission distance can be achieved avoiding big losses.
Connecting several state power systems creates interconnected power systems. Reasons for such interconnections, historical development of European interconnections, current state in the UCTE interconnection, trends in the cross-border electricity tradings and future of European power system connections are stated.
The UCTE interconnection encompasses transmission systems of 23 countries. It represents one of the world's biggest synchronous drive interconnections. Power plant installed capacity within that interconnection amounts to 600 gigawatts, total generation is 2500 terawatthours supplying electricity to 450 million people (2004).
Numerous obstacles are not permitting endless stretching of interconnection reach: different views concerning the quality, safety, efficiency. Different traditions, cultures, languages, discipline views and other differences within too wide an area also lead to necessary caution.

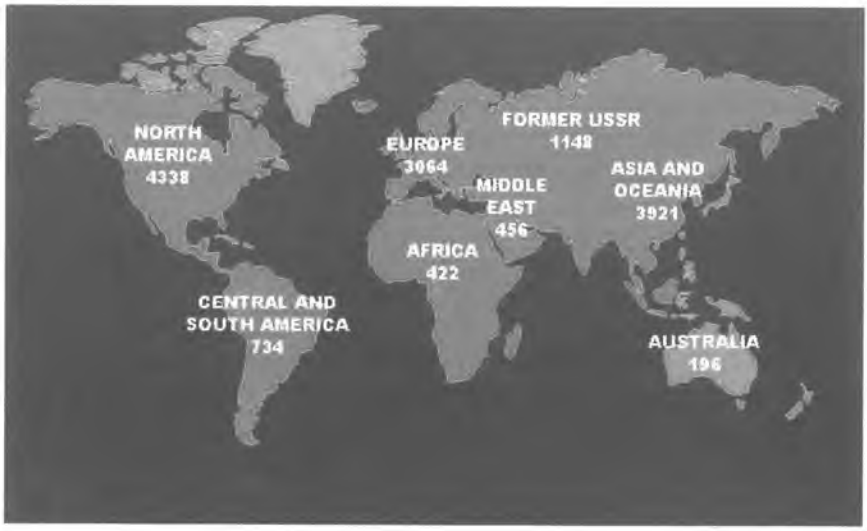
1. Reasons for interconnection

Connecting several state (or interstate in case of geographically large countries) power systems creates interconnected power systems[1] for the purpose of:

- more complete utilization of new big economical power plants, i.e. their complete exploitation immediately following erection;
- a better mix of hydrologic and consumer diversities of connected systems, avoiding hydro power plant overflow and decreasing the fuel consumption in thermal power plants;
- reducing the rotating and cold system reserves, alongside with increased safety between all interconnected power systems, i.e. immediate help in case of a unit outage.

[1] Verbundsystem (German), reseau interconnecte (French)

A power plant of high total capacity and high unit capacity requires smaller financial investments per power unit while erecting it and lower operational costs per energy unit these advantages cannot be utilized in case of a small system.
Total rotating reserve should be at least equal to the capacity of the biggest unit - within small systems it requires the operation of even least economical power plants.
Bigger systems are more inert considering sudden changes - smaller share of regulating power plants achieves favourable frequency continuity. Necessary regulating plant power is proportional to the square root of the peak load; a hundred times bigger system therefore requires a ten times bigger regulating plant power.
If inteconnection expands enough in the east-west direction, the daily peak load zone *travels* with the Sun - total synchronous interconnection load is smaller than a sum of individual interconnected systems peak loads.



Picture 1: Electricity consumption by continents in TWh (2004)
Source: IEA

2. Historical development of European interconnections and UCTE

There have been four big European power system interconnections following the World War II:

- The UCPTE [2]Westeuropean interconnection, the Union for electricity generation and transmission coordination, which has encompassesed power systems in 8 countries since 1951: Austria, Belgium, France, Italy, Luxembourg, Netherlands, Germany (former Federal Republic) and Switzerland. In 1961 the UFIPTE interconnection countries joined the Union (apart from France it included Portugal and Spain), and in 1974 the SUDEL interconnection countries followed (apart from Austria and Italy, it included Greece and former Yugoslavia; Greece joined in 1977);

- The NORDEL NorthEuropean interconnection has encompassed western Denmark, Finland, Norway, Sweden and Island since 1963 (Island, operational separately);
- The OES EastEuropean incorporated energy system encompassing European countries-members of former Economic Aid Council since 1960: Bulgaria, former Checkoslovakia, Hungary, former Democratic Republic of Germany, Poland, Romania and southwest part of an integral power system of former USSR (Moldova and Ukrain);
- Integral power system of former USSR (EES SSSR) was founded last century in the period between sixties and seventies. It encompassed nine integral power systems in the country (out of 11 with almost 100 regional systems) both European and Asian.

Apart from the above, there is the UKTSOA[3] interconnection, which encompasses systems of England and Wales and coordinates the supply from Scotland and import from France. Finally, the ATSOI[4] is interconnection which encompasses systems of the Republic of Ireland and Northern Ireland. These represent two smaller European interconnections.
Established European power system interconnections had some specific natural and developmental features. Some of these features make them complementary Ð and encourage their mutual interconnection. However, some of the features cause difficulties in the connection process:
- geographical position along the east-west line: the demand peak travels daily with the Sun; besides, east is abundant with primary energy sources while the west mostly experiences shortages;
- geographical position along the north-south line: the demand peak travels with seasons, in summer towards the south and in winter towards the north. Central area being too ecologically burdened, therefore north and south with lower loads;
- portion of hydro energy in the total electricity generation;
- portion of nuclear power plants in thermal power plants;
- regulation characteristics of power plants and systems;
- geographical obstacles (sea distances);
- global and political obstacles.

Following the perestroika and the fall of the Berlin wall (1989), social and political changes in the USSR (1991) and eastern Europe, the war in the region of former Yugoslavia (1991-1995) many changes appeared not only within existing European interconnections but also in the multiplication of their mutual interconnections.
First in 1992 a new interconnection CENTREL was founded in Prague. It was joined by power systems of the Czech Republic, Slovakia, Poland and Hungary having the following as one of its most important goals: adjusting the network for the purpose of its integration into the UCPTE. Since 1993 connections towards EES interconnection of former USSR have been switched off. Southeastern part of Ukrain has also been disconnected from the EES interconnection.

[2]Union pour la Coordination de la Production et du Transport de l'Electricite
[3]United Kingdom Transmission System operators Association
[4]Association of Transmission System Operators of Ireland

Germans, unified into one state since October 3, 1990) started building four 400 kv lines with great speed in order to separate new federal states from the OES interconnection and connect them into the system of old federal states i.e. join them with the UCPTE interconnection. This was completed in 1995.

In the late 1995 a trial paralel run of the CENTREL interconnection started, i.e. Poland, Hungary, Czech Republic and Slovakia with the UCPTE interconnection. Continuous synchronous operation was completed in 1998.

Picture 2: European synchronous systems in mid 2004
Source: UCTE

According to the UCPTE, the NORDEL and UKTSOA interconnections divide marine obstacles of such distances which can't be connected via alternating current, a way more economical than direct current transmission.[5]

Several direct current sea cables interconnect NORDEL countries. Three such cable are laid towards the UCPTE. The first one is the BALTIC-cable (the longest sea cable in the world: 250 km long) between Sweden and Germany, 450 kV voltage and 600 MW transmission power, operating since 1994. The second one is the KONTEK-cable between Denmark and Germany, 52 km long in the Baltic sea, with 400 kV voltage and 600 MW transmission power, operating since 1996. The third one is the SwePol-cable laid between Sweden and Poland, with 450 kV voltage and 600 MW transmission power, 230 km subsea lingth, operating since 2003.

The strongest 2000 MW power subsea cable transmission line in the world is the "IFA 2000". It is located under the English Channel with the length of 72 km. Under 270 kV direct current it enables a huge import from France into Great Britain. It has been operational since 1986. There has been a 160 MW direct current cable transmission laid on this location since 1961.

In 1999, following the harmonization with the provisions of 96/92 EU Directive on electricity, which stipulates the market position of electricity generation and division of generation, transmission and distribution, the UCPTE interconnection changes its name, leaving out the word production and becoming the UCTE[6], Union for Coordination of Transmission of Electricity. Coordination of electricity production is deleted from its main tasks and

substituted with providing technical possibilities for conducting such coordination in a market/competitive way. It joins transmission system operators of continental Europe, providing reliable market basis via efficient and secure electric power network of highest voltages (refered by themselves as power highway in their latest representation).
As early as 1991, the war in the region of former Yugoslavia separated the UCPTE interconnection (i.e. the UCTE) into the two zones each operating synchronously. The separation was caused by a complete destruction of 400/110 kV TS Ernestinovo and partial destruction of 400/220/110 kV TS Konjsko as well as consequent damage in the region of Bosnia and Herzegovina. The second synchronous zone included the electric power systems of Southeast Europe (eastern part of Bosnia and Herzegovina, Serbia and Monte Negro, Macedonia, Greece and - synchronously with the second zone since 1994 Romania and Bulgaria since 1996, followed by Albania). The first zone encompassed all other countries, including Croatia and Slovenia. See table 1. Strategically very important for Croatia was the construction of 400 kV Žerjavinec-Heviz transmission line, completed in 1999. This was an alternate connection route for Croatia towards the first UCTE zone via Hungary; both existing 400 kV lines were going via Slovenia (Zagreb-Krško and Melina-Divača).

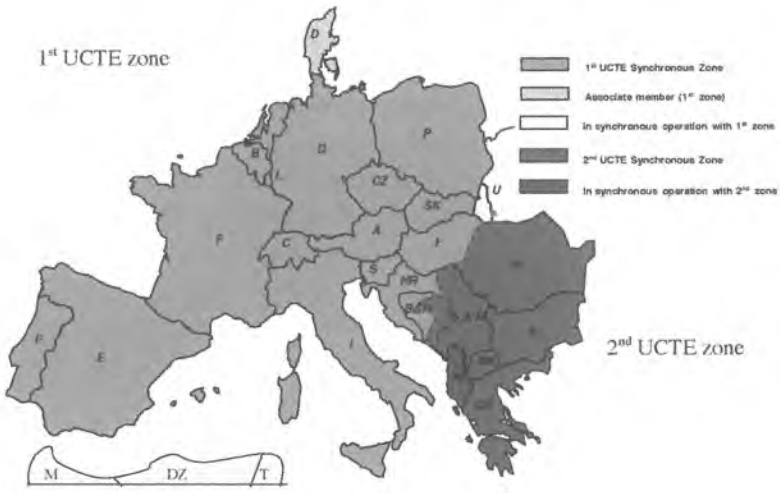
In 2004 following the reconstruction of the transmission network in Slavonia and Baranja, 400/110 kV TS Ernestinovo and the grid in Bosnia and Herzegovina, the UCTE first and second synchronous zones were reconnected, which marked the re-establishment of an integral interconnection going from Portugal to Poland, France to Greece, Macedonia, Bulgaria, Romania and - as an associated member- western Denmark. Systems of Southwest Ukrain and Albania are synchronously tuned with the UCTE although these countries are not members.

Table 1. Two UCTE synchronous zones before reconnection (rounded data), 2004

Synchronous zone	Installed power plant capacity (GW)	Electricity production (TWh)
First	545	2300
Second	55	200
UCTE total	600	2500

UCTE with two sychnronous areas before re-connection

[5]High volatge sea cable alternate current transmission is limited to several dozen kilometres. For longer distances capacity current which flows though the cable would take up all cable diameter at its beginning so there wouldn't be any diameter left available for the active energy transmission. When considering direct current, there are no capacity currents flowing through the cable. However, this system requires - apart from cable placing - an expensive directional plants at its beginning and end. An English acronym for the transmission of high volatge direct current is HVDC.
[6]Union for Coordination of Transmission of Electricity



Picture 3: the UCTE interconnection, mid 2004
Source: HEP-TSO

Reconnection had the following order:
- connection of 400 kv Sandorfalva transmission line (Hungary) - Arad (Romania)
- connection of 400 kV Subotica transmission line (Serbia) - Sandorfalva (Hungary)
- connection of 400 kV Trebinje transmission line (B&H) - Podgorica (Monte Negro)
- connection of 400 kV Mukačevo transmission line (southewest Ukrain) - Rosiori (Romania)
- connection of 400 kV Ernestinovo transmission line (Croatia) - Mladost (Serbia).

The reconnection commenced on October 10, 2004 at 9.34 am and finished on the same day at 10.20 am. It was very carefully prepared, conducted in a very successful manner within less than an hour!

The reconnection was preceded by the harmonization of the phase schedule on the connection lines between the Croatian electric power system and the first synchronous zone countries surrounding Croatia (Hungary and Slovenia). In total, phase schedule had to be changed on ten 400, 220 and 110 kV lines. It was conducted on September 25, 2004.

In the period before the reconnection, Greece decided to build an additional - *politically stable* - connection towards the UCTE, a 163 km long, 400 kV subsea direct current cable on the Strait of Otranto towards Italy with 500 MW transmission power, operational since 2002.

Since 2002 Northern Ireland has been connected with the Scottish network via 500 MW direct current subsea cable.

3. Current UCTE interconnection situation

Picture 4: late 2005 UCTE interconnection
Source: UCTE

The UCTE interconnection therefore encompasses, in its full membership, transmission networks of 22 countries[7] (or 23 with west Denmark as an associated member). It is one of the biggest synchronously operational interconnections in the world. Installed capacity of all power plants in this interconnection amounts to almost 600 gigawatts (thousand megawatts), total production of almost 2500 terawatt hours (billion kilowatthours) supplying electricity to 450 million people (2004). There are about 250 operational 220 and 400 kv connection lines interconnecting UCTE countries.

The ratio between the total power plant inastalled capacity and the peak load is 1.6 for the entire UCTE, which makes the total power plant capacity bigger by 60% from the peak load. This characterizes the interconnection since it provides the information on the interconnected power plant reserves. What characterizes the interconnection demand is the ratio between the total annual consumption and the peak load, the peak load duration. In 2004 it amounted to 6464 hours for the entire interconnection. Within this time frame the placement of all consumed energy takes place at constant load, equal to peak load. (FYI, there are 8760 hours in a year). Relevant information for individual member states for 2004 are shown in table 2. The geographical representation is shown in picture 4.

The most important data given in these tables is that the UCTE interconnection peak load differs from the sum of peak loads in interconnection member states by 6000 MW. Therefore, this is the quantity of power plants to be erected throughout all systems if there was no interconnection!

