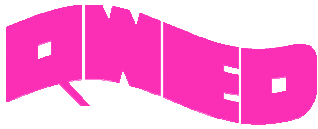


QUICKWAVE 2015

SOFTWARE FOR ELECTROMAGNETIC DESIGN AND SIMULATIONS

QUICKWAVE-3D QUICKWAVE-V2D
QW-ADDIN FOR AUTODESK[®] INVENTOR[®] SOFTWARE
QW-BHM QW-GPUSIM QW-OPTIMISERPLUS QPRONY



QWED has continued efforts on extending functionality of the QuickWave software for electromagnetic design as well as the scope of its applications.

In this release we focus on the extension of the area of applications to cover more real life problems including nonlinear phenomena with third-order nonlinear polarisation given by Kerr-Raman model.

New QViewer display in View Fields window allows viewing all fields' components, power dissipated, temperature, enthalpy, surface current, and even materials in a user defined area.

Batch Run for simulations allows running several simulations, one by one, and save simulation results automatically, without a need of running each simulation separately.

To speed up the process of dynamic template generation for template ports or energy delivery to the circuit with point excitation, the user can enable multipoint option, which extends predefined point source into rectangle (template port) or cube (point excitation in 3D circuit) matrix of points.

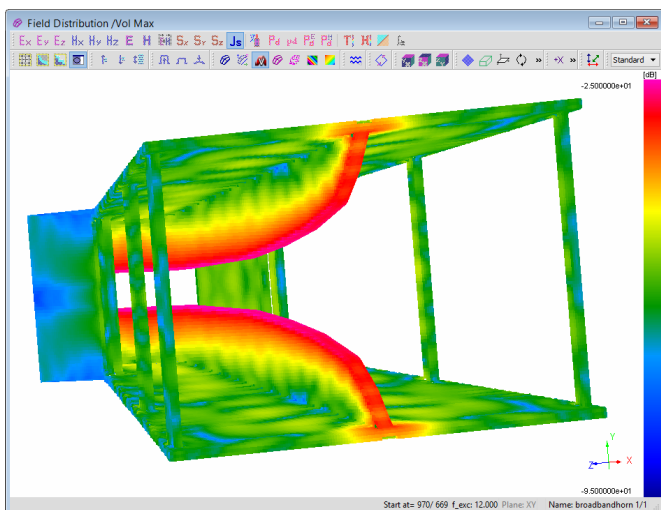
Possibility of introducing *Objective* in decibel scale and as a user defined formula with basic arithmetic operations performed on available results, extends the area of optimisation and parameters sweep. Additionally, starting from QuickWave version 2015, parameters sweep is included in the QuickWave Professional package.

Other small but very useful changes include possibility of importing recent files and settings from previous versions of QuickWave, <DATE> and <TIME> QuickWave variables that allow adding current date and/or current time to the name of the results file, and choice of number of cores that will be used for simulation.

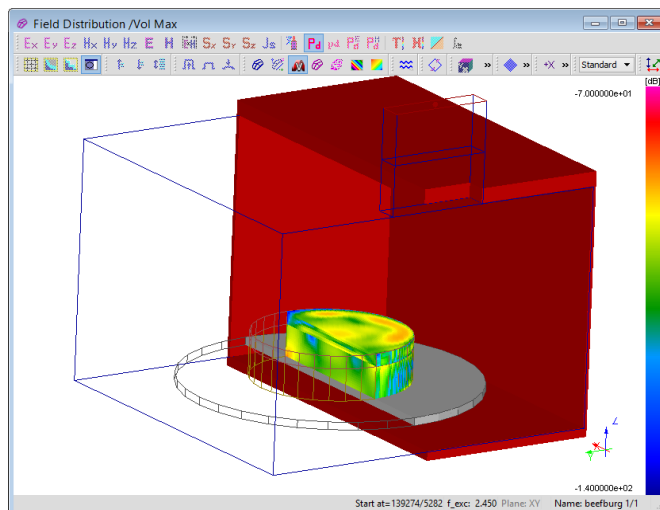
QVIEWER

New QViewer display in View Fields window. The resulting electromagnetic fields are spread over 3-dimensional space.

