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electromagnetic modeling of composite metallic and dielectric structures

General

What is WIPL-D Company?

WIPL-D d.o.o. is a privately-owned company dedicated to development of commercial EM software and consulting in the wide field of electromagnetism.

What does the abbreviation WIPL-D stand for?

WI stands for wires, PL stands for plates, and D stands for dielectrics.

What is WIPL-D software suite?

WIPL-D software suite is a full 3D EM simulation tool comprising two main products (WIPL-D Pro CAD and WIPL-D Pro) and different add-on tools (for circuit analysis, optimization, GPU acceleration, etc.)

What is WIPL-D Pro?

WIPL-D Pro is a general 3D electromagnetic solver that analyzes arbitrary metallic and/or dielectric structure in the frequency domain.

What is the theoretical basis of WIPL-D Pro kernel?

Method of Moments (MoM) applied to Surface Integral Equations (SIE). Related terms: surface integral equations, bilinear quadrilaterals – surface mesh, higher order polynomial approximation of currents, outcore solver, CPU/GPU parallelization. The WIPL-D Pro kernel is fully developed by WIPL-D team. The theory is well documented with more than 30 referenced IEE and IEEE journals and numerous conference articles, with main reference being: B. M. Kolundzija, and A. R. Djordjevic, *Electromagnetic Modeling of Composite Metallic and Dielectric Structures*, Artech House, Norwood, 2002.

What is the difference between Lite and Pro version?

WIPL-D Lite was a limited license of WIPL-D Pro v6, distributed through Artech House (released over 10 years ago). The software was distributed along with the book and was intended to students, hobbyists, small business customers, private consultants and commercial users who solve electrically small problems. Since that time, WIPL-D Pro has been evolving as a commercial product with numerous features added.

WIPL-D Lite is no longer available for purchase. Instead, we offer WIPL-D Starter. WIPL-D Starter is a low-cost version of WIPL-D professional software that includes latest release of WIPL-D Pro with 1,000 unknowns and WIPL-D Microwave Pro.

Who are intended users?

The intended users are engineers (both in industry and research facilities), scientists and graduate students. The primary use is the research and design of various types of antennas, scatterers, passive microwave circuit components, as well as solving EMC/EMI, antenna placement, radome and other common EM problems. The software package is also used in teaching and popular among entrepreneurs, consultants, hobbyists...

How one can test the software?

The software can be tested by trying the 30-day demo (check the WIPL-D Community and DEMO section) or by requesting a benchmark from our team. There is also possibility to test Evaluation version, which supports number of unknowns required by specific problems solved by user, and appropriate set of add-on tools (GPU Solver, Optimizer, etc.).

Advantages of WIPL-D software

What is the advantage of WIPL-D software over codes using wire-grid modeling?

Wire grid EM simulation originates in the beginning of EM simulation tools development, especially for the shielding problems. Since WIPL-D suite uses both wires and plates as mesh entities, it is possible to create and simulate wire-grid models. The disadvantages of using the wire-grid modelling compared to quadrilateral patches are:

- It requires much more mesh elements;
- Manual modelling is more demanding, so advanced algorithms are necessary;
- Such EM simulation requires much more unknowns, resulting with longer simulation time;
- It is not applicable to dielectric surfaces.

WIPL-D suite supports both approaches but the modelling via surface patches is recommended.

The existing online base of wire-grid models (especially from NEC users) can be easily converted to WIPL-D wire mesh, especially with the assistance of the WIPL-D support team.

What is the advantage of the WIPL-D software over the FEM and MoM/VIE based programs?

WIPL-D kernel applies MoM/SIE, where the unknown quantities are surface currents. In the FEM and MoM/VIE, the unknown quantities are volume fields and currents. Hence, the total number of unknowns and analysis time required by the MoM/SIE are typically much lower than those of the FEM and MoM/VIE. Additionally, the FEM and MoM/VIE have difficulties in modelling wire and thin plate structures. Another major difference is the absence of the bounding box for radiating problems. WIPL-D can simulate two antennas using the same requirements whether they are separated 1 or 100 wavelengths.

