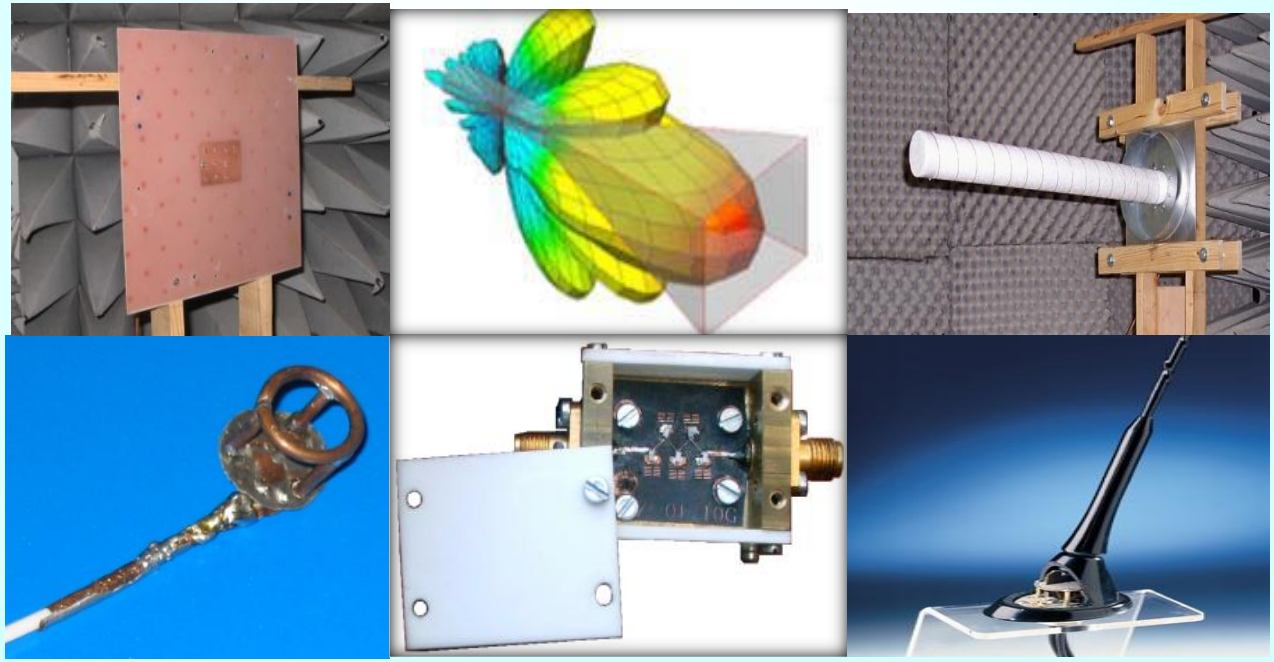
The Department of General Electrical Engineering (GEE)

University of Belgrade
School of Electrical Engineering



Personnel

Full Member of the Academy of Sciences and Arts:
PhD Antonije Đorđević

Full Professors:
PhD Branko Kolundžija
Fellow IEEE

PhD Dejan Tošić

PhD Dragan Olćan

PhD Marija Stevanović

PhD Milan Ilić

PhD Milka Potrebić Ivaniš

Associate Professor:
dr Slobodan Savić

Assistant Professors:
dr Jelena Dinkić

dr Miodrag Tasić

dr Nikola Basta

Teaching Assistants:
Darko Ninković

Jovana Petrović

Teaching Associates:
Anja Kovačević

Filip Nešković

Subject of Study

- Theory of electromagnetic fields
- Numerical electromagnetics and modeling
- Electromagnetics in biomedical engineering
- Antennas and propagation
- Microwave circuits
- Electromagnetic compatibility
- Microwave measurements
- RF/Microwave filter design
- Symbolic simulation of circuits and systems
- Inverse scattering
- Diacoptic analysis of complex electromagnetic structures
- Optimization algorithms applied to electromagnetics
- Automatic meshing for 3D electromagnetic full-wave simulation

Undergraduate Studies

Electrical Engineering and Computing Curriculum

1. Fundamentals of Electrical Engineering 1
2. Fundamentals of Electrical Engineering 2
3. Practicum in Fundamentals of Electrical Engineering 1
4. Practicum in Fundamentals of Electrical Engineering 2
5. Fundamentals of Electrical Engineering - LAB
6. Electric Circuit Theory
7. Electromagnetics
8. Practicum - Computer-Based Circuit Analysis

Module for Telecommunications and IT, Module for Electronics

1. Microwave Engineering
2. Microwave Electronics
3. Electromagnetic Compatibility

Module for Telecommunications and IT

1. Antennas and Propagation
2. Passive Microwave Circuits
3. Microwave Measurements
4. Software Tools for Antenna Design

Master Degree Studies

Module Microwave Engineering

1. Modeling and Simulation of Electromagnetic Fields
2. Microwave Filter Design
3. Electromagnetic Compatibility Testing
4. Millimeter Waves
5. Software Tools for Antenna Design
6. Microwave Imaging
7. Basic Optimization Algorithms in Engineering