4. Tendencies in electricity cross border trading

Diagrams in pictures 5 and 6 clearly show that the UCTE interconnection generation has increased by approximately 3 times and electricity exchange by 5.5 times in the last 30

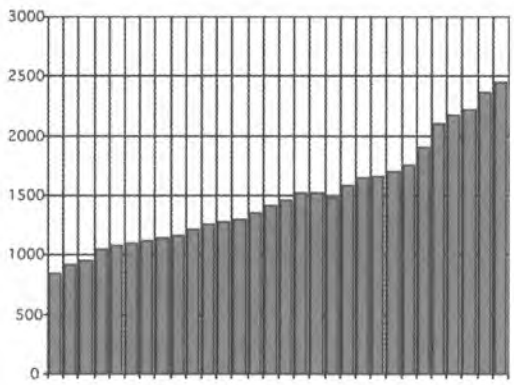
[7]Austria, Belgium, Bosnia and Herzegovina, Bulgaria, the Czech Republic, France, Greece, Croatia, Italy, Luxembourg, Hungary, Macedonia, Netherlands, Germany, Poland, Portugal, Romania, Slovakia, Slovenia, Serbia and Monte Negro, Spain and Switzerland.

years. The share of exchange in the total electricity generation has increased from 6% in 1975 to more than 12% in 2004. The electricity exchange grows much faster than electricity generation, the same applies to interconnection electricity consumption. This trend has especially been visible since 1998.

The above mentioned will be even more increased by new market incentives. Therefore, it is of utmost importance to continue building transmission networks within regulation areas and their connecting (interconnecting) lines in order to impede congestions of existing transmission lines.

France, for example, exports about 12% of its generation, while Italy imports about 14% of its needs (2004). Switzerland, being a transit country due to its central European position, has an equal amount of export and import at the level of 40% of its generation. Total UCTE one-way exchange, import or export, amounts to 300 TWh (2004). Lately, but also even earlier, there has been an appearance of so called European electric power market which functions due to ever more lively transmission network use.

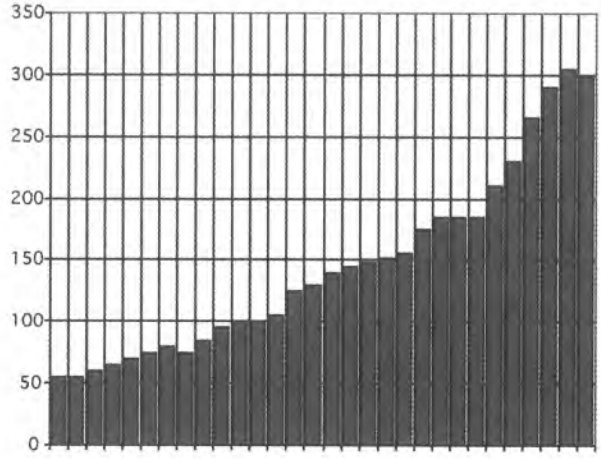
European Transmission System Operators Association (ETSO) was founded in 1999. It is compatible with European interconnections (UCTE, NORDEL, UKSOA, ATSOI) since interconnections put importance on the technical and technological connections between national transmission networks. ETSO, on the other side, foremost deals with organizational-legal-commercial issues of such connections balancing network access terms in all member states as well as terms of network use especially regarding cross border trading. It includes transmission operators in all EU member states, Norway and Switzerland. Since 2004 it was joined by the Romanian transmission system operator, a EU candidate state.



Picture 5. Electricity UCTE net generation (TWh)
Source: UCTE-Memo 2004

In 2004 ETSO supplied electricity to more than 490 million people using member-states' transmission networks. Total annual consumption amounted to approx. 3200 TWh. The length of high voltage transmission lines (400 and 220 kV) is more than 290 thousand kilometres, which means that the Earth's equator could be encompassed by more than 7 times only by using these ETSO 400 and 220 kV lines!

The EU Regulation 1228/2003 on network access terms for the purpose of cross border electricity trading was released on July 15, 2003 (simultaneously with the well know Directive 2003/65 on electricity). It has been applied since July 1, 2004. The difference between the regulation and the directive is that the regulation is directly and literally implemented in member-states, while the directive requires its implementation via member-states' legislature.



Picture 6. Electricity exchange in UCTE (TWh)
Source: UCTE-Memo 2004

Above mentioned regulation on cross border trading has an importance for the European Economic Area.[8] The Regulation was adopted when the EU consisted of 15 members although its provisions apply to all ten new member states (since 2004). Therefore, the regulation currently doesn't apply to Croatia although it is putting constant efforts in becoming ETSO members.
The objective of this regulation is adopting rules on cross border electricity trading in order to improve internal market competition (internal, meaning the European Union) taking into consideration national and regional markets specific features. This includes the mechanism for determining cross border transmission fee (CBT-mechanism, Cross-Border-Tarification-Mechanism and since 2005 so called ITC-mechanism, Inter-TSO-Compensation-Mechanism) as well as allocation of available interconnecting line transmission capacity i.e. the lines crossing the EU member states national borders.

Europe without borders is being encouraged in the electricity sector area as well.

[8]EEA- European Economic Area consists of EU member states and three non-member states: Island, Lichenstein and Norway

5. Prospective future of European electric power connections

In 1991 the special committee MEDELEC was founded, which has a goal to connect electric power systems in the Mediterranean area. The link, expanding the UCTE interconnection onto North Africa, was constructed Đ it included Magreb countries: Marocco, Algeria and Tunisia, which are interconnected. The 400 kV alternate current cable beneath the Gibraltar, 730 MW transmission capacity and 25 km long, has been connecting Spain and Marocco since 1997. The construction of another such cable is under way. Mashreg countries: Lybia, Egypt, Jordan, Lebanon and Syria constitute one interconnection unit. Tunisia-Lybia connection is under way. Next follows the Turkish-Syrian border connection. The Bosporus Strait has been bridged by four 400 kV transmission lines.

Intercontinental connection created in this way would enable European investment to use primary energy sources of north Africa first followed by other southern parts of the continent later - leading to likely economically acceptable future solar solutions massively installed in the equatorial area.

The plan to lay down three new subsea direct current cables in the north has been developed: two between Norway and Germany, one between Norway and Netherlands. Apparently, compatibility of Scandinavian hydroenergy and northern European continental thermal energy as well as ecologically stimulated motives encourages more intensive exchange in these regions. Sweden sees this as an opportunity to replace thermal energy after decomissioning its own nuclear power plant generation.

Synchronous joining of the UCTE and the IPS/UPS interconnections has been under consideration. This connection would expand from Lisbon to Vladivostok. The final report on the possibilities of such a connection must be submitted by 2008. The IPS/UPS[9] interconnection encompasses electric power systems of all Baltic states (Latvia, Lithuania and Estonia), Armenia, Azerbedian, Belorus, Georgia, Moldova, Kazakhstan, Kyrgyzstan, Russia, Tajikistan, Ukrain and Uzbekistan. It was created after USSR breakup, i.e. eastern European unified energy system breakup.

The alternative east-west transmission has been under consideration as well. It would be carried out via direct multiterminal direct current transmission: Russia, Belorus, Poland and two connections in Germany with 4000 MW transmission capacity and total length of 1800 kilometres.

Apart from technical and technological limitations there are numerous obstacles which are not permitting endless stretching of the interconnection reach: different views concerning the quality, safety, efficiency. Different traditions, cultures, languages, discipline views and other differences within too wide an area also lead to necessary caution.

[9] Interconnected Power Systems/Unified Power System

Table 2. UCTE Interconnection in 2004

Country	HPP capacity (MW)	NPP capacity (MW)	Conventional TPP capacity (MW)	Renewable sources power plant capacity (MW)	Total capacity (MW)	HPP generation (TWh)	NPP generation (TWh)	Conventional TPP generation (TWh)	Total generation (TWh)	Consumption (TWh)	Peak load (MW)	Import (GWh)	Export (GWh)	Power plant capacity/peak load	HPP generation/total generation	Peak load duration (hours/years)
Belgium	1493	5802	8081	366	15752	1,6	44,9	34,9	81,4	87,5	13325	14612	6804	1,18	0,02	6567
Germany	9000	20500	68100	17300	114900	22,9	157,1	349,3	529,3	513,0	72000	44214	51519	1,60	0,04	7125
Spain	18014	7876	32855	7361	66106	33,3	60,9	147,9	242,1	234,5	37196	8182	10717	1,78	0,14	6304
France	25394	63363	26908	10056	116721	64,5	428,8	55,4	546,7	477,2	79981	5995	66382	1,46	0,12	5966
Greece	3080	0	7212	380	10852	4,9	0,0	44,2	48,2	51,2	8122	4862	2043	1,34	0,10	6304
Italy	20770	0	57000	1688	79468	47,9	0,0	238,4	286,3	321,5	53093	46265	752	1,50	0,17	6055
Slovenia	862	670	1262	0	2794	3,6	5,2	4,6	13,5	12,7	1930	7442	8199	1,45	0,27	6580
Croatia	2071	0	1670	5	3746	7,0	0,0	5,4	12,4	16,0	2692	10054	6357	1,39	0,56	5944
B&H	2064	0	1957	0	4021	6,0	0,0	6,6	12,6	10,5	1803	1650	3598	2,23	0,48	5824
Macedonia	503	0	907	0	1410	1,5	0,0	4,7	6,2	7,4	1358	2009	833	1,04	0,24	5449
Srbia&M.Negr	3497	0	6400	0	9897	13,4	0,0	25,3	38,7	39,9	6867	6060	4030	1,44	0,35	5810
Luxemburgh	1128	0	477	60	1665	0,9	0,0	3,1	4,0	6,3	877	6500	3133	1,90	0,23	7184
Netherlands	37	440	18770	1406	21152	0,0	3,6	91,0	94,6	110,8	15128	21410	5191	1,40	0,00	7324
Austria	11700	0	5900	670	18270	34,3	0,0	22,1	56,4	56,6	8894	16453	12994	2,05	0,61	6364
Portugal	4717	0	6178	825	11720	10,7	0,0	28,7	39,4	45,5	7840	8523	2130	1,49	0,27	5804
Switzerland	13295	3220	305	290	17335	35,1	25,4	3,0	63,5	60,1	9548	26083	25314	1,82	0,55	6295
Czech	2138	3537	10591	20	16286	2,5	24,8	50,6	77,9	61,1	10097	9770	25489	1,61	0,03	6051
Hungary	46	1755	5685	100	8276	0,2	11,2	19,4	30,8	38,2	6357	13791	6321	1,30	0,01	6009
Poland	2193	0	29350	145	31866	3,5	0,0	136,3	141,8	130,3	20937	5312	14603	1,52	0,02	6223
Slovakia	2429	2640	2290	3	8058	4,0	15,7	8,6	28,3	26,3	4323	8733	10592	1,86	0,14	6084
Romania	6007	655	10081	0	16743	16,3	5,1	30,5	51,9	50,7	8028	1748	2941	2,09	0,31	6315
Bulgaria	2930	2880	6420	0	12230	3,3	16,6	21,2	41,1	35,0	5949	741	6623	2,06	0,08	5883
UCTE	133348	113347	308409	31765	588880	317,3	797,4	1333,4	2448,1	2392,9	370176	270409	276565	1,59	0,13	6464
Sum of peak loads											376345					
W. Denmark	11	0	5098	2379	7488	0,1	0,0	24,2	24,3	20,9	3517	5044	8463	2,13	0,00	5943
W. Ukraine	27	0	2347	0	2374	0,1	0,0	7,6	7,7	4,4	975	1602	5772	2,43	0,01	4513

Predavanja

Lectures

L 1

Patenti Nikole Tesle
Bit patentne zaštite na primjeru patenata Nikole Tesle

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Nikola Tesla je jedan od neospornih i bezvremenih genija tehnologije i znanosti.
Izumiteljstvom se bavio još od najranijeg djetinjstva, imajući u tome veliki uzor i podršku u sredini u kojoj je živio.

U vremenu nakon završetka školovanja u Karlovcu, Grazu i Pragu, te tijekom rada u Telegrafskom uredu u Budimpešti, Tesla je ostvario mnoge izume u području turbina i telegrafije. U tom periodu svoje izume nije štitio patentom.

Došavši u SAD 1884. godine, Tesla je ubrzo shvatio prednosti zaštite izuma patentom, mehanizmom koji će mu omogućiti predstavljanje svog ogromnog znanstveno-tehnološkog potencijala i prenošenje tog znanja na sve zainteresirane, a i "oživotvorenje" njegovih, za čovječanstvo, kapitalnih izuma. To je i sama bit patentne zaštite.

Teslin bogati tehnološki i znanstveni doprinos rezultirao je s 112 američkih patenata te mnogobrojnim reprijavama u različitim zemljama, npr. Velikoj Britaniji i Kanadi.

Tijek Teslina života pokazuje da mu je prvenstvena namjera bila raditi za dobrobit čovječanstva i dozvoliti korištenje informacija sadržanih u njegovim patentima u cilju daljnjeg razvoja tehnologije.

Tesla je znao da se njegova dostignuća koriste za daljnji razvoj pojedinih tehnoloških područja i pri tome nije pokazivao želju da to zabrani.

Bezvremenost njegovih izuma pokazao je tijek vremena, a mnoga nova područja ljudske tehnologije razvijena su zahvaljujući Teslinim idejama.

Vidljiv je razvoj pojedinih grana tehnologije baziran na informacijama sadržanim u Teslinim patentima, te ekonomska i socijalna iskoristivost istih.

Mnogi su se na različite načine okoristili njegovim zamislima. Neki od njegovih patenata bili su "ponovno izumljeni" što je neosporno i dokazano.

Manjkavost sustava patentne zaštite tog vremena omogućila je povredu Teslinog patentnog prava u slučaju Marconi, koji je ponovno "izumio" radio.

Teslin život i dostignuća najbolji su pokazatelji tijeka od ideje i vizije, preko izuma do patenta, a kronologija njegovih patenata pokazuju sve prednosti patentne zaštite, te moguće povrede patentom stečenih prava izumitelja.

L 1

Nikola Tesla's Patents
Essence of Patent Protection shown in the example of Nikola Tesla's Patents

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Nikola Tesla is indisputably one of the greatest minds of technology and science of all times.

He dealt with inventions from his early childhood, having the model and support in the environment in which he lived.

After having finished his schooling in Karlovac, Graz and Prague, and while working in the Telegraph Office in Budapest, Tesla created many inventions in the field of turbines and telegraphy. At that period, he didn't protect his inventions by patents.

Coming to the USA in 1884, Tesla soon realized advances of the protection of inventions by patents, a mechanism which would enable him to present his enormous scientific and technological potential, to transfer such knowledge to the public, and to "put to life" his capital inventions intended for humanity.

Tesla's rich technological and scientific contribution resulted in 112 US patents, and several re-applications in various countries, e.g. in Great Britain and Canada.

The course of Tesla's life shows that his first priority was to work for the welfare of humanity and to allow the use of information contained in his patents for further technological development.

Tesla knew that his achievements had been used for further development of particular technological fields, not showing intention to prohibit it.

The timelessness of his inventions became evident in the course of time. Many new fields of human technology were developed owing to Tesla's ideas.

Development of particular branches of technology based on information contained in Tesla's patents, as well as economic and social usability of the same can be observed.

Many people took advantage of his ideas in various ways. It was proved beyond any doubt that some of his patents were "re-invented".

Deficiencies of patent protection system of that time made possible the infringement of Tesla's patent right in the Marconi case, who "re-invented" a radio.

Tesla's life and his achievements are the best example of the path starting with the idea and vision and leading over an invention to a patent. The chronology of his patents demonstrates all the advantages of the patent protection, and possible infringements of the inventor's right conferred by a patent.