What is the advantage of WIPL-D software over time domain analysis?

Majority of engineering needs are in frequency domain. WIPL-D software performs analysis in the frequency domain (one frequency point after another, sometimes simultaneously at multiple CPUs/GPUs/cluster nodes). In order to obtain the same result by time domain analysis, the analysis should be performed in a sufficient time interval. After that, the Fourier transform must be applied. This is an indirect way of obtaining results in the frequency domain and because of that it is less efficient.

What is the advantage of the WIPL-D software over the FD-TD?

WIPL-D kernel applies MoM/SIE, which means it does not use absorbing boundary conditions and discretization of the volume outside of the simulation model. The accuracy of the FD-TD modeling is mostly related to the discretization quality and minimum one discretization point per tenth of the wavelength is recommended. In case of electrically moderate or large structures, the approach yields a very high number of discretization points. As an end result, this typically leads to extremely long computation time. If the required EM result is simulated at single frequency or at finite number of frequencies, it may be expected that WIPL-D software needs an order of magnitude shorter computation time.

What is the advantage of the WIPL-D software over codes that treat substrates as infinite layers?

WIPL-D suite simulates multilayers structures in a realistic way, as finite size 3D EM problems (finite size dielectric volumes). This includes printed elements, vias, holes etc. In EM simulation, such layers can sometimes be treated as infinite layers of dielectric (as in 2D or 2.5D solvers), but this is always an approximation used in order to speed up simulations and reduce requirements.



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What is the advantage of WIPL-D software over codes based on triangle patch modeling?

WIPL-D software is based on quadrilateral meshing, which is approximately two times more efficient than triangular mesh for the same orders of current expansion. In addition, WIPL-D Pro combines quadrilateral modeling with higher order basis functions, thus requiring an order of magnitude less number of unknowns than classical triangular modeling. Thanks to higher order bases WIPL-D can deal with very large mesh elements (up to 2 by 2 wavelengths), while typical rooftop basis functions have to deal with mesh elements which size is between $\lambda/10$ and $\lambda/6$ for stable and accurate results.

What are the options for speeding-up the solution in WIPL-D?

Numerous. First of all, the users need to adapt to the fact WIPL successfully applies higher order basis functions. In practice this means that entire microstrip patch antenna (typically 0.5 λ by 0.5 λ) should be modeled as a single mesh element (plate). Next, all large EM problems are treated by special features to decrease number of unknowns where possible (antenna placement reduction, shadow reduction, specific features for reflectors and radomes, reduction of simulation referent frequency...). Such numerically efficient model is simulated by using all advantages of parallel processing. CPUs with multiple cores/threads are used in a very efficient way, where parallelization efficiency is close to 100%. For electrically moderate and large EM problems, the tremendous speed-up in WIPL-D is achieved by using GPU acceleration, with an add-on to WIPL-D Pro. It uses one or more GPUs to solve problems which cannot be solved in reasonable time by using only CPU.

WIPL-D technical support team offers customers unlimited assistance to simulate their projects more efficiently.

EM Problems One Can Solve Using WIPL-D Software

What are the typical electrical quantities provided by WIPL-D software?

The result directly available after the simulations finishes is a distribution of currents over the surfaces. By default, for the case of an antenna or a microwave network the kernel calculates Y, Z, and S parameters for the multiport described by the model. Near field distribution or far field radiation patterns can be calculated for the points specified by user. In addition, the calculated current distributions can be processed to obtain SAR, radiation pattern at finite distance, RCS at finite distance and numerous more advanced features.

What are the typical antennas and antenna arrays that WIPL-D software can handle?

WIPL-D team has extensive experience and offers customers assistance in simulation of various wire, solid metallic and dielectric, or printed antennas. The typical examples are: Yagi-Uda arrays, log-periodic antennas, wire and strip helicoidal or spiral antennas, metallic or dielectric horns, reflector antennas (included feeds and struts), slotted waveguide arrays, microstrip patch antennas, dielectric rod and resonator antennas, lens antennas, various shape monopole antennas and so on. Practically speaking, all commonly used antennas or arrays are solvable, with just a few limitations such as usage of part by part homogenous linear isotropic dielectric materials.