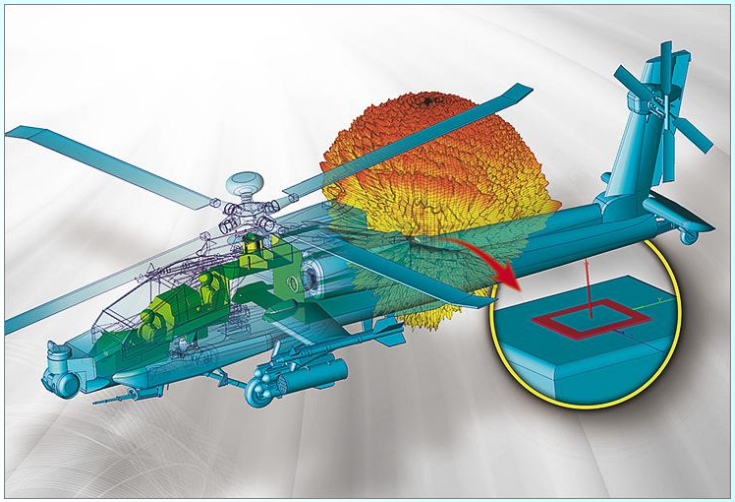
Doctoral Studies

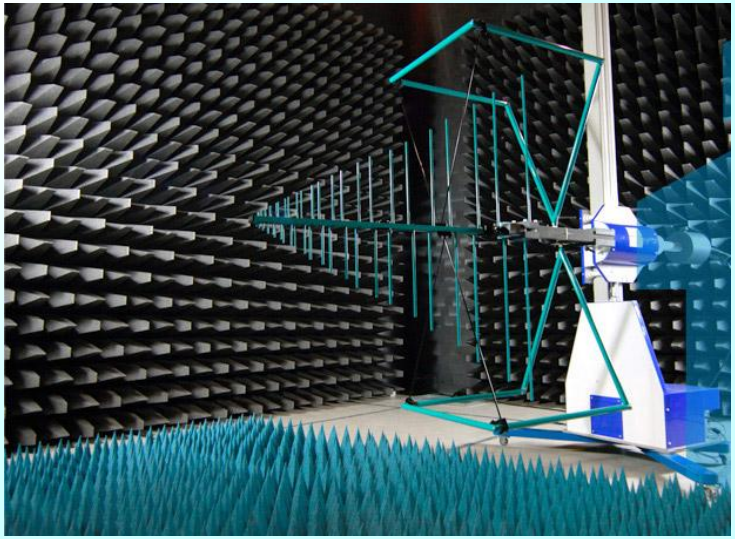
Module Microwave Engineering

1. Electromagnetics
2. Antennas and Propagation of Radio Waves
3. Microwave Engineering
4. Method of Moments in Electromagnetics
5. Finite Element Method in Electromagnetics
6. Analysis and Synthesis of Antennas
7. Electromagnetic Compatibility and Signal Integrity
8. Microwave Electronics
9. Passive Microwave Circuits
10. RF/Microwave Filter Design

Module: Microwave Theory and Techniques

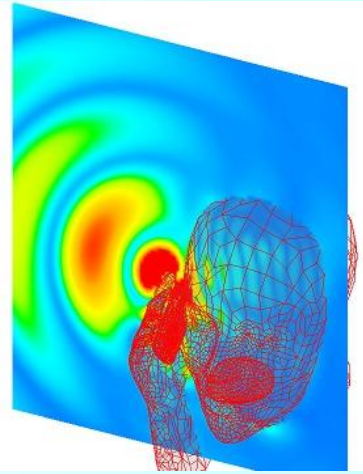
- Development of software for application in electrical engineering
- Design of components for wireless communications and radar systems
- Electromagnetic compatibility
- Design of systems and development of algorithms for Magnetic Resonance Imaging and Microwave Imaging