L 2

Teslini patenti iz područja elektroenergetike

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Tijekom rada u Sjedinjenim državama Tesla je patentirao 99 patenata koji su prihvaćeni od Patentnog ureda, te 14 prijavio, koji nisu bili prihvaćeni. Od tog niza patenata oko 40 ih je sa područja elektroenergetike i to o motorima i generatorima izmjenične struje, o regulatorima, te iz područja transformacije električne snage, iz područja rasvjete, turbina i sličnih naprava te drugih izuma iz područja korištenja energije.

Posebno će se obraditi onih13 patenata iz 1888. koji su iskorišteni kod gradnje hidroelektrane na rijeci Nijagari, puštenoj u rad 15. travnja 1895. godine, prvi agregat, a završene u studenome 1896. godine, kada je i zadnji agregat sagrađen i pušten u pogon prvi trofazni dalekovod od elektrane do grada Buffaloa i distribucija u tom gradu.

Kod prezentacije referata o njegovim patentima bit će predstavljeni originalni crteži i tekstovi prijave patenata. Iz ovog prikaza bit će predstavljen Teslin postupak dolazaka do izuma i metoda prikaza novih saznanja s područja izmjeničnih struja i drugih elektroenergetskih područja.

L 2

Tesla's Patents in the Field of Electric Power

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During his work in the United States Tesla patented 99 designs accepted by the Patent Office and registered further 14 which were not accepted. Out of this range of patents 40 are from the field of electric power i.e. AC engines and generators as well as regulators, from the field of electricity transformation, lighting, turbines and similar devices and all other inventions related to the field of energy use.

Particular attention will be drawn to 13 patents from 1888 used in the construction of the hydro power plant on the Niagara river when the first generating set was put into operation on April 15, 1895. It was completed in November 1896 when the last generating set was built and put into operation alongside with the first three-phase transmission line connecting the power plant and the town of Buffalo and ensuring its power distribution.

The presentation of the papers on his patents will include original drawings and texts relating to patent register. This paper will present Tesla's invention procedure and a method for demonstating new knowledge from the electric power and alternating current fields.

L 3

Hrvatski pogled na spor Tesla - Ferraris i ulogu patenata u njemu

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Elektrotehnologija, poput svih drugih vrsta znanosti i izuma, uvijek je bila kumulativna i kolektivna djelatnost, što znači da se oni kojima se pripisuju inovacije jako oslanjaju na znanja svojih prethodnika, ali i suvremenika. Istovremeno uvijek su neke osobe učinile najveće doprinose ili prve otkrile ili izumile nešto novo, bilo samostalno ili simultano i nezavisno ili u suradnji. Tipičan takav slučaj u povijesti elektrotehnologije je otkriće okretnog magnetskog polja i prvi izum indukcionog ili asinhronog motora. Do danas se na neki način vodi spor oko prioriteta u tome između našeg zemljaka Nikole Tesle i talijanskog profesora Galilea Ferrarisa. Potreba je i prilika progovoriti o tome nešto sa hrvatskog stanovišta, a nakon stanovišta drugih (Talijani, Amerikanci i dr.). Pri tome će se naglasiti uloga ranih Teslinih patenata iz te oblasti.

Ideja i prvi začeci okretnog magnetskog polja nisu ni Teslini ni Ferrarisovi, već pripadaju drugima koji su ranije (D. Arago, W. Bailey) ili istovremeno sa njima (C. Bradley) radili pokuse okretanja bakrenih ploča ili drugih vrsta rotora u magnetskom polju koje su okretali, ali pri tome ne shvaćajući veliki praktični značaj te pojave. U tome se Tesla i Ferraris izdvajaju, jer su prvi do kraja razvili ideju, konstrurali prve demonstracijske motore, razvili vektorsku teoriju (Ferraris) i vjerovali u veliku praktičnu vrijednost otkrića i izuma (Tesla). Iako se za obojicu spominju prva saznanja i rudimentarna rješenja u nekim ranim godinama - za koje nikad nije dana nikakva ozbiljna evidencija (Tesla 1882. u Budimpešti, Ferraris 1884. u Torinu) - puni i zreli izum oboje su objavili gotovo istovremeno i očito nezavisno tek u 1888. godini. Taj pomak govori o težini problema i potrebi dugog rješavanja do izlaska u znanstvenu i stručnu javnost. Ferraris to čini člankom u ožujskom broju časopisa "Electricitá" 1888. (sa nepoznatim datumom predaje rukopisa), a Tesla sa čuvenih 6 prvosvibanjskih (sic!) US patenata 1888. (prijavljenih od X do XII mj. 1887.), te oboje u predavanjima iz iste 1888. godine.

Sa hrvatskog stanovišta trebalo bi naglasiti značaj Teslinih patenata, koji su svi osnovani na eksperimentalnoj provjeri, kojoj je Tesla bio vičan još od srednješkolskih dana u Karlovcu (Teslino jedino zaokruženo školovanje) asistirajući svom čuvenom profesoru fizike (ali i hrvatskog jezika!) M. Sekuliću. U patentima je Tesla u prednosti pred ostalima, posebno svojim najznamenitijim patentom No. 382280 u kojem on za razliku od Ferrarisa predviđa napajanje indukcijskog motora dvofaznim generatorom dajući tako prvi rudimentarni prijedlog prijenosa električne energije na daljinu. To ne umanjuje značaj obojice u skoro istodobnom otkriću pojma rotacijskog polja niti prioritet u matematskoj formulaciji rotacijskog polja G. Ferrarisa.

L 3

Croatian view on quarrel Tesla - Ferraris and role of patents in it

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Electrotechnology, like all other kinds of science and invention activity, has allways been a cumulative and collective activity and that means that those credited with innovations gennerally draw on the knowledge of their predecessors and contemporaries. At the same time some particular individuals made the greatest contribution as being the first to discover or invent something new indenpendently or simulatneously or in collaboration. Typical such case in the history of electrotechnology is the dicovery of rotating magnetic field and the first invention of induction or asynchronous motor. Up to now in some way is present a quarrel on priorities in it between Nikola Tesla, born in Croatia and Galileo Ferraris, Italian professor. It is a need and an opportunity to speak about it from Croatian standpoint after standpoints of others (Italians, Americans etc.). It will be stressed the importance of early Tesla's patents from that field.

Idea and the first trials of rotating magnetic field are not Tesla's or Ferraris' and belong to others which earlier (D. Arago, w. Bailey) or during the same time (C. Bradley) made the experiments with rotation of copper plates or other rotors in the magnetic field which they rotated, but they didn't realized the great practical implications of that fact. In that sense Tesla and Ferraris are separated because they fully developed the idea, they constructed the first demonstrating motors, developed the vector theory (Ferraris) and believed in the great practical value of the discovery and inventions (Tesla). Although for both of them it is mentioned the first cognition and rudimentary solution in some earlier years - for which was never given any serious evidence (Tesla 1882 in Budapest, Ferraris 1884 in Torino) - they announced full and mature inventions almost simultaneously and obviously independently in 1888. Such time distance speaks about the complexity of problem and about the need for long solution before informing professional and scientific community. Ferraris made it in March edition of review "Electricitá" in 1888 (with unknown date of giving the manuscript to editors) and Tesla with his famous six patents on 1st of May (sic!) in 1888 (registered from October till December in 1887) and both with famous lectures in the same, 1888 year.

From the Croatian standpoint it is necessary to stress the importance of Tesla's patents based on experimental verification to which method Tesla was accustomed from his High school days in Karlovac, Croatia during his assistance to his famous professor of physics (and Croatian language!) M. Sekulić. Tesla gave in his most famous patent No. 382280 the first rudimentary proposal for power transmission by two-phase system. That fact doesn't minimize the importance of both in discovery of rotating field and Ferraris importance in its matemathical formulation.

L 4

Teslini izumi u fizici i elektrotehnici i njegove inženjerske intuicije

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U radu se opisuju Teslini izumi u fizici i elektrotehnici i njegove inženjerske intuicije, usporedbom s M. Faradayevim i A. A. Michelsonovim otkrivačkim duhom u elektromagnetizmu. Opisat ćemo neka otkrića i pojedine pokuse u američkoj fazi Teslinih istraživanja nakon 1884., koji su važni za razvoj modernih tehnologija. To je supravodička radiofrekvencijska tehnologija u kojoj je glavni cilj dobivanje što većeg gradijenta ubrzavanja čestica u linearnim supravodičkim ubrzivačima, čiji se počeci vežu na Teslin transformator kao izvor visokofrekvencijskih polja velikih napona, te Teslina unipol-antena elektromagnetskih valova velikih snaga i dosega u kojoj se koristi princip Teslinog transformatora. U okviru klasične elektromagnetske teorije, izveli smo proračune i modernu analizu sklopa za istraživanja Teslinog modela bežičnog prijenosa elektromagnetske snage i/ili informacije, te električnu rasvjetu na daljinu, dokazujući znanstvenu utemeljenost tih Teslinih zamisli. Ukazujemo i na važnost glasovitog Teslinog predavanja s demonstracijom njegovog transformatora 1891. u Sveučilištu Columbia, uspoređujući tehnološke pomake koje je Tesla napravio prema H. R. Hertzovu otkriću elektromagnetskih valova četiri godine prije toga, te O. J. Lodgeovim pokusima s rezonantnim elektromagnetskim titrajnim krugovima. Veličanstven znanstveni doček i uspjeh na Columbia sveučilištu u New Yorku nakon Tesle, imao je početkom 1939. i drugi poznati Europljanin Enrico Fermi. Njegov dolazak i znanstveni uspjesi u Americi u eksperimentalnoj i teorijskoj fizici, podsjećaju na Teslin slučaj i njegove doprinose u fizici i elektrotehnici.

Osvrnut ćemo se i na zastupljenost Tesle i njegovih izuma i doprinosa u nastavi fizike i elektrotehnike na Sveučilištu u Zagrebu, napose u udžbenicima i radovima I. Supeka, V. Lopašića i T. Bosanca. Znanstveno-filozofski ćemo, na kraju, protumačiti Teslin interes za Goetheovom poezijom, što je stalno poticalo Teslinu težnju za izumima i spoznajom, po uzoru na Faustovu težnju za otkrivanjem novih i neiskušanih mogućnosti čovjekova života u stvarnome svijetu.

Teslino ime i njegovi izumi, kao i strast za pomaganjem čovječanstvu razvojem znanosti i tehnologije, ostaju trajnim uzorom u svjetskoj znanosti i kulturi.

L 4

Tesla's Inventions in the Fields of Physics and Electrotechnics and His Engineer Intuitions

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Inventions, engineer intuitions, and thoughts of Nikola Tesla in the both fields of physics and electrical engineering will be discussed in the presentation. Tesla's contributions to electromagnetism will be enlightened with respect to those of M. Faraday and A. A. Michelson, following by an attempt of brief characterization of the ingenious mind of each of them, respectively. A few discoveries and basic experiments in the American phase of the Tesla's work and life after 1884, which were important for the development of modern technologies, will be described. That is particularly superconducting radiofrequency science and technology (SRFS&T) where the main goal, today, is to achieve the highest possible cavity's accelerating gradient for particles in linear superconducting colliders. The beginnings of this technology were undoubtedly connected with the use of Tesla's transformer as the source of the RF–field of very high potential. The brilliant project of using Tesla's monopole antenna as the high power emitter, based on the principle of the Tesla's transformer, will be emphasized in the presentation. A modern analysis and wide analytical calculations of the Tesla's circuit with a monopole antenna as the emitter were made, in order to justify a scientific foundation of the Tesla's ideas on the wireless transmission either of energy or information as well as the electrical illumination at the long distances. A famous Tesla's lecture in 1891 at the Columbia University, with a demonstration of the Tesla's transformer with a new performances for the new revolutionary applications, will be also recalled in the presentation. Technological steps forward which Tesla made by his inventions will be figured out from a view of the history of science, by referring to the H. Hertz's discovery of electromagnetic waves four years before Tesla's lectures and famous O. J. Lodge's experiments dedicated to the resonant electromagnetic oscillations. Another famous European who had a glorious welcome at the Columbia University in the very early 1939 was Enrico Fermi. His arrival to America followed by his scientific accomplishments in both spheres of theoretical and experimental physics, pretty reminds on the Tesla's case and his contributions in physics and electrical engineering.

A special attention will be paid to the issue to what extent the Tesla's inventions and contributions are included in the courses of physics and fundamentals of electrical engineering at the University of Zagreb, by examining the text-books and papers of the three Croatian scientists: I. Supek, V. Lopašić, and T. Bosanac. At the end, by the philosophy of science approach will be tried to understand a unique Tesla's love for Goethe's poetry, which permanently gained up Tesla's seeking for inventions and knowledge according to Faust's dedication to look for a new and non-experienced options of the human life in the real World.

Tesla's name together with his inventions, as well as his obsession to help mankind by the development of science and technology, remain as the unique monument in the world's science and culture.

L 5

Teslina djela i djela o njemu u hrvatskim knjižnicama pretraživa putem online kataloga

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Čovječanstvo za svoj napredak duguje velikanima znanosti. Poslije Svjetske godine fizike 2005. posvećene Albertu Einsteinu dolazi Godina Nikole Tesle posvećena velikanu koji potječe iz Hrvatske. Možda će ove posvete velikanima pobuditi pažnju novim mladim naraštajima da prepoznaju važnost tehnički i prirodnih znanosti u sveopćem napretku čovječanstva. Danas se tehnologija toliko brzo mjenja, te se ljudi novih generacija ne stižu ni osvrnuti na temelje njenog postanka. Mobiteli, računala (kompjutori), audio i video uređaji, automobili i slični uređaji doživljavaju tako velike promjene, te mnogi ne stižu ni da upoznaju detaljne procese tih promjena. Znaju samo da je pojam tehnologije proces kojima ljudi mijenjaju prirodu da bi je prilagodili svojim potrebama.

No, međutim, bit će uvjek mladih znanstvenika koji će potražiti znanstvene informacije te se naći u knjižnicama, muzejima, arhivima u novim bazama podataka na Internetu da bi spoznali temelje znanstvenog istraživanja kako bi krenuli u daljnju nadgradnju znanost.

Upravo jedna takva specijalna knjižnica sa svojom bogatom knjižnom građom postoji u Hrvatskoj. To je Središnja knjižnica za fiziku, Prirodoslovno-matematičkog fakulteta u Zagrebu, koja datira zajedno s razvojem Sveučilišta (1874.) i u svom fondu ima vrijednu knjižnu građu iz fizike. U svom fondu posjeduje veći broj djela Nikole Tesle s osobnim potpisom samog autora. Osim toga u knjižnici se nalazi i osobno pismo Nikole Tesle, te je prigoda da se u ovoj godini predstave široj javnosti ta djela. Knjižnica posjeduje stručna djela od 1662. pa nadalje: Johannesa Keplera, Isaaca Newtona, Rogerii Josephi Boscovicha, Jamesa Watta, Michaela Faradaya, Alessandra Volta i mnoga druga. Cjelokupna knjižna građa je unesena u baze podataka i pretraživa online katalozima, što se može pogledati preko web stranice knjižnice http://www.knjiznica.phy.hr. Knjižnica se prošle godine uključila, s uspjehom, u obilježavanje Einsteinove godine postavljanjem izložbe u svojim prostorima, te istu namjeru ima i ove godine postavljanjem izložbe o Nikoli Tesli. Za ovaj skup pripremiti će se rad u kojem će se snimiti nastala knjižna građa od Tesle i o Tesli a nalazi se u hrvatskim knjižnicama.