Can I model antennas mounted on vehicles (aircraft) and still use PC for simulation?

Answer is YES, but up to certain frequency limit. WIPL-D software offers very effective calculation on inexpensive desktop or laptop multicore PCs. The required number of unknowns per square wavelength for electrically large plates is very small (10-20). This is the essential difference and advantage over other frequency domain codes. Using only 15,000 unknowns and applying 1, 2 or 3 symmetry planes WIPL-D Pro can handle structures up to 10 000 wavelength squared on regular desktop machines. Such PCs can be practically transformed into WIPL-D workstation by adding even a single low-cost NVIDIA GPU card (CUDA enabled) and add-on named WIPL-D GPU Solver. For electrically extremely large problems GPU Cluster Solver and Domain Decomposition Solver can be used.

Does WIPL-D software take into account influence of a radome on antenna characteristics?

YES, it does. WIPL-D software offers very precise modeling and accurate simulation of radomes as dielectric bodies, with extensive experience of our technical support team. There are numerous techniques to reduce number of unknowns, but preserve accuracy for the radome simulations. One of the most efficient ones is using a metallic radome where the actual dielectric radome is being replaced by the distributed loading features. This reduces number of unknowns four times. In addition, WIPL-D offers automatic feature which calculates through which part of the radome surface the majority of antenna power is radiated (such as 99%, 99.5%, 99.9%...). The user defines which part of the antenna radiated power is accounted, and the code only simulates the minimum part of radome surface through which such power is radiated. Such automatic radome feature run can reduce number of unknowns several times.

Can I model antennas above the real ground using WIPL-D Pro?

YES, you can. The influence of infinite ground to the antenna radiation pattern is invoked by a special switch. In that case, the kernel takes antenna radiation and modifies it by reflection coefficients from infinite ground. The number of unknowns and simulation time are not affected.

In addition, the effect of the ground to the antenna current distribution can be accounted if finite size ground clump is added below the antenna. The clump and all objects below it (buried objects) only influence the antenna current distribution, but they are ignored during the radiation pattern calculation. The clump size can be increased as a convergence test. When the clump is large enough, the radiation pattern does not change with further increase of clump size.

Can I use WIPL-D Pro to de-embed s-parameters of multiport devices, modeled together with real feeding structures?

YES, you can. The de-embedding procedure for the s-parameter extraction is provided as a feature of the WIPL-D Pro. User needs to simulate N-port network as well as the additional N projects of feeders. If all feeders are identical, one feeder project can be copied N times. Using obtained results, de-embedded network parameters are obtained by single click.

In addition, the geometry of the feeder port is not predefined, user can simulate literally any waveguide technology provided it supports propagation of single dominant mode. This offers possibilities for simulation of non-standard waveguides such as SIW ports.

The WIPL-D Pro CAD offers the usage of waveguide ports. Several technologies are supported, where the de-embedding procedure is automated.

Is WIPL-D software able to model and analyze planar (single and multi-layer) structures?

YES it is. WIPL-D software assumes modelling and simulation of planar structures as finite-size structures. The suite offers several distinctive features for this kind of simulation. Copy Layer manipulation in WIPL-D Pro is useful for ease modelling of planar structures with identical mesh. WIPL-D Pro CAD is solid modeler suitable for this kind of modelling featuring the solid modelling, Boolean operations, automated mesh etc.

Can I calculate complex waveguide junctions and filters using WIPL-D software?

YES, you can. WIPL-D software has been already benchmarked and applied numerously for the design of: waveguide components and systems, 3D dielectric filters, cavity filters, corrugated horns, etc. Many designed devices in these areas have been tested through measurements.

Can I efficiently model 3D TEM cell and other EMC facilities by WIPL-D software?