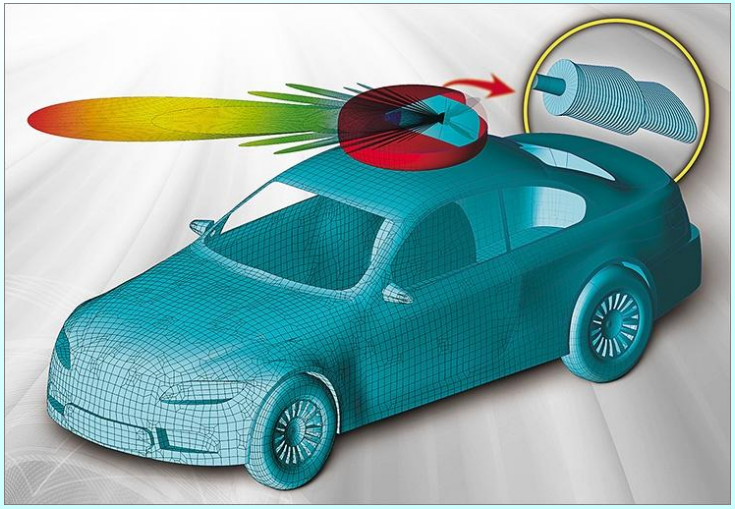




About our Work

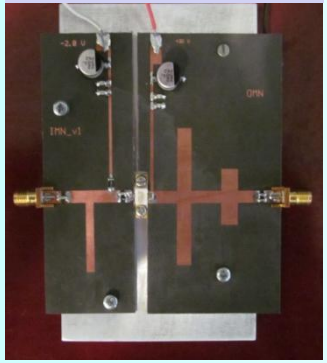
- Radiation of electronic devices
- Influence of EM fields on biological tissues
- Radio-wave propagation
- Projects: Ministry of education, science and technological development, EU FP7, EU/RS IPA, EU COST Actions, USA NSF, USA DARPA
- Collaboration with students