Ovim radom želi se odaslati snažna porukom o važnosti tehničkih (elektrostrojarstva, energetike, komunikacija, teleautomatike i dr.), prirodnih (fizike, kemije, biologije i dr.), biomedicinskih, društvenih i humanističkih znanosti. Već dugo je Nacionalna akademija SAD-a dala ocjenu da će 21. stoljeće biti stoljeće interdisciplinarnosti. Ovo je, također, zgodna prilika da i ustanove koje arhiviraju i čuvaju intelektualna dobra ovog čovječanstva pokažu mladim naraštajima da znanstvena kreacija i znanstveno stvaralaštvo je nešto najvrednije u životu svakog čovjeka. Posjetom i članstvom u knjižnicu korisniku se pružaju mogućnosti usvajanja znanja drugih autora, pohranjenog u knjigama (e-knjigama), te da i oni budu graditelji knjižnica pohranom svoje građe.

L 5

Tesla's Works and Works about Tesla in Croatian Libraries, Searchable via Online Catalogue

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The mankind owes a great deal to scientists. After 2005 being a year dedicated to Albert Einstein, this year is the Year of Nikola Tesla, giving honor to the scientist coming from Croatia. Perhaps these dedications to the great physicists will draw attention of young people to the importance of natural sciences in the overall progress of mankind. Today the technology is changing very quickly, so that the new generations cannot possibly take into account all the roots of its beginnings. Cell-phones, computers, audio and visual appliances, cars and other technical equipment are going through changes from day to day, making it difficult for ordinary people to know all the details of the technology and its changing processes.

But there will always be young scientists willing to look for scientific information in libraries, museums and archives, as well as in the new databases found on Internet. Their willingness for data mining will enable them to widen their scientific horizons.

One such special library is the Central Physical Library, located on the Faculty of Science, University of Zagreb, founded in 1874. The Library has in its possession valuable documents regarding physics, dating from 1662, such as works of Johannes Kepler, Isaac Newton, Ruggero Giuseppe Boscovich, James Watt, Michael Faraday, Alessandro Volta and others. There are also a lot of Nikola Tesla's works, many of them bearing Nikola Tesla's signature, as well as a personal letter from Nikola Tesla. This year makes an important occasion to present these works to the public in general. The whole Library's collection is searchable via online catalogue, available on the Library's web page: http://www.knjiznica.phy.hr.

Last year the Library got successfully involved in celebrating Einstein's year, laying out an exhibition dedicated to Albert Einstein. This year the exhibition about Nikola Tesla will be set in the Library, presenting Tesla's valuable works, as well as the works of other authors about Nikola Tesla, that can be found via online catalogues of Croatian libraries.

This scientific and professional meeting about the life and work of Nikola Tesla will bring forward the importance of technical, natural and biomedical sciences, as well as of the social sciences and humanities. The U.S. National Academy has predicted a long time ago that 21st century will be the interdisciplinary century. The institutions archiving and preserving the intellectual goods have the opportunity to show to young people how valuable the scientific creation is. Users are motivated to widen their knowledge by reading books or e-sources, as well as to enrich the libraries by contributing their own intellectual works to them.

L 6

Prvi koraci blistave znanstvene karijere - Tesla u Budimpešti

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L 6

First steps of a glorious scientific career - Tesla in Budapest

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After his studies at the TH Graz and University Prague the young Tesla got his first job as electrical engineer in Budapest, in the capital of Hungary in 1881. No wonder, that the first place of his scientific career was just in this rapidly developing metropolis. Budapest was at that time, after the compromise between the Habsburgian monarch Franz Josef and Hungary in 1867 a gate to West for the Middle- and East-European countries, among others for Serbia and Croatia. In Budapest lived a number of famous artists, writers and scientist from that part of Europe. The Serbian minority was a very strong and liable colony in Hungary. The families, flying from the Turkish occupation to this land 200-300 years before, kept their languge and religion, nevertheless related to the Hungarian society and had Hungarian friends. Such a friendship was between the uncle of Tesla, Paja Mandic and Ferenc Puskás, the founder and builder the telephone net and exchange of the capital. They both were officers of the Austrian-Hungarian Military, but Ferenc Puskás put off the uniform and became a deputy of his brother Tivadar, the leader of the Edison-office in Paris and close friend of Edison. Mandic draw the attention of Puskás to the young Tesla. It was the starting-point of Tesla's way to America.

The Puskás Company built in Budapest not only a telephone-net, but was also an agency of the Edison Lighting Company, of the Edison-dynamos and incandescent lamps. Tesla met again with the main problem of the d.c. dynamos, the sparking of the commutators and frequent defect of the copper brushes, that he learned already by time his studies at the TH Graz. The sparking of two Gramme-machines, a d.c. generator supplying a d.c. motor at an experiment of energy transport led him to the idea of the brushless multiphase a.c. system. As he wrote in his memories, he found the solution walking in the town-park of Budapest together with his Hungarian friend and assistant Antal Szigeti. The idea of a rotating magnetic field was far from the conventional view, that couldn't imagine the electromagnetic induction without definite poles of a magnet, but as an effect of changing a magnetic field. The theory of Maxwell was known only by very few scientists. The electricians refused the application of a.c., but in Budapest the engineers of the Ganz company, at that time Károly Zipernowsky and Miksa Déri were pioneers of this technology. Their results certainly encouraged Tesla going on this unknown trail. In 1882 he went to Paris and two years later to the United States, where he realized his inventions, the multiphase energy transport and the induction motor.

L 7

Termomagnetski motor

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Među brojnim Teslinim patentima slabo je poznat patent pod nazivom "Termomagnetski motor"(N. Tesla, Thermo-Magnetic motor, USA patent No. 396121, 1889) kojeg je Nikola Tesla objavio krajem 19. stoljeća. Iza ovog naziva krije se potpuno originalan i zanimljiv toplinski stroj koji pretvara toplinsku energiju izravno u mehanički rad. Stroj radi na principu neprekidne promjene magnetske sile kojom stalni magnet privlači feromagnetski materijal. Zagrijavanjem iznad Curieve temperature feromagnet gubi svoja magnetska svojstva, a hlađenjem ih ponovo stječe. U kružnom procesu toplina prelazi s toplog na hladni spremnik preko feromagneta u magnetskom polju stalnog magneta, a kao rezultat dobivamo koristan rad.

U vrijeme kada je Tesla izdao patent nije bilo velikog interesa za takav motor, uglavnom zbog njegove male korisnosti. Puno je veću korisnost imao parni stroj. Danas, kada su razvijeni materijali s niskom Curievom temperaturom i jaki stalni magneti, Teslina zamisao postaje zanimljiva.

Osmislili smo vlastitu konstrukciju termomagnetskog motora. Konstrukciju smo poboljšavali kako bismo dobili što bolje karakteristike. Rad novorazvijenog stroja provjeren je i u praksi. Motor se sastoji od kotača na čijem je obodu žica od monela, stalnog neodimijskog magneta i izvora topline. Curieva temperatura monela, legure nikla i bakra, je oko 50 °C. U radu smo diskutirali princip rada termomagnetskog motora, izmjerili smo njegovu snagu i procijenili njegovu korisnost. Stroj je posebno zanimljiv jer može raditi i uz malu razliku temperatura između toplog i hladnog spremnika, a zbog njegove izuzetno jednostavne konstrukcije postoji mogućnost primjene u mikrotehnologiji.

L 7

Thermo-Magnetic Motor

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Among numerous Tesla's patents, the one named "Thermo-Magnetic Motor" (N. Tesla, Thermo Magnetic Motor, USA patent No. 396121, 1889) published at the end of the 19th century is poorly known. Behind this name hides the original and interesting heat engine which converts heat energy directly into mechanical work. The engine works by the continuous alteration of attractive force between the permanent magnet and the ferromagnetic material. This is achieved by heating the ferromagnet above the Curie temperature, at which it loses magnetic properties, and then by cooling it down so that it becomes magnetic again. In the closed-cycle process the heat flows from the hot to the cold reservoir and some useful work is done.

When Tesla published this patent there was no interest for this kind of engine. The steam engine was much more efficient. Today, with the development of novel materials with low Curie temperature and strong permanent magnets, this Tesla's idea becomes interesting.

We developed the prototype of the thermo-magnetic motor. The construction of the prototype has been enhanced over the time to gain the better performance, and the work of the engine has been tested. It consists of the aluminum wheel with the monel wire on the rim, the strong permanent neodymium magnet and the heat source. The Curie temperature of the monel metal, the copper and nickel alloy, is about 50 °C. We measured the power and estimated the efficiency of our prototype. In our work we discuss the physical principle of thermo-magnetic engine. What makes this engine particularly interesting is the fact that it can work with a small temperature difference between the hot and the cold reservoir, and also its possible use in micro technology applications due to its simple construction.

L 8

Borba struja od Edisona i Tesle do danas

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Moderni elektroenergetski sustavi datiraju od posljednjeg desetljeća devetnaestog stoljeća. Oni su rezultat tzv. "borbe struja" koja se u SAD vodila između pobornika istosmjerne struje - predvođenih Edisonom - i pobornika izmjenične struje - predvođenih Teslom, a potom i tzv. "konflikta sustava". Hrvatska je posredno kroz izume N. Tesle, a izravno i kroz druge izume i otkrića (npr. Hanaman), te kroz djelo graditelja prvog našeg kompletnog sustava "Krka - Šibenik" dala znatan doprinos na svjetskoj razini u tom razvoju. U radu će se prikazati pregled važnijih događaja u razvoju modernih sustava uz naglasak na Tesline doprinose u tome.

U tom razvoju neke godine su posebno važne i nezaobilazne i to redom: 1879. (Edisonov izum žarulje sa ugljenom žarnom niti), 1882. (Edisonova gradnja prvih velikih istosmjernih elektrana), 1885. (izum transformatora Derija, Blathya i Zypernowskog), 1888. (Ferrarisovo i Teslino nezavisno otkriće okretnog polja i izum asinhronog motora i Teslini patenti prijenosa i distribucije električne energije), 1889. (uvođenje trofaznog sustava Dolivo-Dobrowolskog), 1891. (Millerova demonstracija prvog trofaznog prijenosa: Laufen-Frankfurt n./M.), 1892. (izum kaveznog asinhronog motora Scotta i Lammea, tzv. konačni izum), 1895. (Adamsovo puštanje u pogon prve velike izmjenične dvofazne elektrane na Nijagari - u najvećem broju po Teslinim patentima, ali i Meichsner-Šupukovo puštanje u pogon malog, ali kompletnog sustava na bazi tranzicijskog dvofaznog generatora), 1901. (Lučić-Lucasovo otkriće velikih naftnih izvora i izumi pridobivanja nafte kao jednog od temeljnih izvora energije za pretvorbu u električnu), 1903. (Hanamanov i Justov izum žarulje sa volframovom niti, opet tzv. konačan izum) itd. Kako se vidi hrvatski izumitelji i graditelji dali su značajne doprinose, a posebno N. Tesla. Iako su se istosmjerni sustavi odupirali par desetljeća ipak su u većem dijelu proteklog stoljeća definitivno pobijedili izmjenični i to trofazni sustavi, te postali najveće tehničko dostignuće XX stoljeća.

Međutim, osnovna borba izmjenične i istosmjerne struje opet je i ponovno aktualizirana nakon skoro punog stoljeća dominacije izmjeničnih sustava. Danas temeljem novih tehnoloških mogućnosti istosmjerni prijenos velikih snaga na daljine i uz vrlo visoke napone postaje nova i već korištena alternativa, ali ono što je još u začetku i sa velikom perspektivom razvoja to su niskonaponski istosmjerni sustavi (800 V). Zanimljivo je da je u sadašnoj fazi "borbe struja" kao i u onoj početnoj jedan element sustava postaje bitan u njegovoj širokoj primjeni. U prvoj fazi spomenute borbe taj nedostajući element praktički je riješio Tesla (asinhroni motor), a sadašnje rješenje elementa koji nedostaje (jeftini niskonaponski istosmjerni prekidač!) tek se očekuje.

L 8 The "Battle of currents" from Edison and Tesla till now

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Moderm electric power systems dated from the last decades of the XIX century. They are the result of s.c. "Battle of currents" which took place in the USA between supporters of DC current - led by T. A. Edison - and supporters of AC current - led by N. Tesla, and after that as the result of s.c. "Conflict of systems". Croatia indirectly through inventions of N. Tesla and directly through other inventions (e.g.. Hanaman) and the first small complete AC system (Krka-Šibenik) gave the important contribution in that development on the world's scene. In the article will be given a review of the most important events in the development of moderm electric power systems with the stress on Tesla's contributions in it.

In the development of power systems some years are particularly important such as: 1879 (Edison's invention of incandenscent lamp with coal filament), 1882 (Edison's building of first great DC power stations),1885 (invention of transformer by Deri, Blathy and Zypernowski), 1888 (Ferraris' and Tesla's independent discovery of rotating field and Tesla's patents on transmission and distribution of electrical energy), 1889 (introduction of three-phase system by Dolivo-Dobrowolsky), 1891 (von Miller's demonstration of the first three-phase transmission Laufen - Frankfurt a/M), 1892. (invention of cage type of asinchronous motor by Scott and Lamme, s.c. final invention), 1895 (Adams' putting into operation of the first great AC two-phase power station on Niagara Falls - mostly based on Tesla's inventions, and Meichsner-Šupuk's introduction of small and complete system based on transition type of two-phase generator on river Krka), 1901 (Lučić-Lucas' discovery of great oil deposits as one important source for the transformation into electrical energy), 1903 (Hanaman's and Just's invention of tungstem lamp, again s.c. final invention) etc. As it can be seen Croatian inventors and builders have given important contributions, particularly N. Tesla. In the past century AC systems have won the "Current's battle" and become the biggest technical achievement of the XX century.

But today due to technological improvements "Battle of currents" is again in some sense on the scene. HV DC transmission is still existing alternative, but also LV DC systems (800 V) have great perspectives. It is interesting that in today's phase of "Battle of currents" again one element is missing for broader application of LV DC systems. In the past the missing element (asinchronous motor) was practicaly solved by N. Tesla, but solution for today's missing element (cheap LV switchgear) is still expecting.