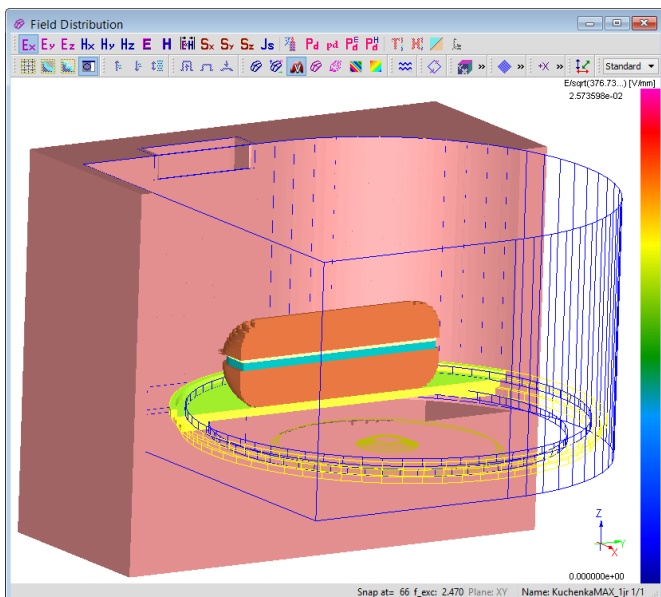
This display allows viewing all fields' components, power dissipated, temperature, enthalpy, surface current, and even materials in a user defined area. The area of interest may be chosen either by narrowing down the display boundaries and/or by selecting a particular material, where the variable should be displayed.



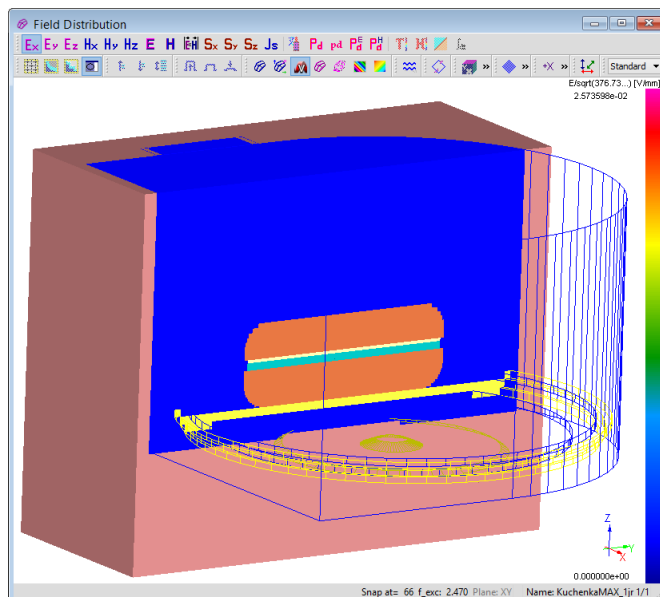
Surface current distribution on broadband antenna simulated in at 12 GHz.



Cross section of dissipated power in the sandwich including plate and microwave oven box.



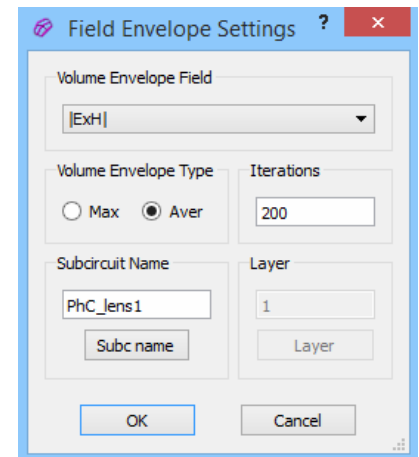
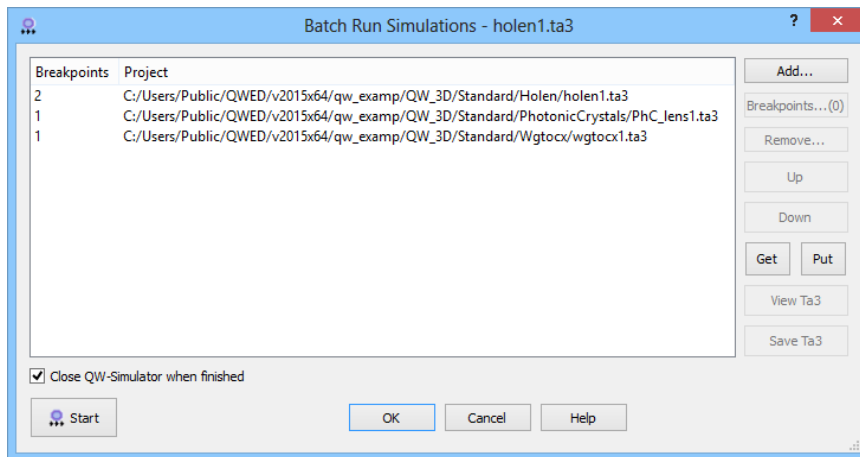
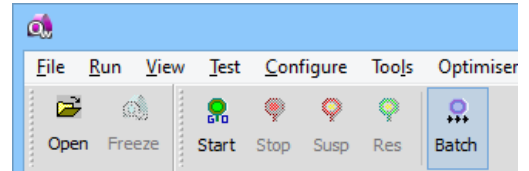
Cross section of sandwich in microwave oven - material view without air inside.