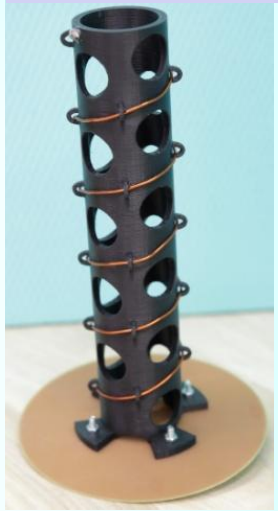
Student Projects

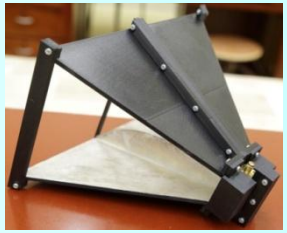
Amplifiers



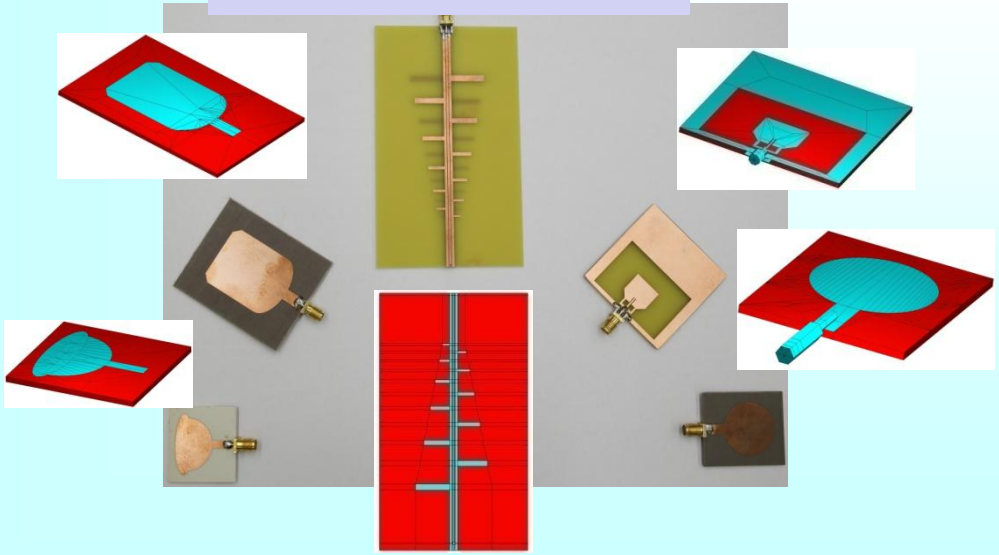
Filters

3-D Printed Antennas

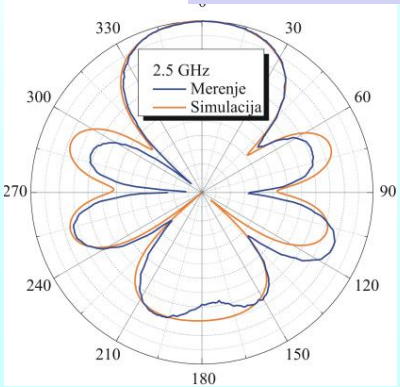


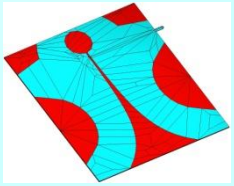


Printed Antennas



Measurements





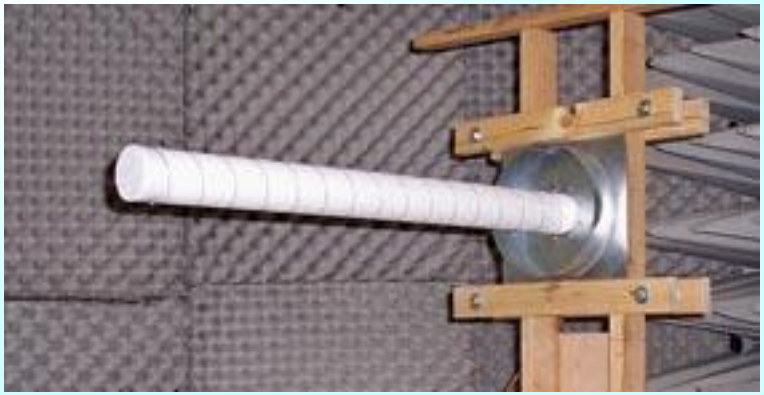
Science and Career

- Careers of our students in Serbia:
  - WIPL-D d.o.o, IMTEL Komunikacije a.d., Emisiona Tehnika i veze a.d., ENDAVA/PStech d.o.o., Telekom, Telenor, VIP, Ericsson, Bosch a.d., Insitut za fiziku, Institut Mihajlo Pupin, Idvorsky Laboratorije, Tehnički opitni centar, Institut bezbednosti, Microsoft, Novel, UBConnect INT d.o.o...
- Scientific collaboration with foreign institutions:
  - Colorado State University, University of Colorado Boulder, EPFL Switzerland, Georgia Tech USA, Wolfram Research, Inc. (Mathematica), Washington University in St Louis, University of Westminster London, ELEDIA research center Trento, Italy, CNR IREA Italy, University of Rennes, Universidad Politechnico de Madrid...
- Careers of our students in foreign countries:
  - INTEL, Hewlett Packard, Bomdardier, Airbus, Nokia, Skyworks solutions

The Department of General Electrical Engineering

Labs and Hands-on Work

http://www.idvorsky.com/en/single-page/about-us/



Collaboration with Companies

WIPL-D

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WIPL-D offers cutting-edge software for fast and accurate electromagnetic and circuit modeling and simulation, including various application areas:

- Antennas
- Microwaves
- Scattering
- EMC

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SOFTWARE PRODUCTS

WIPL-D Pro

New version!

The main WIPL-D tool, a powerful engine for modeling and solution of surface-meshed models, the cornerstone for every other product.

Learn more

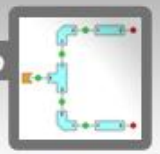
WIPL-D Pro CAD

New version!

The solid modeler and importer, with the sole purpose to make the transfer of complex geometries into WIPL-D simulation-ready projects simple and easy.

Learn more

Microwave Pro



The circuit simulator of WIPL-D product suite, immensely powerful tool for co-simulation of circuit and 3D-EM structures with WIPL-D Pro in the background.

Learn more

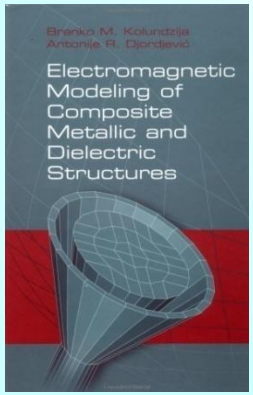
News | Events

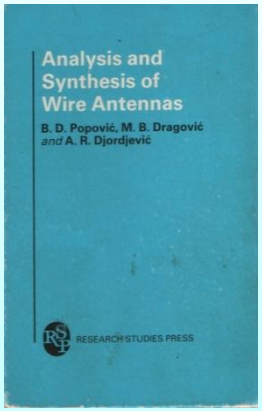
- WIPL-D Pro CAD 2017 is now officially released!
- WIPL-D Pro v14 is now officially released!
- WIPL-D Microwave Pro 4 is now officially released
- WIPL-D 2D Solver is now officially released!

View all

Our Books

1. B.M. Kolundžija and A.R.Djordjević, ***Electromagnetic modeling of composite metallic and dielectric structures***, *Boston, Artech House, 2002.*
2. B.D. Popovic, M.B. Dragovic, and A. R. Djordjevic, ***Analysis and Synthesis of Wire Antennas***, *Chichester, U.K.: Research Studies Press, 1982.*
3. M.D. Lutovac, D.V. Tosic, and B.L. Evans, ***Filter Design for Signal Processing using MATLAB® and Mathematica®***, Upper Saddle River, NJ, *Prentice Hall*, 2001.
4. A. Đorđević, ***Electromagnetics***, Academic Mind, Belgrade, *2008.* (in Serbian)
5. A. Đorđević and D. Tošić, ***Microwave engineering***, Academic Mind, Belgrade, *2010.* (in Serbian)



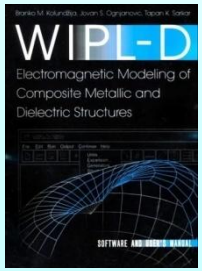


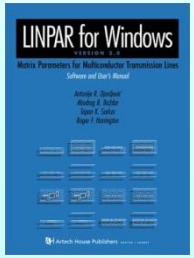
Our Books

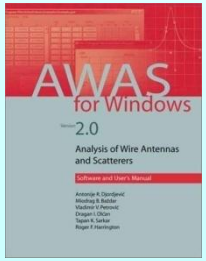
6. V. V. Petrović, D. V. Tošić, and A. R. Đorđević, ***Microwave Passive Circuits***, University of Belgrade, School of Electrical Engineering, Belgrade, 2010. (in Serbian)
7. A. Đorđević and D. Olćan, ***Electromagnetic Compatibility Testing***, *Academic Mind*, Belgrade, 2012. (in Serbian)
8. A. Đorđević, ***Fundamentals of Electrical Engineering****, parts 1-4: Electrostatics*, *Stationary Currents, Electromagnetism, Alternating Current Circuits,* Academic Mind, Belgrade, 2012. (in Serbian)
9. *M. Ilić and S. Savić,* ***Microwave electronics***, Academic Mind, Belgrade, 2017. (in Serbian)