L 9

Naponske i strujne prilike na isključenoj trojki dvosistemskog dalekovoda

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Prilikom isključenja jedne od dviju trojki dvosistemskog dalekovoda dok druga ostaje u pogonu, elektromagnetskom i kapacitivnom spregom inducirat će se naponi na isključenoj trojci koji u nekim slučajevima mogu biti dovoljno visoki da ugroze život osoba koje se nalaze u blizini. Stoga je potrebno izvršiti detaljnu analizu naponskih i strujnih prilika po svim fazama (a1, b1, c1, a2, b2, c2), uključujući zaštitno uže (zu) razmatranog voda za sve stupove u svim karakterističnim pogonskim stanjima. Time se istodobno eliminira mogućnost ugrožavanja života ljudi u neposrednoj blizini voda i povećava raspoloživost elektroenergetskog sustava, jer druga trojka nesmetano ostaje u pogonu. U ovom radu prezentiraju se osnove analize induciranih napona na isključenim trojkama dvosistemskih dalekovoda i rezultati provedenih proračuna. U Energetskom institutu Hrvoje Požar izrađen je programski paket "Dvostruki dalekovod - DVDV" čime je automatiziran postupak proračuna naponskih i strujnih prilika na dvostrukom dalekovodu u uvjetima isključenja jedne trojke. Rezultat ovakvog pristupa podrazumijeva slijedeće rezultate: 1) vrijednosti induciranih napona po pojedinim stupovima, 2) vrijednosti napona po svim stupovima istodobno, 3) struje po pojedinim rasponima, 4) struje kratkospojnih veza te 5) struje po pojedinim uzemljivačima stupova. To je posebno važno u pogonskim stanjima kratkog spoja u kojima naponske i strujne prilike značajno odstupaju od nazivnih vrijednosti, pa je opasnost za živote ljudi i raspoloživost sustava značajno povišena. Ovim postupkom se određuje najpovoljnije mjesto na trasi za uzemljenje druge (isključene) trojke kako bi se osigurale najniže vrijednosti induciranih napona duž trase i povećala sigurnost osoblja. Prikazani su konkretni rezultati provedene analize za karakteristične vodove u hrvatskom elektroenergetskom sustavu (Konjsko - Bilice 220 kV, Zakučac Đ Meterize 110 kV), čime se potvrđuje neophodnost ovako detaljnog pristupa u cilju eliminiranja mogućnosti ugrožavanja života ljudi u neposrednoj blizini voda i povećanja raspoloživosti elektroenergetskog sustava.

L 9

Voltage and Current Analysis Of Phase Disconnection Of Double Circuit Overhead Line

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Due to phase disconnection of double circuit overhead line inducted voltages appear on disconnected circuit. Voltage induction is based on electromagnetic and electrostatic relationship between two circuits. In some operational cases inducted voltages are high enough to present life danger for people that are close to the line. So it is necessary to perform detailed voltage and current analysis on all three phases (a1, b1, c1, a2, b2, c2), including zaštitno uže (zu) for all line towers in all operational system states. Using this approach possible life danger is eliminated and system reliability is increased simultaneously, because second circuit can be safely in operation. This paper presents basics of theory of induced voltage in the case of single phase disconnection of double circuit line as well as results of performed study. Software package "Double circuit line - DVDV" is developed in Energy Institute Hrvoje Požar. Using this software the process of evaluation of voltage and current profiles on the given line is user friendly. This procedure gives the following results: 1) induced voltages values on all line towers, 2) voltage values on all towers simultaneously, 3) currents on all line sections, 4) short circuit connection currents, 5) currents on all tower groundings. It is especially important in operational conditions with short circuit when voltages and currents are significantly different than respecting nominal values. Accordingly, life danger and system reliability problems are significantly increased. This procedure gives the most suitable location for grounding of second (disconnected) circuit over the whole line trace, which means the lowest values of induced voltages over the line. Also existing typical lines in Croatian power system are tested (Konjsko - Bilice 220 kV, Zakučac - Meterize 110 kV) and results are given in the paper.

L 10 Topljenje i zagrijavanje metala u elektromagnetskom polju

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Osim njegovih glavnih otkrića, u radu Nikole Tesle ima i niz izuma koje nije patentirao i posebno isticao. Tako je, primjerice, otkrio hlađenje transformatora u ulju, Rentgenske zrake, metode mjerenja vrlo visokog napona i frekvencije, indukcijsko taljenje metala, neonsku rasvjetu i niz drugih rješenja. Odlučili smo se da obradimo temu indukcijskog grijanja i topljenja metala koja danas ima značajno mjesto u obradi metala sa stanovišta kvalitete i uštede energije. Pri izboru teme imali smo u vidu da se tim područjem u našoj sredini vrlo intenzivno bavio jedan od naših najboljih poznavalaca Nikole Tesle, pokojni akademik, prof. Tomo Bosanac. On je konstruirao nekoliko vrlo uspješnih uređaja od kojih je većina i danas u funkciji. Uspješan razvoj tog područja omogućen je zahvaljujući poluvodičkoj tehnici, odnosno razvoju tranzistora i tiristora za velike snage i visoke frekvencije pomoću kojih se grade razni VF generatori. Tesla je prvi pokazao kako se indukcijski tope metali, a današnji uređaji mogu vrlo uspješno i brzo zagrijavati dijelove metala pa i vrlo tanke slojeve, a da ostali dijelovi pritom ostanu hladni. Teoretsko objašnjenje tog fenomena zasniva se na induciranju vrložnih struja, odnosno dubini prodiranja elektromagnetskog vala u vodič. U daljnjem dijelu ovog rada bit će dane teoretske postavke tog fenomena.

L 10 Melting and heating of metals in electromagnetic field

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Except his main inventions, Nikola Tesla had many findings which are not specially emphasized or patented. For example, he invented an oil cooling of transformers, X-rays, methods of measuring very high voltages and frequencies, induction melting of metals, neon lighting and series of many other solutions. We decided to discuss the induction heating and melting of metals, which is important topic in the domain of its industrial treatment linked to quality and energy saving. In the selection of topic, we bore in mind that one of the best connoisseur of Nikola Tesla, our deceased academician prof. Tomo Bosanac, had very intensive preoccupation in this subject. He was successfully developed several devices, and most of them are still in function today. Prosperous evolution of this area is enabled owing to semiconductor technic, particulary to development of high-frequency power transistors and tyristors, which are utilized in various HF generators. Tesla takes the lead in showing how metals can be melted by induction heating, and today's modern devices can very successfully and quickly heat the sections or very thin layers of metal structures, while its other parts stay cold. The theoretical explanation of this phenomenon is based on induction of eddy currents, in other words penetration depth of electromagnetic wave into the conductor. In additional part of this paper, the theoretical thesis of this phenomenon would be shown.

L 11

Reprodukcija efekta skalarnog vala Teslinog Wardenclyffe tornja

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L 11

Reproduction of the scalar wave effects of Tesla´s Wardenclyffe Tower

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The power transmission of longitudinal electric waves will be presented by a small boat moving only by Tesla radiation, without battery or cable connection.

It is a historical experiment, because already 100 years ago the famous experimental physicist Nikola Tesla has measured the same wave properties. From him stems a patent concerning the wireless transmission of energy[1]. Since he also had to find out that at the receiver arrives more energy, than the transmitter takes up, he spoke of a „Magnifying Transmitter".

By the effect back on the transmitter Tesla sees, if he has found the resonance of the earth and that lies according to his measurement at 12 Hz. Since the Schumann resonance of a wave, which goes with the speed of light, however lies at 7.8 Hz, Tesla comes to the conclusion, that his wave has 1.5 times the speed of light[2]. This has to be the group velocity, if energy is transported wirelessly!

As founder of the diathermy Tesla already has pointed to the biological effectiveness and to the possible use in medicine. The diathermy of today has nothing to do with the Tesla radiation; it uses the wrong wave and as a consequence hardly has a medical importance.

Scalar waves, normally remaining unnoticed, are very interesting in practical use for information and energy technology for reason of their special attributes[3].

Literature

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L 12

Tesla kroz viziju komunikacija

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Nikola Tesla je najšire prihvaćen kao vizionar u području električne energije, jer je to područje u kojem su njegovi patenti naišli na najbržu i najučinkovitiju primjenu. No, također je dobro poznat njegov značajan doprinos u području komunikacijskih postupaka, posebno kroz patente i ideje u domeni bežičnog prijenosa. Danas gotovo svi primjenjujemo bežične komunikacijske uređaje i modele komuniciranja. Za svoj bežični sustav Tesla je 1900. godine napisao: „Nemam dilemu da će se sustav pokazati vrlo uspješan u prosvješćenju širokih masa, zasigurno u manje razvijenim zemljama i teže dostupnim regijama, te da će povećati opću sigurnost, prikladnost i održivost miroljubivih odnosa". Kompanija Ericsson Nikola Tesla je ostvarila globalnu prepoznatljivost noseći ime tog priznatog svjetskog inovatora i u svoje je poslovanje ugradila težnju za stalnim unaprjeđenjem komunikacijskih mogućnosti na dobrobit čovječanstva. Udruživanjem imena Nikole Tesle s imenom Larsa Magnusa Ericssona, poduzetnika poznatog po primjeni inovacija u telefoniji, predstavljena je vrlo zanimljiva sinergija koja služi kao podloga komunikacijske sadašnjice i pokušaj zavirivanja u budućnost.

U radu će biti predstavljena kratka povijest razvoja mobilnih komunikacija i dana analiza tehnološke osnove koja je osigurala masovnu primjenu bežićnog prijenosa (Global System for Mobile Communications - GSM, Universal Mobile Telecommunication System - UMTS). Rad će pružiti uvid sve rasprostranjeniji komunikacijski model kojega karakterizira maksimalna dostupnost i upotreba raznih pristupnih tehnologija kao što su Bluetooth, Wireless Local Area Network - WLAN, Radio Frequency Identification - RFID te mrežne okosnice koja, na neki način, već danas pruža dobar tehnološki temelj za razmatranje komunikacijskog grida, usporedivog s Teslinom vizijom elektroenergetskog grida. Za kraj, rad predstavlja neke potencijalne komunikacijske modele koji bi u potpunosti mogli ostvarivati ideju komunikacijskog grida, čime bi se pokazala bit i stvarna vrijednost Tesline izjave iz 1900. godine.

L 12

Nikola Tesla from the aspect of communication

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Nikola Tesla is perceived as a man of vision, especially when it comes to electrical power because in that area his patents found the fastest and most effective implementation. We also know that his contribution in patents and ideas was significant in the field of communication procedures, especially in wireless transmission. Today most of us are involved in an overall wireless communication and the use of wireless communication models and equipment. In 1900 he wrote about his wireless system: "I have no doubt that it will prove very efficient in enlightening the masses, particularly in still uncivilized countries and less accessible regions, and that it will add materially to general safety, comfort and convenience, and maintenance of peaceful relations". The company Ericsson Nikola Tesla that carries his name acquired a global recognition as it incorporated in its activities the desire to permanently improve communication for the good of mankind. The united names of Nikola Tesla and Lars Magnus Ericsson represent an interesting synergy enabling us to show the present and perhaps the future of communications.

The paper provides a short history of mobile communication development and it analyzes the technological basis that enabled a widespread implementation of wireless transmission (Global System for Mobile Communications - GSM, Universal Mobile Telecommunication System - UMTS). The paper also analyzes the omnipresent and always available communication model realized through the use of various technologies, such as Bluetooth, Wireless Local Area Network - WLAN, Radio Frequency Identification - RFID and network backbone, so that technologically we may use the term communication grid, similar to the vision Tesla had about electrical power grid. Additionally, some possible communication models are analyzed that could fulfill the concept of communication grid and to prove essence and validity of Tesla's statement from 1900.

L 13 Upravljanje inovacijama - osnova uspješnoga razvoja

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Izumi Nikole Tesle promijenili su svijet. Danas kada se tvrtke na različitim tržištima, pa tako i telekomunikacijskom, konstantno i sve oštrije bore za svoj udio, sposobnost produkcije inovacija, u kojoj je Tesla bio pravi majstor, postala je ključna odlika po kojoj se uspješne tvrtke razlikuju od onih neuspješnih. Stoga su suvremene tvrtke, pa tako i korporacija Ericsson, razvijanje inovativne kulture prihvatile kao jednu od temeljnih strateških odrednica svojega djelovanja.

Međutim, inovator u današnjim tehnološkim i tržišnim uvjetima više ne može uspješno djelovati sam. Podrška razvoju inovacija treba biti organizirana aktivnost, proces s točno određenim i planiranim koracima koje poduzimaju timovi stručnjaka i inovatora. Takav sustav upravljanja inovacijama implementiran je i u Ericssonu Nikoli Tesli, tvrtki koja s ponosom, pored Teslinog, nosi i ime velikog švedskog poduzetnika iz čije se radionice za popravak telegrafa razvila današnja korporacija. Da bi bila uspješna u upravljanju inovacijama tvrtka njeguje pobjedničku kulturu utemeljenu na maksimalnom iskorištavaju sinergije kompanijinih stručnih kompetencija.

Primjer uspješne inovacije stručnjaka Ericssona Nikole Tesle je ideja implementacije protokola za pokretanje sesije (SIP - Session Initiation Protocol)) u tradicionalnom AXE sustavu. Na osnovu te ideje izveden je prototip koji je pobijedio na internom Ericssonovom natjecanju, a ideja je kasnije urodila razvojem produkta na kojem je godinu dana radilo preko 100 kompanijinih stručnjaka. Rad daje pregled nove slojevite arhitekture telekomunikacijske mreže s naglaskom na moguće implementacije SIP protokola koji je postao jedan od najvažnijih protokola u svijetu današnjih telekomunikacija.

L 13

Innovation management as a base for successful development

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Nikola Tesla's inventions changed the world. Today, when in various markets, including the telecom market, companies continually and aggressively compete for their market share, the ability to produce innovations, which Tesla mastered brilliantly, is the key factor in differentiating the successful and unsuccessful companies. To develop and maintain a company culture favoring innovative approach is the main strategic guideline of any modern company, the Ericsson Group included.

However, an innovator in today's technological and market conditions can no longer act on his own. Handling and supporting innovations should be organized activities, a process with recognized steps practiced by teams of experts and innovators. Such innovation management system has been implemented in Ericsson Nikola Tesla, the company that in its name unites the great inventor Nikola Tesla and the successful entrepreneur Ericsson who laid the foundations of the Ericsson Corporation. To be successful in innovation management, the company nurtures the winning spirit that motivates project teams to maximize the synergy of the competencies of the company's experts.

An example of a successful innovation by experts of Ericsson Nikola Tesla is the implementation of the Session Initiation Protocol (SIP) in the conventional AXE system. Based on this idea, a prototype was elaborated that won the internal Ericsson contest. The further step was product development, which involved over one hundred company's specialists who worked on the project over one year. The paper gives a survey of the new layer architectures of telecom network with emphasis on SIP that has become major protocol in the world of contemporary telecommunications.

L 14

Smjernice razvoja konvergentnih mreža i buduće generacije mreža

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L 14

Evolution Trends of the Converged Networks and Next Generation Networks

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The evolution strategy of the converged networks towards the Next Generation Network (NGN) architecture will be presented in the contribution. The up to date outputs and results of the standardization institutions: International Telecommunication Union Đ Telecommunications (ITU-T) and European Telecommunication Standards Institute (ETSI) in the area of the converged networks and NGN, as well as the research and development activities and trends of main Information and Communication Technologies (ICT) producers were taken into account in the formulation of migration scenarios and development processes of the possible conception of the future NGN architecture.