YES. Owing to the high efficiency of MoM and HOBFs, the analysis can be performed at extremely high frequencies (at which 3D cell becomes electrically very large). Such frequencies are unreachable to other commercially available full wave EM solvers. The inexpensive GPU cards push the frequency limit further. Specific features (built-in interpolation,

adjusting number of unknowns to the current simulation frequency) allow simulation in wide frequency range. The WIPL-D TDS solver is used when the output results are required in the time domain. Another advantage is the simulation without boundary box. Thus, the simulation of geometrically distant devices are performed without discretizing the space between. This enables simulations of devices at distances measured in hundreds of lambdas without actually increasing the simulation requirements.

Modeling

Is it possible to specify lossy materials, with possibly high dielectric and magnetic constant?

YES, it is possible. Stable and accurate results are obtained even if product of relative electric and magnetic permittivity is ultra-high. Moreover, the advanced features in numerical kernel supports high contrast materials with relative differences in permittivity and permeability of up to 10^6 , as well as low contrast materials with the relative differences of down to 10^{-6} .

Is the simulation possible at extremely low frequencies (kHz, 50 Hz simulations)?

YES. New generation of integral methods for highly accurate evaluation of MoM matrix elements, which combines singularity extraction technique and singularity cancellation techniques, together with advanced matrix equilibration techniques, implemented in WIPL-D numerical kernel brings a significant extension of low frequency breakdown limit. In order to obtain accurate results when working with electrically very small models, which size is $\lambda/1,000$ and lower, precision used for storing system matrix should be set to double precision, while Integral Accuracy should be increased to Enhanced3 or higher.

Can I take into account skin-effect losses?

YES, the customer is able to define Skin-effect by adding the distributed loading. Different conductivities can be assigned to particular wires, plates, or their groups. Conductivity can also be added to all metallic parts (the loading is assigned automatically). Another approach is to model the metal as the dielectric material with the assigned Sigma. This is numerically far more demanding, but needed for certain type of EMC problems (penetration through metallic walls at low frequencies, field inside metallic shells etc.).

Can I take into account end effect or abrupt changes in wire radius of fat wires?

You can adjust independently starting and ending wire radius. Wire ends can be represented as almost flat cone, while abrupt change of wire radius can be represented as almost flat frill. Note that WIPL-D uses thin-wire approximation (the current distribution along radius is considered constant), so the simulation accuracy should be verified by modelling short and fat wires as solid objects, i.e. wire model should be replaced by plate model.

How can I model curved surfaces with quadrilateral surface patches?

Accurate geometry modeling of the spherical surfaces requires mesh size of approximately 0.4 wavelength, while for cylindrical surfaces it should be about 0.5 wavelengths over the radial axis of a cylinder. In WIPL-D Pro modeler, it is directly controlled by manual creation of mesh elements or setting the correspondent number of segments for pre-defined objects. In CAD modeler it is controlled by surface and edge mesh angular tolerances. According to defined angular tolerances and mesh size which can be up to 2 wavelengths, large mesh elements are automatically created on flat or mainly smooth model surfaces, while small mesh elements are created on model parts where small details and features are present. Elongated mesh elements are created over the model parts which are flat or smooth along one axis and curved along another.



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Is wire automatically connected to the plate if they are in contact?

The wire and plate in physical contact are not automatically in electrical connection. To achieve electrical connection between wire and plate when they are in contact, user has to define wire-to-plate junctions. Further, if wire protrudes plate it should be split and junction added. Different types of wire-to-plate junctions are available. User can connect wire to the middle of plate, to plate edge, to plate corner, to wedge and to tip of a metallic body.

Is it possible to import different CAD formats into WIPL-D?

Using WIPL-D Pro CAD, customer is able to import the following CAD formats: Parasolid, Stereolithography, CATIA v4, CATIA v5, Pro/Engineer, Unigraphics, Inventor, Solidworks, ACIS (SAT), IGES, STEP, DXF and VDA-FS.

How should I perform structure optimization?

WIPL-D Pro and WIPL-D Pro CAD offer symbolical definition of the projects. The symbols can be optimized using the WIPL-D Optimizer. The aim, optimization of the structure to satisfy user-defined criteria, can be obtained using various optimization methods available, including Genetic algorithm, Simulated Annealing, Simplex, Gradient, Random and Systematic Search.