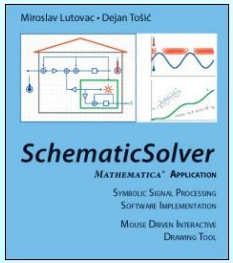
Our Software

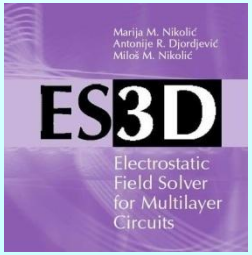
1. B.M. Kolundžija, J.S. Ognjanović, T.K. Sarkar, D.S. Šumić, M.M. Paramentić, B.B. Janić, D.I. Olćan, D.V. Tošić, M.S. Tasić, ***WIPL-D Microwave Software and User's Manual***, WIPL-D/Artech House, Belgrade/Norwood, 2005.
2. A. R. Djordjevic, et al., ***LINPAR for Windows: Matrix Parameters for Multiconductor Transmission Lines—Software and Users' Manual***, Norwood, MA: Artech House, 1996.
3. A. R. Djordjevic, et al., ***AWAS for Windows, Version 2.0: Analysis of Wire Antennas and Scatterers (Software and User's Manual)***, Norwood, MA: Artech House, 2002.
4. M.D. Lutovac and D.V. Tosic, ***SchematicSolver 2.2***, A Mathematica package for mixed symbolic-numeric analysis, processing, and design of analog and digital systems, distributed by Wolfram Research, 2009.
5. Marija Nikolic, Antonije Djordjevic, and Milos Nikolic, ***ES3D: Electrostatic Field Solver Software***, Norwood, MA: Artech House, 2006.









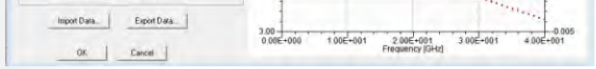


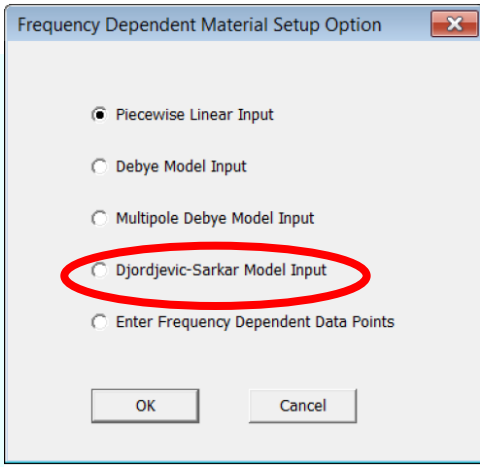
Our Achievements

- More than 30 monographs and textbooks
- Over 150 journal papers (JCR Sci IF)
- About 400 conference papers
- Courses
- Software
- Consulting and Research Projects
- Patents
- IEEE MTT Microwave Prize

Djordjevic-Sarkar Method

- HFSS allows you to enter the relative permittivity and loss tangent at a single measurement frequency. You may optionally enter the relative permittivity and conductivity at DC.
- This is the best method if you don't have measured data.

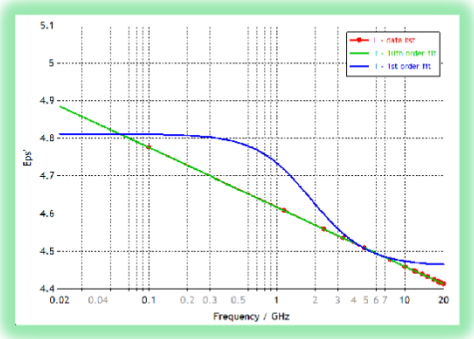




CST – Computer Simulation Technology

Materials - dielectrics

- Dielectric properties extracted from measurements need to be **passive** and **causal**
- Common PCB/package dielectric materials exhibit gradual change in dielectric constant over a very broadband frequency range (Debye models with many relaxation terms)



- **Cole-Cole**

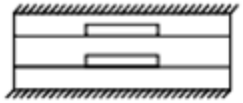
$$\varepsilon^*(\omega) - \varepsilon_\infty = \frac{\varepsilon_s - \varepsilon_\infty}{1 + (i\omega\tau)^{1-\alpha}}$$

- **Djordjevic Sarkar (#)** - wideband Debye model; the model captures the physics of the composite dielectrics, it is causal and requires just two coefficient to describe it