Using the actual NGN conceptual model the distributed conception of the NGN architecture (individual network layers) will be shortly described.

The process of the interworking of two different types of network platforms (circuit switched connection oriented and packet switched connection less) has to be solved to create the unified NGN platform. The vision how to create the pure optical packed network at the transport level will be also presented in the contribution.

There are several requirements at each level of the NGN conceptual model, which have to be solved:

- connection control at the transport and signaling levels,
- access reference points (at the transport layer),
- protocol platforms,
- signals and protocols conversion,
- routing,
- network management,
- quality of service (QoS),
- information and network security,
- resources sharing, etc.

The conception of the application layer, as well as the portfolio of NGN services and applications (service architecture, service capabilities, development, deployment and provisioning of NGN services) will be described in the contribution.

As the case study, the developed reference architecture of the converged ICT infrastructure of the Slovak Republic based on NGN will be presented. This reference architecture is the output of the research and development project granted by Slovak Government within the State programme "Building of information society".

L 15

Modeliranje Teslinog odašiljača pristupom preko teorije antena

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U radu je predložen matematički model zračenja Teslinog odašiljača [1], [2]. Zračeći dio Teslinog odašiljača opisan je primjenom ekvivalentne monopol antene napajane idealnim strujnim izvorom kojim se zamjenjuje Teslin transformator. Formulacija problema zasniva se na teoriji žičanih antena i homogenoj Pocklingtonovoj integro-diferencijalnoj jednadžbi u frekvencijskom području [3]. Numeričkim rješavanjem Pocklingtonove jednadžbe primjenom Galerkin-Bubnovljeve inačice metode rubnih elemenata dobiva se raspodjela struje uzduž ekvivalentne monopol. Poznavanje raspodjele struje po anteni omogućava proračun izrađenog električnog polja integrirajući induciranu struju uzduž žice. U radu su izloženi ilustrativni numerički rezultati za raspodjelu struje po anteni i pripadno polje. Ovaj rad treba smatrati uvodom u problematiku, odnosno prvom stepenicom u izradi preciznog modela Teslinog odašiljača.

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[3] D. Poljak, Electromagnetic Modelling of Wire Antenna Structures, WIT Press, Southampton Boston, 2002.
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L 15

Modeling of Tesla's Transmitter using the Antenna Theory Approach

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Mathematical model of the radiation from Tesla's transmitter [1], [2] is proposed in this work. The radiating part of the Tesla's transmitter is represented by an equivalent monopole antenna which is end-driven via ideal current source replacing the Tesla's transformer. The formulation is based on the wire antenna theory and homogeneous Pocklington integro-differential equation in the frequency domain [3]. Solving the Pocklington equation numerically via the Galerkin Bubnov variant of the Indirect Boundary Element Method (GB-IBEM) [4] the current distribution along the equivalent monopole antenna is obtained. Knowing the current distribution on the antenna the radiated electric field is readily obained integrating the induced current along the wire. Some illustrative computational results for the antenna current and related field is presented in the paper. This work should be regarded as an opener to this subject, i.e. the first step in the full wave model of the Tesla's transmitter.

LITERATURA

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L 16

Osnovni sustav radiokomunikacija - izum radija

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Nikola Tesla je prvi u svojim istraživanjima i patentima postavio temeljne postavke onoga što danas nazivamo radijskim komunikacijama, bez obzira što su za daljnji razvoj radija vrlo značajan doprinosi imali A. S. Popov, G. Marconi i E. Branly. Već 1893. god. na Franklinovu institutu u Philadelphiji Tesla je u znamenitom predavanju predložio da se za bežični prijenos signala upotrijebe signali proizvedeni visokofrekvencijskim električnim strujama. U osnovnom patentu br. 649 621, Apparatus for transmission of electrical energy koji je prijavio 1897. god., a odobren je 1900. god., Tesla je postavio osnove radija. Iako su njegova istraživanja bila usmjerena na bežični prijenos električne energije, u obrazloženju patenta sam kaže kako će uređaji imati i druge korisne primjene, kao što je na primjer prijenos signala. Dok je svima drugima, kojima se pripisuje izum radija, radio bilo glavno područje zanimanja, za Teslu je prijenos signala bilo samo nešto usputno i samo po sebi razumljivo. U svojim prvim istraživanima Tesla je postavio osnovna načela radija: odašiljač i prijamnik moraju biti u električnoj rezonanciji. Time je riješio problem istodobnog rada više uređaja za bežićnu telegrafiju, a poslije i bilo kakvih drugih sustava za prijenos informacija električnim putem. U tim prvim patentima postavljena su i četiri osnovna načela radija:

1. za bežićni prijenos upotrebljavaju se struje visoke frekvencije, pa je osnovni dio uređaja visokofrekvencijski oscilator,
2. sustav sadrži četiri usklađena titrajna kruga, dva u odašiljaču, dva u prijamniku, a u vanjskim su titrajnim krugovima odašiljača i prijamnika antena i uzemljenje,
3. svi titrajni krugovi odašiljača i prijamnika su u rezonanciji,
4. u prijamniku su osjetljivi uređaji za opažanje visokofrekventnih struja.

Radiotehnika kao jedna od najmlađih grana elektrotehnike, razvijala se od samog početka pa sve do danas velikom brzinom. Već 1924. god. Hrvatski su radioamateri osnovali prvi radio-klub u Zagrebu i organizirali "podizanje radiofonijske postaje u Zagrebu", pa je samo tri desetljeća poslije prvih Teslinih izuma koji su postavili temelje radio komunikacija 1926. počeo odašiljati Radio Zagreb.

L 16

The Fundamental System of Radio Communication - Invention of Radio

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Nikola Tesla in investigations and patents was the first who established fundamentals what we call today radio communications, irrespective of further development of radio communication, which contribution had A. S. Popov, G. Marconi and E. Branly. In 1893 Nikola Tesla in well-known presentation in Franklin Institute in Philadelphia had proposed to use high frequencies electrical current for wireless transports of signals. In basic patent Apparatus for transmission of electrical energy, which applied 1897 and ratified 1990 Tesla establish fundamentals of radio communications. Though his investigations were wireless transmitting power, he said that this system could be used even for transmitting signals. For other investigators radio communications were priority in investigations, but for Tesla wireless transmitting signals were side effect. In first investigations Tesla established fundamentals of radio communications: transmitter and receiver has to be in electrical resonance. Whit this statement, he solve a problem how work simultaneous several equipments for wireless telegraphy, and later for all electrical systems for wireless transmission of signals. In his investigations he made four fundamental postulates of radio communications:

1. Use high frequencies for wireless transmission, and basic equipment is high frequency oscillator
2. System is based on four circuits tuned in resonance, two in transmitter and two in receiver. Secondary resonance circuits are connect to earth and antenna
3. All circuits have to be in resonance
4. There are sensitive equipments in receiver for detecting high frequencies currents

Radio communications had very fast progress. Croatian radio amateurs 1924 established 1924 first radio club in South-East Europe and started to organize first commercial radio station-Radio Zagreb. Thirty years after first Tesla investigation of radio, 1926. Radio Zagreb was the first radio station to broadcast in Southeast Europe.

L 17

Od Teslinih izuma u području radiokomunikacija do digitalnog radiodifuznog odašiljanja za multimedijske usluge

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Nikola Tesla je bio izumitelj, fizičar, elektrotehnički i strojarski inžinjer. Tesla je bio genije u području elektrotehnike. Teslini pronalasci u području radiokomunikacija započeli su sa eksperimentima kako bi si sam objasnio pojavu visokofrekvencijskih struja. U Engleskoj 1873. Maxwell je teoretski rješio propagaciju elektromagnetskih valova. Maxwell je matematički postavio da svjetlo mogu biti elektromagnetski valovi koje je on definirao sa izrazima poznatim kao "Maxwellove jednadžbe". U 1888. Heinrich Hertz potvrdio je eksperimentalno da električna iskra širi elektromagnetske valove u prostor koji se pojavljuju na svim frekvencijama. Nekoliko godina kasnije Tesla je pokazao sistem bežične komunikacije na nižim frekvencijama koje su omogućile komunikaciju na veliku udaljenost. Danas mi znamo da elektromagnetski valovi prodiru duboko u atmosferu i da se mogu promatrati televizijske slike koje su odaslane sa Mjeseca na Zemlju.

Tesla je nastavio sa eksperimentima na visokim frekvencijama i osvjetlio je vakumsku cijev s bežično odaslanom energijom kroz zrak 1890. godine. U 1891. godini Tesla je patentirao zavojnicu nazvanu Teslina zavojnica, i objasnio je sistem bežičnog komuniciranja i razvio je visokofrekvencijski oscilator, koji može odaslati i primiti snažne radio signale pomoću antene. Taj pronalazak je i danas još u upotrebi u svim radiodifuznim odašiljačima.

U 1918. godni započinje elektronička era sa strujama visokih frekvencija koje se mogu generirati pomoću visoko naponskog upravljanja mrežice vakumskih cijevi, omogućujući dobivanje visokih frekvencija. Jedan od tih pronalazaka je amplitudo moduliran visokofrekvencijski signal za radiodifuzno odašiljanje u 1924. godini.

Krajem 20. stoljeća započela je primjena tehnologije digitalnog signala u području odašiljanja. Ta nova tehnologija omogućila je razvoj mobilnih sustava, računarske tehnologije, digitalnog radiodifuznog odašiljanja i multimedijskih usluga. Sva ta nova tehnologija bila su Teslina razmišljanja - Teslin san, koji se danas ostvario.

L 17

From Tesla's Inventions in the Field of Radiocommunications to Digital Broadcasting for Multimedia Services

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Nikola Tesla was inventor, physicist, electrical and mechanical engineer. Tesla was genius in the field of electrical engineering. Tesla's Inventions in the field of radio communication starts with experimentation to explore himself a phenomenon of high frequency electricity. In England in 1873 Maxwell theoretically predicts electromagnetic waves. Maxwell found mathematically that light could be electromagnetic waves which he defined with " Maxwell equations". In 1888 Heinrich Hertz from Germany confirm with experiments that an electric spark propagates electromagnetic waves into space which could exist at all frequencies. Some years letter Tesla presented wireless communication system at lower frequencies which made long distance communication possible. Today we known that electromagnetic waves penetrate deep into space and it is possible to see television images which was transmitted from the Moon to the Earth.

Tesla continue with experiments with high frequency and he illuminated in 1890 a vacuum tube wirelessly transmitted energy through the air. In 1891 Tesla patented Tesla coil, and explained a wireless communication system and developed high frequency oscillator, which could transmit and receive powerful radio signals over antenna. This development is still in use in all broadcasting transmitters today.

In 1918 started electronic age and high frequency currents could be generated by help of high voltage grid control vacuum tubes, making higher frequencies possible. On this invention around 1924 the amplitude modulated radio communication high frequency signal was possible, for broadcasting transmission.

At the and of 20th century started digital signal technology in transmission field. This new technology enabling development of mobile systems, computer technology, digital television broadcasting and multimedia services transmission. All this new technology was Nikola Tesla's dream and this dream is now reality.

L 18 O modeliranju Teslinih odašiljača prijenosnom linijom

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U ovom članku analizira se modeliranje prijenosnom linijom (TL) raznih Teslinih odašiljača. Spomenuti model je izuzetno prikladan za opisivanje rezonantnih sklopova, imajući na umu da je u takvim sklopovima disipacija uslijed elektromagnetskog zračenja koje se odvaja od strujnog kruga vrlo mala, a može se promatrati kao gubitak snage. No, i taj gubitak može se ugraditi u TL model uvođenjem imaginarnog induktiviteta i kapaciteta u shemu kruga. S pomoću ovog modela daju se simulirati mnogi zanimljivi efekti u rezonatoru pa se on kao takav pokazuje vrlo korisnim pri dizajniranju takvih naprava. Primjerice karakteristika stojnog vala, omjer povećanja, raspodjela struje u dijelovima rezonatora koji su otvoreni za elektromagnetsko zračenje itd. lako se dobivaju takvom analizom. Ovaj model ima svoja ograničenja u primjeni; primjerice ukoliko se nekoliko prostornih modova propagira kroz promatranu strukturu, svaki od njih mora se zasebno modelirati. To znači da se svaka TL reprezentacija mora primjenjivati pažljivo, u skladu s geometrijskim i električnim karakteristikama strukture. Uobičajeni TL model koji uključuje koncentrirani izvor na jednom kraju linije nije međutim dostatan za objašnjenje cijele Tesline opreme; primjerice određene karakteristike stojnog vala ne mogu se u potpunosti objasniti takvim modelom. Stoga, umjesto koncentriranog izvora, za odgovarajuće Tesline naprave upotrijebit će se TL model s raspodijeljenim naponskim izvorom. U tom modelu mali segment linije sadrži izvor napona uslijed indukcije. Taj se napon može promatrati kao posljedica konstantne izmjenične struje koja teče sekundarnim namotajem uslijed aktivnosti u primarnom krugu. Pri tome se pretpostavlja da su primarni i sekundarni krug slabo spregnuti, što omogućava slobodno osciliranje u sekundaru. Spomenute karakteristike stojnog vala lako se dobivaju korištenjem takvog TL modela. Štoviše, TL analizom antena korištenih u Colorado Springsu (str. 198, Colorado Springs Notes) koja slijedi, pokazano je da se raspodijeljeni naponski izvor može zamijeniti s koncentriranim smještenim u čvoru naponskog stojnog vala, koji razdvaja promatrani rezonator na dva dijela koja osciliraju na istoj rezonantnoj frekvenciji. U svezi s tim, zanimljivo je primijetiti smještaj primarnog u odnosu na sekundarni namotaj pri čemu se da zaključiti da je smješten u ili blizu čvoru stojnog vala. Pri svojim proračunima Tesla nije koristio diferencijale, a ova analiza jasno pokazuje da je njegov pristup u potpunom skladu s TL koncepcijom.

L 18

Some Notes on Transmission Line Representations of Tesla's Transmitters

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In this paper, we analyse the transmission line (TL) representations of various Tesla's transmitters. This type of modelling is very suitable for description of resonator circuits, as in such arrangements the dissipation caused by electromagnetic radiation detached from the circuit is very small, and can be regarded as loss. And even such a waste of power can be incorporated in a TL model by introducing imaginary capacitances and inductivities in the circuit scheme. With this model it is possible to simulate many interesting resonator effects and as such it may be very useful in designing such apparatus. For instance, the standing wave pattern, magnification ratio, current distribution on the resonator parts open to electromagnetic radiation, etc. are easily obtainable by such an analysis. However, this model has its limitation, for instance, if several spatial modes propagate through examined structure, every electromagnetic mode must be modelled separately. This means that every TL representation must be carefully applied in accordance to the geometrical and electrical characteristics of the structure. The most common TL model that incorporates a lumped source on one end of the line is however not sufficient to explain all Tesla's equipment, e.g. the various standing wave patterns obtained. Therefore instead of the lumped source, for the corresponding Tesla's apparatus we are going to employ a TL model with distributed voltage source on the line. In this model a small line segment contains a voltage source due to the induction. This voltage can be viewed as a consequence of the constant alternate current that flows through the secondary circuit due to the activity of the primary. It is assumed that the primary is loosely coupled to the secondary, which permits the secondary to vibrate freely. All the standing wave characteristics of the Tesla's resonators are easy obtainable by such a TL model. Moreover, from the analysis of the antennas used in Colorado Springs (p. 198 of Colorado Springs Notes) by TL models that follows, it is shown that the distributed voltage source can be exchanged by a lumped one settled in the standing wave node, which divides the resonator on two parts that resonate on the same frequency. In relation to this, it is interesting to note the settlement of the primaries in the arrangements, where it seems that the primary coil is settled at or near the assumed node of the secondary. In his calculations Tesla never used differentials and this analysis clearly shows that his approach is fully in accordance to the TL concept.