Cross section of sandwich in microwave oven - material view with air inside.

BATCH RUN FOR SIMULATIONS

In some situations the user wants to run several simulations, one by one, and save simulation results automatically, without a need of running each simulation separately. The routine provided for that is a *Batch Run*. Until version 2015, the user needed to set up it manually via external *.bat file, using specific command line options for *QW-Editor* and *QW-Simulator*. In *QuickWave* version 2015 we introduced more intuitive and user friendly procedure, in which the scenarios that should be run and results that should be saved are specified directly in *QW-Simulator*.



We need to indicate, which projects are to be run and define *breakpoints* (instructions that will be executed during simulation i.e. save results, save fields, etc.) for them.

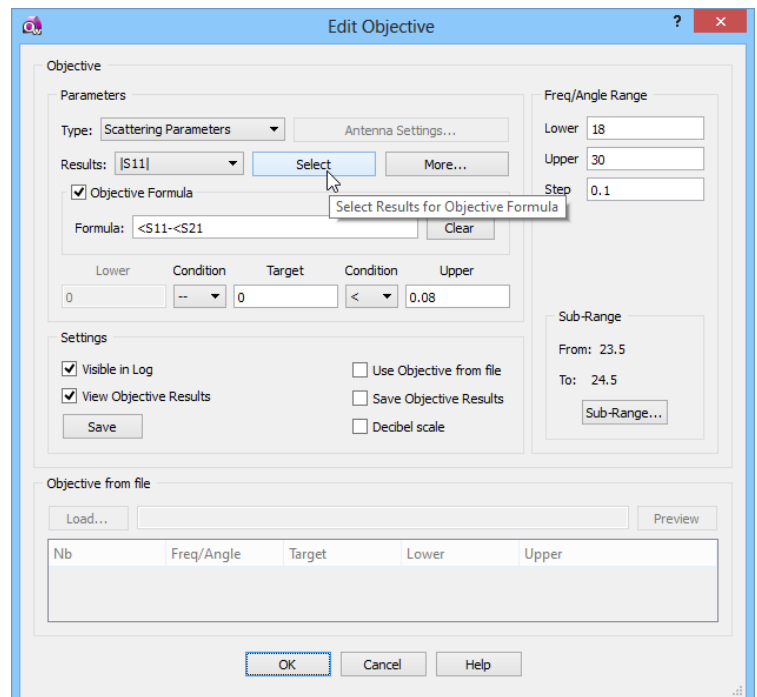
OPTIMISATION AND PARAMETERS SWEEP

Starting from *QuickWave* version 2015, the *Objective* can be introduced as a user defined formula, in which the arithmetic operations are performed on available results. After checking *Objective Formula* option the user may introduce names of the variables manually or select them from the *Results*. Arithmetic operators should be entered manually and the following operators are available:

- +
- -
- *
- /

Operations with constant values and brackets are also allowed i.e. $(<S11-<S21)*2$.

Decibel scale option allows setting *Lower*, *Target* and *Upper* values in decibel scale, also for objective from file.

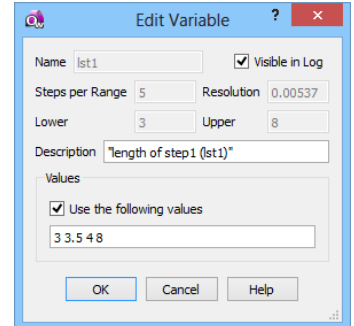


PARAMETERS SWEEP

Starting from QuickWave version 2015, parameters sweep is included in the QuickWave Professional package.

Parameters sweep (grid search) may be a good choice as an indication of good starting point for further use in Optimisation. Instead of setting steps per range for each enabled variable, user defined values can be used. After checking *Use the following values* in the *Edit Variable* dialogue the user can enter values which will be used in Grid Search.

Parameters sweep can be started either from the first step or one of the following, specified by the user.