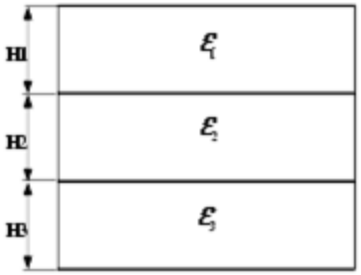
(#) A.R. Djordjevic, R.M. Biljic, V.D. Likar-Smiljanic, Tapan K. Sarkar, " Wideband Frequency-Domain Characterization of FR-4 and Time-Domain Causality", IEEE TRANSACTIONS ON ELECTROMAGNETIC COMPATIBILITY, VOL. 43, NO. 4, NOVEMBER 2001

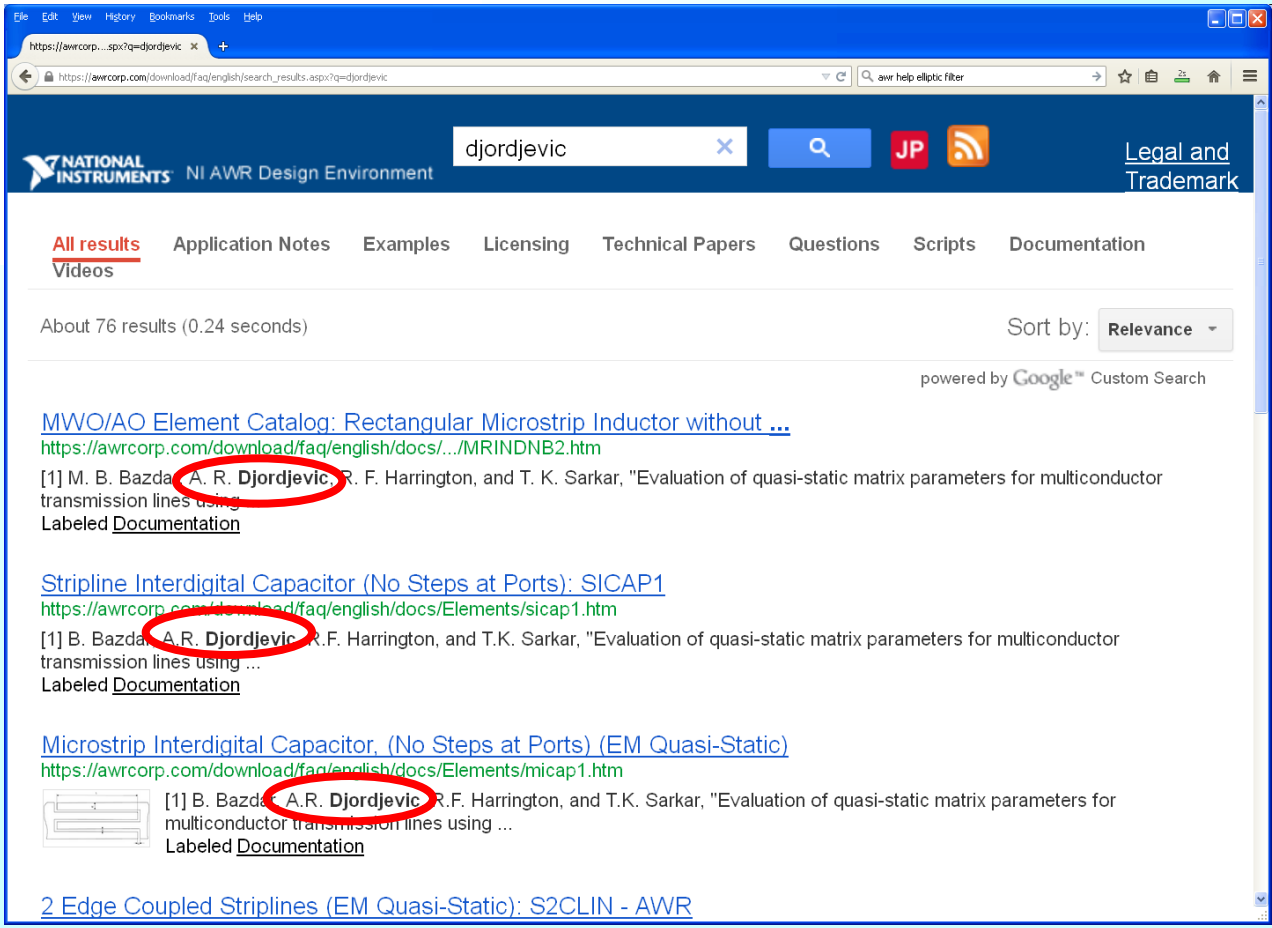
3-Layer Stripline Substrate Definition: SSUBT