L 19

Jedan aspekt modeliranja radio kanala pogodan za estimaciju parametara fedinga

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U teorijskom i praktičnom smislu postoje različiti pristupi za procjenu amplitudskog koeficijenta fedinga i uglavnom tretiraju pojedinačne modele sa dominantnim multipath fedingom. Većina rješenja je bazirana na modelima koji najčešće koriste pilot signal ili pilot simbol. U prvom slučaju odgovarajuće rješenje koristi faznu petlju u konstelaciji tzv. koherentne automatske regulacije pojačanja. Ovdje postoje dva dodatna problema: korištenje pilot signala sa energetske tačke gledišta je problematično i ovaj estimator ima izrazite funkcionalne probleme pri vrijednostima odnosa signal/šum < 10 dB. U drugom slučaju, korištenje pilot simbola podrazumjeva da se u sekvenci predajnih simbola periodično umeće poznata sekvenca od nekoliko simbola, pa se na prijemu, na osnovu njene analize procjenjuje vrijednost za dubinu fedinga. Novija rješenja tretiraju ovu problematiku sa aspekta on-line mjerenja koeficijenta dubine fedinga pri prenosu digitalnih signala koji imaju konstantnu obvojnicu (modulacije tipa PSK i CPM). Poznato je, da se takvi mjerači mogu sintetizovati po ML (maximum likelehood) kriteriju ili na intuitivnoj osnovi. Međutim, za oba pristupa postoje tri istovjetna ograničenja: raspoloživi su samo za određene konstelacije digitalnih signala; neefikasni su pri malim vrijednostima odnosa signal/šum (<5 dB) i rade na bazi jednog uzorka po simbolu, a za adekvatnu procjenu patrebno je reda 10 uzoraka.
U radu je, pretpostavljajući opšti slučaj modela radio kanala gdje je prenos podvrgnut kompleksom aditivnih i multiplikativnih smetnji, obrađen aspekt analitičkog modeliranja istoga pogodan za estimacije parametara fedinga. Ovakav pristup analitičkog modeliranja kanala i estimacije parametara fedinga testiran je na aktuelnim modulacijskim formatima. U rješavanju problema korišteno je novo eksplicitno analitičko rješenje za funkciju gustine vjerovatnoće kompozitne obvojnice pri simultanom djelovanju promjenljivog Nakagami brzog fedinga i sporog, shadowing, fedinga koje uzima u obzir alternativnu aproksimaciju na bazi gama-raspodjele. Predloženi model estimacije parametara fedinga predstavlja relativno jednostavno rješenje koje bazira na simultanom procesiranju radio signala i koje nije vremenski zahtjevno.

L 19

An aspect of radio channel modeling suitable for estimation of fading parameters

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Theoretically and practically there are different approaches for estimation of amplitude coefficient of fading and those mainly deal with individual models with dominant multi-path fading. Most solutions are based on the models which mainly use pilot signal or pilot symbol. In the first case, appropriate solution uses phase loop in constellation of, so called, coherent automatic regulation of amplification. It has two additional problems in it: usage of pilot signal from energetic point of view is problematic and this estimator has evident functional problems with rates signal/noise which are < 10 dB. In the other case, usage of pilot symbol means that in the sequence of transmitting symbols, familiar sequence of several symbols is being inserted, so according to its analysis the value of the fading depth is estimated at the recipient side. Latest solutions treat this issue from the aspect of on-line measuring of fading depth coefficient during transmission of digital signals with constant envelope (modulation type PSK and CPM). It is known that such measurers could be synthetized by either ML (maximum likelyhood) criterion or intuitively. However, both approaches have three identical limitations: available only for specific constellations of digital signals; non-efficient at small values of rate signal/noise (< 5dB) and work on the basis of one sample per symbol although adequate estimation requires up to 10 samples.

By assuming a general case of radio channel model where the transmission is subject to the complex of additive and multiplicative disturbances, this paper describes the aspect of analytical channel modeling for estimation of fading parameters. Such an approach of analytical channel modeling and estimation of fading parameters is tested on actual modulation formats. In solving the problem, a new explicit analytical solution for function of probability density of composite envelope under simultaneous activity of changeable Nakagami fast fading shadowing fading that takes into account alternative approximation on the basis of gamma-distribution is used. The proposed model of fading parameter estimation is relatively simple solution based on simultaneous processing of radio signals and it is not time consumed.

L 20

Primjena naprednog enkripcijskog standarda u implementaciji virtuelnih privatnih mreža

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Ovaj rad se bavi implementacijom naprednog enkripcijskog standarda (AES), u protokolima za autentikaciju i enkripciju, u cilju kreiranja sigurnih konekcija, baziranih na protokolu za komunikaciju od tačke do tačke (PPP). Predloženo rješenje kreira konekcije, čiji je nivo sigurnosti određen nivoom sigurnosti samog AES-a. AES, takođe poznat i kao Rijndael, je simetrični blok enkripcijski algoritam, koji je usvojen kao standard od strane američke vlade. AES se može efikasno koristiti kod autentikacije, enkripcije i generisanja ključeva, pa je stoga podesan za primjenu u PPP konekcijama, u cilju implementacije virtuelnih privatnih mreža (VPN). VPN je privatna računarska mreža, koja se uspostavlja kroz javnu telekomunikacijsku infrastrukturu (Internet). Privatnost, tj. sigurnost i zaštićenost komunikacije korisnika se postiže korištenjem tuneliranja i sigurnosnih procedura. Trenutno u praksi postoji nekoliko rješenja VPN mreža baziranih na enkripciji. Pomenuta rješenja su osporavana, kako sa aspekta sigurnosti koju osigurava upotrijebljeni enkripcijski algoritam, tako i sa aspekta implementacije. U ovom radu iznesen je prijedlog korištenja Rijndael algoritma u procesu autentikacije korisnika, odnosno implementacija PPP Rijndael Challenge Handshake Authentication Protocol-a (PPP RCHAP-a). Takođe, predloženo je korištenje AES-a kao enkripcijskog algoritma u PPP-u. Iako AES može da koristi više blok modova, ovdje je opisana samo upotreba Electronic Codebook (ECB) i Cipher-Block Chaining (CBC) moda, pri čemu je moguća upotreba svih dužina bloka i ključa.

L 20

Application of Advanced Encryption Standard in Virtual Private Networks implementation

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This paper considers implementation of Advanced Encryption Standard (AES) in authentication and encryption protocols in order to create secure connections based on Point-to-Point Protocol (PPP). Suggested solution creates connections whose security level is determined by that of AES. AES, also known as Rijndael, is a symmetric block cipher adopted as an encryption standard by the US government. AES can be efficiently used in authentication, encryption and key generation, therefore it is applicable for use in PPP connections implementing Virtual Private Networks (VPNs). VPN is private computer network which is set up through public telecommunications infrastructure (Internet). Privacy, i.e. communication security and protection is achieved using tunneling and security procedures. Current encryption-based solutions for VPNs are derogated in both security and implementation aspects. This thesis suggests use of Rijndael algorithm in user authentication process, i.e. implementation of PPP Rijndael Challenge Handshake Authentication Protocol (PPP RCHAP). Also, it is suggested to use AES as an encryption algorithm in PPP. Although AES can use multiple block cipher modes, this thesis only describes use of Electronic Codebook (ECB) and Cipher-Block Chaining (CBC) modes, with all block and key lengths permitted.

L 21

Utjecaj različitih modela slabljenja na vjerovatnost greške u kanalu pod utjecajem sporog fadinga i promjenjivog Nakagami-m fadinga

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Kako bi se izvršila analiza kvaliteta prenosa u uslovima gdje su prisutne fluktuacija amplitude signala koje se razlikuju po brzini i dinamici, neophodno je formirati odgovarajuće statističke alate koji moraju sadržavati parametre za tri važne karakteristike mobilnog kanala: slabljenje u kanalu, spori lognormalni shadowing i brzi multipath fading. Rješenja su formirana koristeći novu egzaktnu zatvorenu analitičku formu, za funkciju gustine vjerovatnoće kompozitne obvojnice pri simultanom djelovanju promjenljivog Nakagami-m fadinga i sporog fedinga, koja koristi alternativnu aproksimaciju baziranu na gama raspodjeli.

U ovom radu su date numerička evaluacija i grafička interpretacija vjerovatnoće greške za GMSK (Gaussian minimum shift keying) modulacioni format u kanalu u kome djeluje istovremeno promjenjivi brzi Nakagami fading i spori fading, koristeći alternativnu aproksimaciju pomenutu ranije, a u zavisnosti od udaljenosti mobilnog terminala od bazne stanice. Rezultati koji koji predstavljaju ove relacije između vjerovatnoće greške za GMSK prijemnik i udaljenosti od izvora signala, su formirani uzimajući u obzir sljedeće različite modele slabljenja: Okumura-Hata model (za makro ćelije), Cost231 model (za mikro ćelije) te Cost-Walfish-Ikegami model (za mikro ćelije), i uzimajući različite vrijednosti parametara korištenih u Matlab alatima. Svi ovi rezultati bit će verificirani korištenjem odgovarajućeg simulatora.

L 21

Influence of path loss models on error probability in gamma shadowed Nakagami-m fading channel

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In order to analyze quality of transmission in circumstances of accidental fluctuations of signal amplitude which differ in speed and dynamics, it is necessary to form responding statistic tools which must contain parameters for three important characteristics of mobile channel: deterministic path loss in the channel, slow lognormal shadowing and fast multipath fading. The solutions were found using new exact analytical closed form solution for the pdf (probability density function) of composite envelope, influenced by shadowed and varying Nakagami-m fading, which considers alternative approximation based on gamma-distribution.

In this paper, the numerical evaluation and graphics interpretation of probability of error for GMSK (Gaussian minimum shift keying) modulation format is provided, depending on distance of mobile terminal from the base station, in channel simultaneously affected by varying fast Nakagami fading and shadowing, which considers alternative approximation mentioned above.

Results that represent relations between the average probability of error for GMSK receiver and the distance from the signal source, are formed using following path loss models: Okumura-Hata model (for macro cells), Cost231 (for micro cells), Cost-Walfish-Ikegami model (for micro cells) and having in mind parameters used in Matlab tools. All these results are going to be verified using responding simulator.

L 22

Tesline VF struje u elektroterapiji

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Prikazuju se Teslini načini proizvođenja visokofrekvencijskih (VF) struja, od indukcijskih generatora do oscilatora s iskrištem. Razmatraju se njegovi pokusi s VF strujama, te prikazivanje pojava u VF električnim poljima na javnim predavanjima, u stručnim člancima i patentnim prijavama.

Analiziraju se Tesline naznake mogućnosti progrijavanja ljudskoga tijela. Opisuju se uređaji za elektroterapiju koji su slijedili iz Teslinih pokusa i elektroterapijski postupci u prvim desetljećima 20. st., osloncem na onodobnu literaturu.

Razmatraju se suvremeni elektroterapijski uređaji i postupci razvijeni na temelju iskustava s primjenom Teslinih VF struja.

Uspoređuju se nazivi pojedinih elektroterapijskih uređaja i postupaka koji su slijedili iz Teslinih pokusa s VF strujama, primijenjenim na živom tkivu, te često i neopravdano izostavljanje Teslinoga doprinosa. Uspoređuje se navođenje Teslina doprinosa elektroterapiji u rječnicima, leksikonima i enciklopedijama.

L 22

Tesla's HF Currents in Electrotherapy

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Tesla's ways of producing high-frequency currents from the inductive generator to the sparkling oscillator are shown. His experiments with high-frequency currents and their demonstration in electric fields phenomena at public presentations, in expert articles and with patent registrations are being considered.

Denotations by Tesla about the possibility of warming the human body are also analyzed. The devices for electrotherapy are described that follow Tesla's experiments as well as electrotherapy procedures in the first decades of the 20th century by relying upon the literature of that time.

Particular contemporary electrotherapy devices and procedures are being studied based on the experiences in the application of Tesla's high-frequency currents.

Moreover the names of particular electrotherapy devices and procedures are compared, those that follow Tesla's experiments with high-frequency currents applied on live tissue, as well as the frequent omission of Tesla's contribution without any reason. The citations of Tesla's contribution to electrotherapy in dictionaries, lexicons and encyclopaedias are also being considered.

L 23

Tesla i medicina

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Najvažniji Teslin doprinos medicini je terapijska primjena struja visokih frekvencija i visokog napona. Početkom 1891. Teslini eksperimenti sa visokofrekventnim strujama rezultirali su u konstrukciji, tzv., "Tesline zavojnice", novog daleko savršenijeg načina dobivanja visokofrekventnih struja pomoću dvaju magnetski slabo vezanih LC titrajnih krugova u stanju rezonancije. Već u veljači 1891. Tesla po prvi puta u povijesti medicine obznanjuje opažanje da visokofrekventne struje (20-40 kHz) mogu bez opasnosti proći kroz ljudsko tijelo. Te nove struje su Teslu zanimale prvenstveno radi rješavanja problema rasvjete i daljinskog prijenosa električne energije. No, on je također uočio da se pomoću tih struja može bez ikakve opasnosti zagrijavati tkiva u unutrašnjosti ljudskog tijela. U prosincu iste godine Tesla objavljuje poseban članak o mogućnostima medicinske primjene visokofrekventnih struja. Budući da Tesla nije imao medicinsku naobrazbu u članku se nije previše bavio fiziološkim indikacijama za terapijsku primjenu tih struja. Za njihovo uvođenje u medicinsku praksu zaslužan je francuski fiziolog Arsene d'Arsonval. Danas se ove visokofrekventne struje koriste u radiotehnologiji, industriji i procesima oslobađanja nuklearne energije te u polju medicine kao što je to Tesla i predvidio.

Tesla je također imao i drugih otkrića koja su se kasnije pokazala od velikog značaja za medicinu.

U mojem prikazu o Tesli i medicini, prvo će biti dan opis i objašnjenje princip rada "Tesline zavojnice" za dobivanje visokofrekventnih struja, zatim moguća medicinska primjena tih struja u elektroterapiji, magnetoterapiji i termoterapiji.