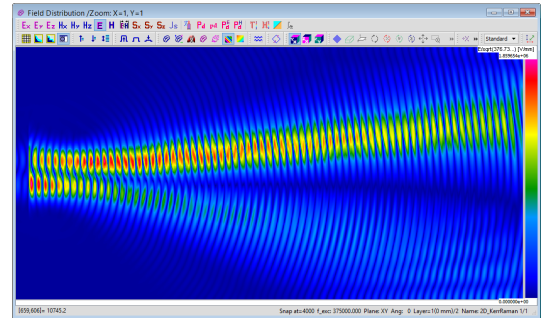
NONLINEAR DISPERSIVE MATERIALS

Third-order nonlinear polarisation given by Kerr-Raman model can be set for dispersive material described with Lorentz model. Kerr-Raman model is described by:

$$P^{(nonlinear)}(t) = \varepsilon_0 \chi_0^{(3)} E(t) \int_{-\infty}^t g(t-t') E^2(t') dt'$$

$$g_R(t) = \frac{\tau_1^2 + \tau_2^2}{\tau_1 \tau_2} \exp\left(-\frac{t}{\tau_2}\right) \sin\left(\frac{t}{\tau_1}\right) u(t)$$

$$g(t) = \alpha \delta(t) + (1 - \alpha) g_R(t)$$



Eq. 26-28 in M. Fujii, M. Tahara, I. Sakagami, W. Freude, and P. Russer, "High-order FDTD and auxiliary differential equation formulation of optical pulse propagation in 2-D Kerr and Raman nonlinear dispersive media," *IEEE J. Quantum Electron.*, vol. 40, no. 2, pp. 175-182, 2004

where:

tau1 (τ_1) inverse of the characteristic frequency [fs],

tau2 (τ_2) damping time constant [fs],

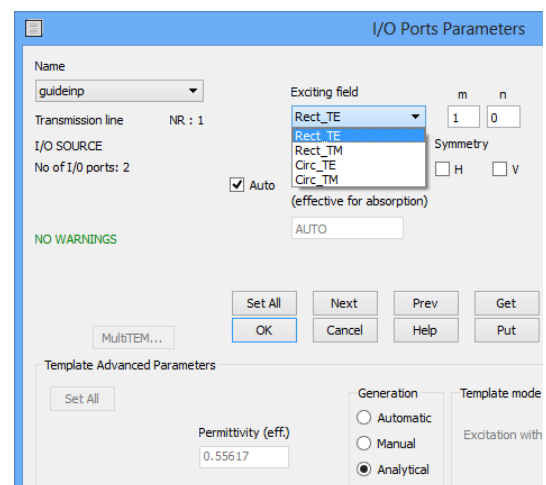
hi3 (χ_0) strength of the third-order nonlinearity [(m/V)²],

alpha (α) Kerr contribution to the total Kerr-Raman nonlinearity [unitless],

ANALYTICAL PORT TEMPLATE

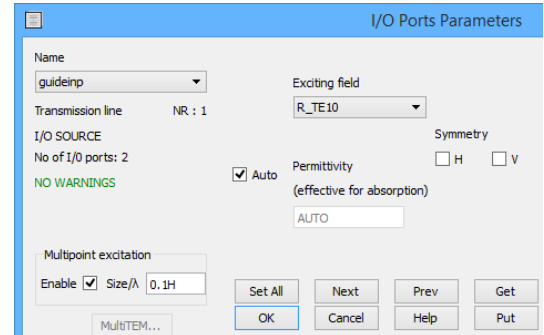
For *Analytical* mode generation the software generates theoretical template shape for a chosen mode at the *matching frequency*. A warning will be issued if the matching frequency cannot be found (*matching frequency* below cut-off frequency for a given mode).

Now, *Analytical* mode generation is available also for periodic structures.