What solvers are used throughout the WIPL-D suite?

The default and mostly used method is MoM SIE with HoBF. It applies both direct solver (LU decomposition) and iterative solvers (CG method). In addition, electrically largest problems can be run by Domain Decomposition Solver (DDS). Infinity long problems, with constant cross section of geometry are simulated in the 2D solver. Eigen values of geometries are determined by the CMA solver. FEM solver is under development.

WIPL-D Community and DEMO

What is WIPL-D demo?

WIPL-D demo is a free 30-day trial of the latest release of WIPL-D software.

How can I get WIPL-D demo?

WIPL-D demo can be downloaded from our web-site upon the registration in WIPL-D community. It also comes on a CD inside the promotional brochure that is being handed out by our representative on the shows we attend worldwide.

What is in the WIPL-D Demo download?

The download contains executables, pdf manuals, and example projects.

Should I uninstall any previous demo version of WIPL-D software?

Please uninstall any old versions of the software.

I registered into WIPL-D Community and got message to confirm the registration by verifying my e-mail address (click the link in e-mail), but I got no e-mail?

Sometimes, our e-mails end up into SPAM folder, so please check your SPAM e-mail. If our e-mail is not there, please contact us so we can complete your registration manually.

WIPL-D Software: Licensing & Setup Info

When opening the WIPL-D software for the first time, the software asks for a password. Which is it?

The initial password is: wipl (4 characters). You can change the password in Configure/Password.



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Which Operating Systems are supported?

WIPL-D software is supported on 64-bit Windows 7 and later, and Windows Server 2003 and later. Support for Windows Vista and lower versions is no longer available. Also, version for 32-bit systems can be made per user request except for GPU add-ons, which are only supported on 64-bit systems. The kernel can run on Linux platforms as well. For more information about Linux platforms and cluster options, contact our sales department.

What are the minimum hardware requirements?

The software runs on Intel x86-64 processor or compatible processors. A minimum of 8GB RAM and up to 4 GB free hard disk space (depending on add-on tools) is required.

How can I check which version of software I run?

Open Help>About submenu. The opened window shows information about the license.

Pricing Info

How can I get a price for the software?

You can contact our sales department and get the quotation for any product you might need.

What comes with the WIPL-D software suite?

WIPL-D software consists of WIPL-D Pro (MoM numerical kernel and basic modeler) and various add-on tools (for CAD modelling and CAD import, for optimization, for time domain analysis, etc.).

What is the price for professional WIPL-D software license?

The price of the software is formed based on the items included in the license (WIPL-D Pro and add-on tools if there are any included). For more detailed explanation and official price list, please send your request to [Sales](#) team.

How the price for WIPL-D Pro is formed?

The price for WIPL-D Pro depends on the number of unknowns and supported number of threads. The number of unknowns depends on the size of the problem you need to simulate. The default number of supported threads is 4 - support for more threads is available for the additional fee.

How many unknowns I need?

To give you an idea how many unknowns you would need, it usually takes around 30 unknowns per $\lambda \times \lambda$ patch in case of metallic structures, while it requires twice as much for dielectrics. The more adequate estimate can be made once our support team receive the benchmark project from a customer.

What options are there for purchasing of the software?

Software can be purchased in a form of permanent license or rented on a yearly basis depending on your needs and budget.

Are there any discounts for small companies/ start-ups?

Yes, we offer certain discount for small companies and start-ups. For more info, please contact [Sales](#).

Company Info

When was the company founded?

The first commercial product was sold back in 1995, while WIPL-D d.o.o. (HQ office in Belgrade) was formally founded in 2002.



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Where are your offices located?

WIPL-D HQ is located in Belgrade, Serbia, while we have distributors worldwide – please have a look at our [Representatives](#) page.

Where people can meet your representatives in person?

Each year we attend conferences worldwide (USA, Europe, etc.). For more info, please check our [News&Events](#) section on the web-site, the category labeled as “Events”.