L. 23

Tesla and Medicine

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The Tesla's most important contributions to medicine are applications of his high-frequency and high-voltage currents for therapeutic purposes. At the beginning of the year 1891, Tesla's experiments with high-frequency alternating currents resulted in the construction of the so called "Tesla coil", a new more efficient way of obtaining high-frequency currents by means of two magnetically weakly coupled LC-oscillators tuned in resonance. Already in Februar 1891 Tesla published an article, first in the medical literature, about his observations that passing high- frequency currents (20-40 kHz) through the human body is harmless. These new currents interested Tesla primarily because he wanted to solve the problem of lighting and wireless transport of electric energy. However, he also noticed that by means of high-frequency currents one could heat the tissues deep inside the human body without danger. In the December of the same year, Tesla published a special paper on possibilities of applications of high-frequncy currents to medicine. Since Tesla did not have the medical background education, he did not dwell too much upon the physiological indications for applications of his high-frequency currents. Arsene d'Arsonval, a French physiologist, was the first to introduce the high-frequency currents into medical practice. Nowadays such currents of high frequency are used in radiotechnology, industry and in the process of releasing nuclear energy and, as Tesla himself forsaw, in the field of medicine. Tesla had also many other discoveries, which later turned up to be of great practical value for medicine. In my presentation of Tesla and Medicine, I will first give a short description of "Tesla coil" and its physical background and then the possible applications of high-frequency currents to electrotherapy, magnetotherapy and thermotherapy.

L 24 Modulacija ultrazvučnog signala u vrtložnom toku fluida

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U vrtložnom toku fluida, u von Karmanovoj vrtložnoj stazi, dolazi do modulacije ultrazvučnog talasa koji se prostire od prijemnog do predajnog ultrazvučnog pretvarača okomito na tok fluida. Frekvencija modulirajućeg signala direktno je proporcionalna brzini fluida. Ovaj fenomen se može iskoristiti za mjerenje protoka fluida i poboljšanje karakteristika mjerila protoka koja se baziraju na ovom principu (vortex mjerila). Usljed interakcije fluidnog i ultrazvučnog polja brzina u von Karmanovoj vrtložnoj stazi, dolazi do istovremene amplitudne i ugaone modulacije ultrazvučnog signala. Frekvencija modulirajućeg signala odgovara frekvenciji pojave vrtloga u vrtložnoj stazi. Modulisani signal na prijemnoj strani može se približno opisati relacijom:

$$u(t) = [U_1 (1 \pm m_a \cos \omega t)] \cos(\omega_0 t + m_p \cos \omega t)$$

gdje su m_a i m_p koeficijenti amplitudne i fazne modulacije, a ω_o i ω ugaone frekvencije modulisanog (ultrazvučnog) i modulirajućeg signala respektivno. Primjenom ovog fenomena kod vortex mjerila moguće je optimizirati karakterističnu dimenziju generatora vrtloga d, a da to ne utiče na mjerni opseg i nesigurnost mjerila. Ovim se eliminira ključna slabost vortex mjerila - značajan pad pritiska na generatoru vrtloga. U toku fluida čiji protok mjerimo pojavljuju se šumovi, koji su posljedica vibracije instalacije (nisko-frekventni šum) i prirode tečenja fluida (visokofrekventni šum). To predstavlja krupan problem kod mjerenja protoka fluida pomoću vortex mjerila na bazi ultrazvuka. Ovaj problem je riješen zahvaljujući činjenici da u vrtložnoj stazi istovremeno dolazi do amplitudne i ugaone (fazne) modulacije ultrazvučnog signala. Na protocima manjim od 50% opsega korišten je fazno modulisani, a na većim protocima amplitudno modulisani ultrazvučni signal. U cilju potvrde iznesenih tvrdnji izvršeno je ispitivanje za pet oblika generatora vrtloga čije su karakteristične dimenzije od 3mm ÷ 12mm. Za ispitivanja i testiranje korišteno je prototipno vortex mjerilo protoka (PVMP50) posebno razvijeno za ovu namjenu. Analizom dobivenih rezultata odabran je generator vrtloga sa optimalnim oblikom (cilindrični) i karakterističnom dimenzijom (3mm). Za ovaj generator izvršeno je testiranje i kalibracija prototipnog vortex mjerila (PVMP50) i utvrđena linearnost kalibracione konstante i nesigurnost mjerila. Minimalni postignuti protok je 98 l/min. što odgovara brzini od 0.2 m/s, a linearnost kalibracione krive bolja je od ± 0.75% u punom mjernom opsegu. Potvrđeno je da je korištenjem istovremene amplitudne i fazne modulacije ultrazvučnog talasa u von Karmanovoj vrtložnoj stazi, moguće smanjiti karakterističnu dimenziju generatora vrtloga , a da mjerilo zadrži mjerni opseg i klasu mjerne nesigurnosti.

L 24 Modulation of ultrasonic signal in vortex street of fluid

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In vortex path of fluids, in von Karman vortex street, modulations of ultrasonic wave happen. The wave passes from transmeter to receiver of ultrasonic transducers, perpendicular to the flow of fluid. Frequency of modulating signal is directly proportional to the mean flow velocity. This phenomenon could be used in measuring the flow as well as improvement of characteristics of flow meter based on this principle (vortex flowmeter). As consequences of the interaction between the fluid and ultrasound velocity field in von Karman vortex street, amplitude and angle modulation of ultrasonic signal have happend at the same time. Frequency of modulating signal corresponds to the frequency of appearance of vortices. Modulated (ultrasonic) signal on the recieving side could be described approximetly by the next relation:

$$u(t) = U_1 (1 \pm m_a \cos\omega t) \cos(\omega_0 t + m_p \cos\omega t),$$

where m_a and m_p are coefficients of amplitude and phase modulation, and ω_o and ω are circular frequencies of modulated (ultrasound) and modulating signal respectively. By using this phenomenon for detection of vortices in vortex flow meters, it is possible to optimise characteristic dimension of bluff body d, for it not to influence on uncertenity of measuring. By this, the main deficiency of vortex flow meters (considerable drop of pressure on vortex meter) is eliminated. In the flow of fluid which is measured, noises appear as the consequences of instalation vibration (low - frequent noise) and the nature of fluid flow (high - frequent noise). That represents huge problem of vortex flow meters, based on ultrasonic detection of vortices. Thanks to the fact that amplitude and phase (angle) modulation of ultrasonic signal, in vortex street, are happening at the same time, this problem could be solved. Phase modulated ultrasonic signal is used in flow less than 50% of flow rate, and on a higher flows amplitude one is used.

To affirm stated claims, testing of prototype vortex flow meter (PVMP50) was done for five bluff bodies of a different shape which characteristical dimensions were 3mm-12mm. Testing and calibration prototype vortex flow meter for optimal bluff body have been used. Linearity of calibrated curve and uncertenity of a vortex flowmeter was determined. Minimum achived flow was 98 l/min; which corresponds to the velocity of 0.2 m/s. The linearity of the calibrated curve was better then ±0.75% in full flow rate. Thanks to the phenomenon of simultaneous amplitude and phase modulation of ultrasonic wave in von Karman vortex street, it is possible to reduce the drop of pressure on the vortex flow meter, and to establish the retainment of measuring flow rate of vortex flowmeter and class of measuring uncertenity.

L 25

Teslini zapisi iz Colorado Springsa

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Tijekom 1899. sagrađen je, na Teslin poticaj, u Colorado Springsu u državi Colorado visokonaponski laboratorij. U njemu je od 17. svibnja 1899. do lipnja 1900. Tesla istraživao s naponima koji su bili previsoki i opasni za rad u laboratoriju kojeg je Tesla imao u New Yorku. Čitavo vrijeme Tesla je vodio bilješke u dnevniku ispitivanja. Ove bilješke objavljene su 1976. godine od Teslinog muzeja u Beogradu, na engleskom i srpskom jeziku. Taj dnevnik obuhvaća oko 400 tiskanih stranica sa slikama i crtežima.

Laboratorij u Colorado Springsu poslužio je za proučavanje visokih napona. U njemu je Tesla proizveo napone od preko 4 milijuna volti, prve munje duže od 135 stopa (41,2 metra), a grmljavina se čula na udaljenosti od 15 milja (24 km). Tesla je u zapisima utvrdio da može postići (ili da je postigao) i napone od 12 milijuna volti ali ih ne može mjeriti, te da bi bio sposoban dobiti i 100 milijuna volta.

U referatu se, temeljem Teslinih zapisa, želi utvrditi što je sve Tesla istraživao, jer on je ovdje istraživao o bežičnim vezama, otkrio električne oscilacije Zemlje i ima li Zemlja električni naboj. Osim toga je istraživao bežićni telegrafski prijenos vijesti i ljudskog glasa preko odašiljača snage 200 kW. Kako je laboratorij bio opremljen visokonaponskim transformatorima, generatorima, kondenzatorima s uljnom izolacijom, što je je originalni Teslin izum, očito je da je planirao i druga istraživanja. Zašto su istraživanja prekinuta i zašto se Tesla okrenuo istraživanjima na drugim područjima? U prezentaciji će biti i slike laboratorija u Coloradu Springsu i njegovih ispitivanja.

L 25

Colorado Springs Notes of Nikola Tesla

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The High Voltage Laboratory in Colorado Springs, Colorado was built in 1899. Tesla used this laboratory in the period between May 17, 1899 and June 1900 for research in the area of voltage levels too high and dangerous to experiment on in his New York laboratory. During this whole time Tesla was taking notes in his diary. These notes were published in 1976 by Tesla's museum in Belgrade in both English and Serbian. The diary includes 400 printed pages with pictures and drawings.

Colorado Springs Laboratory was used for conducting high voltage experiments. Tesla generated there voltage levels of over 4 million volts, first lightnings longer than 135 feet (41.2 meters), thunder heard at the distance of 15 miles (24 km). Tesla noted he could reach (or already had) voltage levels of 12 million volts but couldn't measure them as well as a possibility to reach a voltage level of 12 million volts.

Following Tesla's notes the paper wishes to determine the scope of his research including wireless links experiments, discovery of Earth's electric oscilation and presence of Earth's electric charge. He had also conducted experiments of wireless telegraphic news and voice transmission via 200 kW transmitters. The laboratory equipment included high voltage transformers, generators, oil insulation capacitors - an original Tesla's invention - which obviously implies his plan to conduct other experiments as well. Why had these experiments been stopped? Why had Tesla started experimenting in other fields? The presentation will include the photos of Colorado Springs Laboratory as well as his experiments.

L 26 Nikola Tesla i društveno okružje u kojem je živio

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Nikola Tesla je živio u vrijeme kada je industrijska revolucija utemeljena na parnom stroju polako počela gubiti dah i kada je svijet počeo osjećati potrebu za novom vrstom energije. Nova snaga svjetskoga gospodarstva zvala se je elektricitet.

Istovremeno rođen je u doba nove preraspodjele svjetske moći. Vrijeme njegove mladosti doba je propasti dva velika carstva - austrijskog i turskog. Mjesto njegovog rođenja bilo je na crti dodira ta dva nemoćna starca. Iz turskog carstva izišla je mala ali agresivna Srbija, a iz austrijskog troma i mlačna Hrvatska. To je bio izvor buduće tragedije. Kao sin pravoslavnog svećenika, Nikola Tesla je i protiv svoje volje bio uvučen u tu bitku.

Tesla je rođen na selu, ali je živio okružen intelektualcima, ili u najmanju ruku prirodno nadarenim ljudima. Njegov otac se je isticao visokim znanjem, sposobnošću pisanja, govora i pamćenja cijelih knjiga, čime je daleko nadmašivao suvremenike. Majka, iako navodno nepismena žena, bila je prirodni rudnik inovacija.

Tesla je bio impulzivan i beskompromisan, što ga je vodilo od studentskog rekordera uspjeha do propasti studija, a onda preko Budumpešte, Pariza i Strasbourga do SAD, nove ekonomske supersile.

Amerika ga je zapljusnula najprije neograničenim mogućnostima, a onda suočavanjem s grubošću pravila businessa. Nikada nije naučio postupati s novcem. Trčao je samo za novim istraživanjima gušeći se u sve većim i bezizlaznijim dugovima.

Svoj život uredio je tako da funkcionira bez žena, iako je uživao u njihovom društvu. Ipak, ima neka tajnovita naznaka da u tome nije bio sasvim dosljedan, pa čak i da je imao sina.

Cijeli život dao je znanosti za svijet, ne za sebe. Za uzvrat svijet mu je pružio ne samo nezahvalnost, nego čak i ignoriranje njegovih dometa. Tako se danas gotovo nigdje ne vrti njegova turbina, njegova visokofrekventna struja nikome ne svijetli i malo kada nekog ili nešto grije. Nitko ne snima s njegovim X-zrakama s udaljenosti od 10 ili više metara bez ikakve opasnosti. Svijet je odbacio nevjerojatni stroj za projektiranje skriven buboko u njegovom umu.

Tesla je umro sam, odbačen i siromašan. Nije sigurno ni kada je točno umro, pa čak ni od čega. Bio je ne samo svetac znanosti kao što je rekao slovenski inženjer France Avčin, nego po mnogo čemu i mučenik humanosti.

L 26 Nikola Tesla and the social environment in which he lived

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Nikola Tesla lived in the time when the industrial revolution based on the steam engine began to lose its breath and the world began to feel the need of another art of energy. The new power of the world economy has been called electricity. At the same time he was born in the time of the new share of the world power. The time of his youth was the age of the destruction of two great empires - Austrian and Turkish. The place of his birth was on the line of contact of those two weak giants. From the Turkey's Empire went out the little, but agressive Serbia and from the Austrian slow and tepid Croatia. That was the source of later tragedy. Nikola Tesla, as a son of the orthodox priest was against his own will envolved in that struggle. Tesla was born in the village, but he still lived sorrounded by the educated or at least natural creative people. His father had enormous knowledge, was a wonderful writer, orator and was able to memorize the whole books. In those abilities he far surpassed his contemporaries. His mother, although pretendedly an illiterate woman, was a natural well of innovations.

Tesla was impulsive and uncompromising, what led him from the record of the success in the study to the completely disaster and than from Budapest, Paris and Strasbourg to USA, the new economical superpower.

America splashed him at first by unlimited possibilities, and than by the cruelty of the business rules. He never learned to handle with money. He always ran after the new researches choking in ever greater and more hopeless debts.

He arranged his life to work without women, although he enjoyed in their accompany. Still he seems not to be completely consistent in his specific celibate. There are some information that he even had a son.

He gave the whole his life to the science not for himself, but for the world. The world thanked him by ignorance. Today almost nowhere turns his turbine, his high frequency current doesn't shine to anyone and doesn't warm almost anyone and anything. Noone makes photographs by his X-rays from the distance of 10 or more meters without any danger. The world despited his amazing "designing machine" that was hidden in his unbelievable brain.

Tesla died lonesome, abandoned and poor. Noone knows when he exactly died, even not what caused his death. As the Slovenian engineer France Avčin (Avtchin) said, he was a saint of science. We could say even more. He was a martyr of humanity.

Kazalo autora / *Autor Index*

Bilješke / Notes