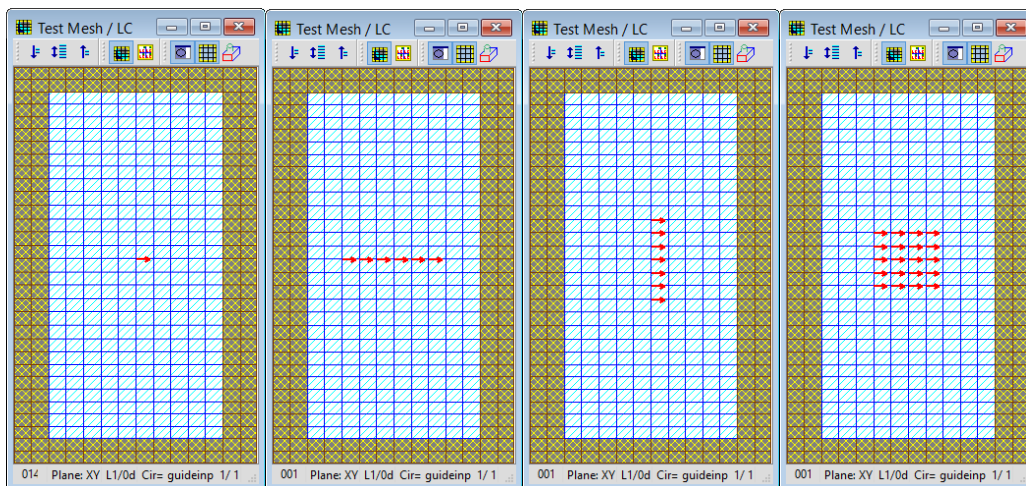


MULTIPOINT EXCITATION FOR DYNAMIC PORT TEMPLATES AND POINT PORTS

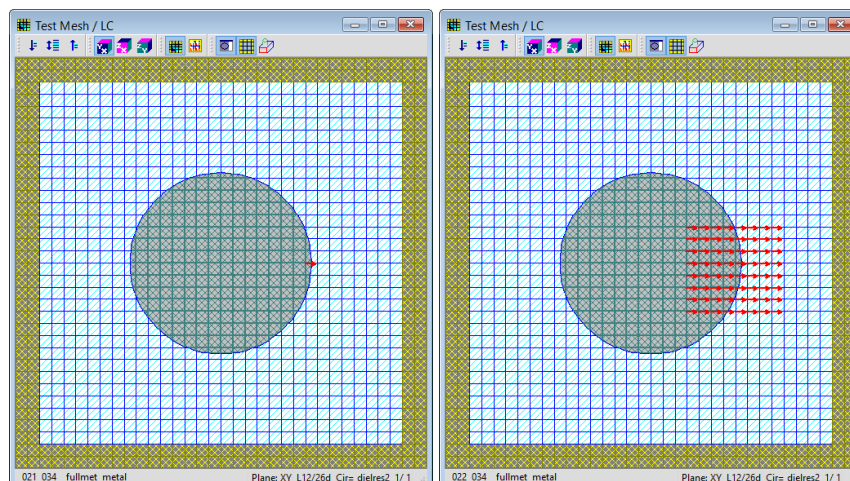
Standard point excitation is applied to a single mesh cell. In cases, when mesh is dense and port/circuit contains many cells, point source is weakly coupled with circuit/port. Such situation requires longer simulation time. To speed up the process of dynamic template generation or energy delivery to the circuit with point excitation, the user can enable multipoint option which extends predefined point source into rectangle (template port) or cube (point excitation in 3D circuit). The user defines size of extension as dimension/wavelength ratio. Optionally rectangle may be reduced to line and cube to plane.



New *UDO* command (*MULTIPOINT*) allows activating multipoint excitation, defining size of extension as dimension/wavelength ratio and the shape of extension.



Multipoint excitation for dynamic port template.



Multipoint excitation for point port.

OTHER IMPROVEMENTS

1. Import Recent Files and Preferences from previous QuickWave versions.
2. Type change (*Source* or *Load*) of template port available for existing port.
3. Type change (*Point* or *Probe*) of point port available for existing port.
4. Type change (*Mur with superabsorption* or *PML*) of absorbing wall available for existing wall.
5. Export to subdirectory specified in *Preferences* dialogue.
6. Number of cores used in simulation can be specified for OMP versions of QW-Simulator.
7. New QuickWave variables: *<DATE>* (contains the actual date in the form of YEAR_MONTH_DAY, *<TIME>* (contains the actual time in the form of HOURS_MINUTES_SECONDS).
8. Improvement of backward radiation calculation for antenna radiation patterns.
9. *PARL* UDO command allows defining UDO parameter with a list of possible choices.
10. 3dB bandwidth available in View Results window.
11. Accuracy improvement for geometry drawing in XY plane.
12. Accuracy improvement for curved boundaries approximation.
13. QW-AddIn for Autodesk® Inventor® Software: medium parameters (Relative Permittivity, Relative Permeability, Electrical Conductivity and Magnetic Loss) can be configured using user parameters.
14. QW-AddIn for Autodesk® Inventor® Software: ports and boxes located outside the mesh are truncated during exporting to UDO.