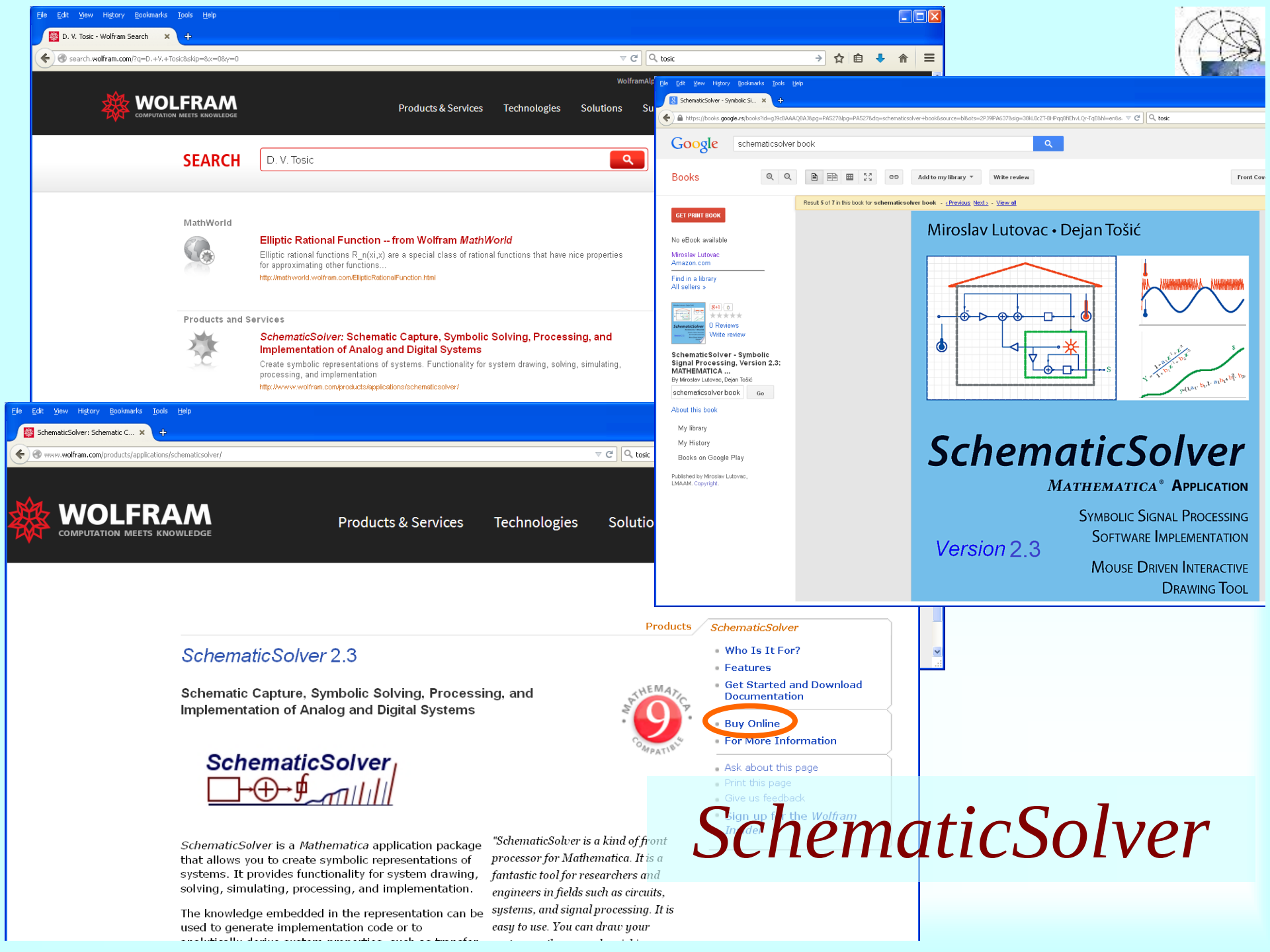
Symbol



Topology



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Elliptic rational functions R_n(xi,x) are a special class of rational functions that have nice properties for approximating other functions...
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Schematic Capture, Symbolic Solving, Processing, and Implementation of Analog and Digital Systems
SchematicSolver is a Mathematica application package that allows you to create symbolic representations of systems. It provides functionality for system drawing, solving, simulating, processing, and implementation.
The knowledge embedded in the representation can be used to generate implementation code or to
"SchematicSolver is a kind of front processor for Mathematica. It is a fantastic tool for researchers and engineers in fields such as circuits, systems, and signal processing. It is easy to use. You can draw your
SchematicSolver

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https://awrcorp.com/download/faq/english/search_results.aspx?q=tosic

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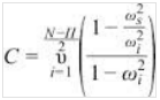
Elliptic-Function Lowpass Filter (Closed Form): LPFE

https://awrcorp.com/download/faq/english/docs/Elements/LPFE.htm

[1] Miroslav D. Lutovac, Dejan V. **Tosic**, and Brian L. Evans, Filter Design For Signal Processing Using MATLAB and Mathematica, (Prentice Hall, 2001), ...
Labeled Documentation

Elliptic-Function Bandpass Filter (Closed Form): BPFE

https://awrcorp.com/download/faq/english/docs/Elements/bpfe.htm



[1] Miroslav D. Lutovac, Dejan V. **Tosic**, and Brian L. Evans, Filter Design For Signal Processing Using MATLAB and Mathematica, (Prentice Hall, 2001), ...
Labeled Documentation

1

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MWO/AO Element Catalog: Elliptic...

https://awrcorp.com/download/faq/english/docs/Elements/bpfe.htm

awr help elliptic filter

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[1] Miroslav D. Lutovac, Dejan V. Tosic, and Brian L. Evans, Filter Design For Signal Processing Using MATLAB and Mathematica, (Prentice Hall, 2001), Chapters 6, 12, and 13.

[2] Alexander J. Grossman, "Synthesis of Tchebycheff parameter symmetrical filters," Proceedings of the IRE, pp. 545-473, April 1957.

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Elliptic Rational Function -- fro...

mathworld.wolfram.com/EllipticRationalFunction.html

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Created, developed, and nurtured by Eric Weisstein at Wolfram Research

Calculus and Analysis > Special Functions > Elliptic Functions >

Elliptic Rational Function

Elliptic rational functions $R_n(\xi, x)$ are a special class of rational functions that have nice properties for approximating other functions on the interval $x \in [-1, 1]$. In particular, they are equiripple, satisfy $|R_n(\xi, x)| \le 1$ over $|x| \le 1$, are minimax approximations over $|x| \ge \xi$, exhibit monotonic increase on $x \in [1, \xi]$, and have minimal order n. Additional properties include symmetry

$$R_n^2(\xi, -x) = R_n^2(\xi, x), \tag{1}$$

normalization

$$R_n(\xi, 1) = 1, \tag{2}$$

the property

$$R_n(\xi, x) = \frac{R_n(\xi, \xi)}{R_n\left(\xi, \frac{\xi}{x}\right)}, \tag{3}$$

and the nesting property

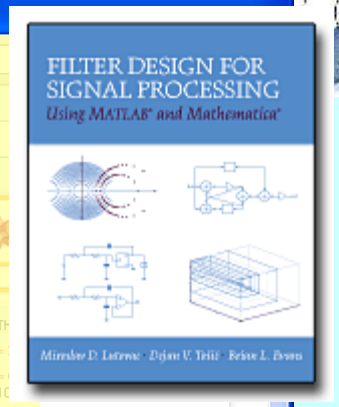
$$R_{mn}(\xi, x) = R_m(R_n(\xi, \xi), R_n(\xi, x))$$

(Lutovac et al. 2001)

Mandelbrot set .2+.3i

For those who aren't afraid to stand on the shoulders of giants.

Miroslav D. Lutovac, Dejan V. Tosic, Brian L. Evans, **Filter Design for Signal Processing using MATLAB® and *Mathematica*®**. Upper Saddle River, NJ: Prentice Hall, 785 pages, 1st ed., ISBN 0-201-36130-2, ©2001. ---, **Translated in Chinese**, Publishing House of Electronics Industry, PHEI, Beijing, P. R. China, ISBN 7-5053-8710-3, ©2004.



SEE ALSO:

Chebyshev Polynomial of the First Kind, Elliptic Function, Rational Function

REFERENCES:

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International Projects

1. **Influence of near EM field on human body** with Institute of Informatics and Telecommunications NCSR "Demokritos“, Athens, Greece
2. **COST 284:** "Innovative Antennas for Emerging Terrestrial & Space-based Applications", 2002-2006
3. **COST IC0603:** "Antenna Systems and Sensors for Information Society Technologies" (ASSIST), 2007-2011
4. **COST IC1102:** "Versatile, Integrated, and Signal-aware Technologies for Antennas" (VISTA)
5. **COST IC1401:** "Memristors - Devices, Models, Circuits, Systems and Applications" (MemoCiS), 2014–2018
6. **COST TD1301:** "Development of a European-based Collaborative Network to Accelerate Technological, Clinical and Commercialisation Progress in the Area of Medical Microwave Imaging” (MiMed), 2014-2018

National Projects

1. **Passive RF and microwave modules and antennas for digital transmission and wireless internet systems** (ИТ.1.17.0241.Б), 2002-2004.
2. **RF and microwave components and antennas for wireless computer networks and WiFi internet infrastructure** (TP-6154A), 2005-2007.
3. **Development of algorithms and software for complex RF and microwave components, antennas and systems design** (TP-11021), 2008-2011.
4. **Algorithms and software for frequency-domain and time-domain simulation of RF subsystems and electromagnetic sensors in ICT** (TP-32005), 2011-2017.

Some of Our Publications

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Simić, S.K. Tošić, D.V., “The Index of Trees with Specified Maximum Degree”, *MATCH Communications in Mathematical and in Computer Chemistry*, vol. 54, no. 2, pp. 351-362, 2005.

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Ilić, M.M., **Savić, S.V.**, **Ilić, A.Ž.**, Notaroš, B.M., “Constant Speed Parametrization Mapping of Curved Boundary Surfaces in Higher-Order Moment-Method Electromagnetic Modeling”, *IEEE Antennas and Wireless Propagation Letters*, vol. 10, pp. 1457-1460, 16 December 2011.

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