QUICKWAVE 2014

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. With the introduction of QuickWave 2014 we expand the possibilities with fast and easy project design, fast and accurate simulation and more flexible user interface.

The major requirements of microwave engineers during the design are to have a convenient way to import geometrical data from mechanical CAD software, setting a few simulation parameters and obtaining the results in a reliable time. QWED adjust the development of the QuickWave electromagnetic software to fulfil these needs.

In this release we focus on the extension of the area of applications to cover more real life problems and phenomena. We provide the user a full settings' control. New *ExH time integral* processing allows observation of the power flux. New manual tuning option for BHM scenarios provides the ability of changing excitation frequency to an arbitrary value – not necessary the one with the deepest resonance as in automatic tuning. *Freeze* feature is extended to BHM scenarios with rotation or movement of heated load(s), what makes the simulations more flexible.

An improved *QW-AddIn for Autodesk® Inventor® Software* (popular and wide-spread mechanical tool), allows defining complete electromagnetic simulation directly in the mechanical data environment. Now extended with possibility of designing axisymmetrical structures (V2D) and automatic mesh generation using *Automatic Meshing Intelligent Generation Option (AMIGO)*. Additionally *QW-AddIn for Autodesk® Inventor® Software* can be used for optimisation and parameters sweep with *QW-OptimiserPlus*.

The speed of simulation is an important issue. With new *Analytic* option for port mode generation, the generation of the port field pattern takes seconds, what is especially perceptible for big projects.
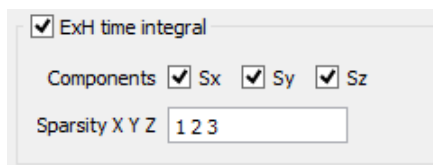
ExH TIME INTEGRAL PROCESSING

New postprocessing, *ExH time integral*, can be used for monitoring the time-integrated Poynting vector in a particular part of space. That operation is performed in all areas defined as *FD Monitors 3D*. Time domain integral of the Poynting vector has the meaning of a power flux and is expressed in [J/m^2]. Thus that value is typically compared to the total energy available from the input pulse source and thus, this postprocessing should be used together with the *FD-Pavailable* postprocessing, which provides information about the spectrum of the input pulse and the total energy available in it.

It should be noted that when this postprocessing is active, *QW-Simulator* starts integrating the *ExH* components over time from the first iteration and indicates that in the *Project Tree* and *Simulation Log* window with a statement like "*Postprocessing [2]: fdm3d_1, (ExH Time Integral): Components: Sx Sy Sz, Sparsity: X=1 Y=2 Z=3".*
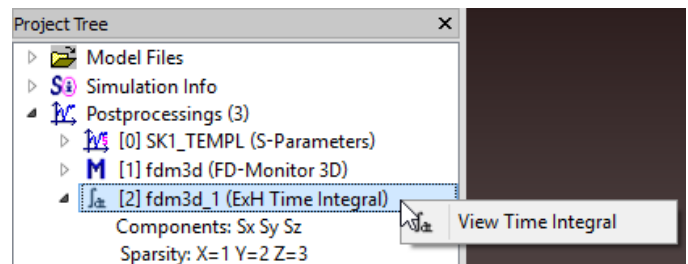
The integration is relatively time consuming and thus in big scenarios it is recommended to use this postprocessing with a reduced space resolution, obtained by setting an appropriate sparsity factors.
Attention: The *ExH time integral* is calculated in the area defined by the *FD-Monitor 3D* but it does not include calculation of Fourier transformation in time. Thus its results are displayed in *QW-Simulator* using *View-Fields* command instead of *View Fields Monitor* command used for *FD-Monitors*.

The parameters for *ExH time integral* postprocessing can be set in *QW-Editor* in *Processing/ Postprocessing* dialogue. The results of the postprocessing can be watched in *QW-Simulator* in the *View Fields* window for Poynting vector (components: *ExH, Sx, Sy, Sz*) under *Calculate the Integral* button.
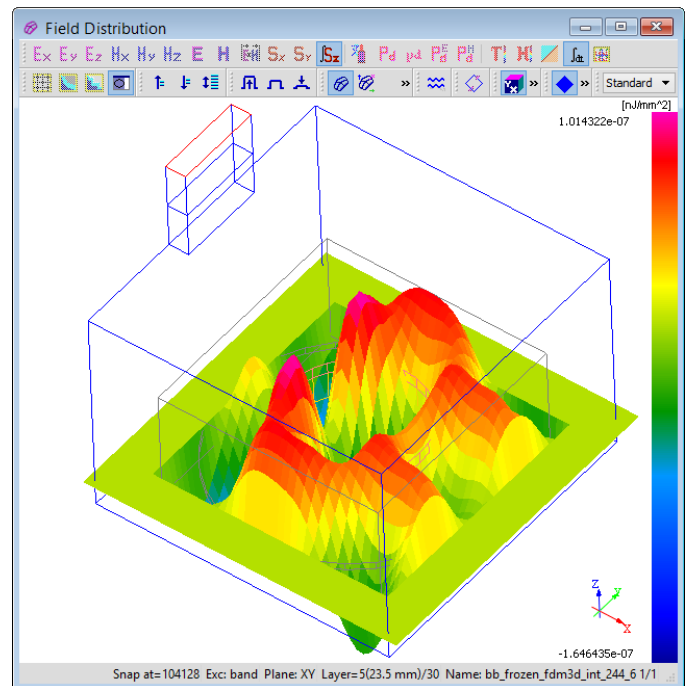
New UDO command (*EXHTIMEINTEGRAL)* allows activating *ExH time integral* postprocessing, setting components and spatial sparsity for X, Y and Z directions, directly from UDO script.
New tasker commands (*Save_Calculated_Time_Integral_Results* and *Save_Time_Integral_Results*) allow saving *ExH time integral* results to the specified file.

MANUAL TUNING IN QW-BHM

The approach of applying a monochromatic source is the most popular one in microwave power modelling and has been followed so far. However, it does not reflect all phenomena that occur in real life applications. The most widespread microwave power source, a magnetron, is an imperfect device gradually changing its frequency during the heating, and in fact, it may even "jump" from one frequency to another.

The physical behaviour of various real power sources under various conditions can be simulated using *QW-BHM* together with automatic frequency tuning. It assumes that the source tunes automatically to the deepest resonance in the considered frequency band. This assumption perfectly suits microwave power applications with solid state power sources, where the return loss versus frequency can be monitored in time, and the source frequency can be tuned to the deepest resonance by the controller, so as to maximise the matching.

Manual frequency tuning is the new possibility of introducing new operating frequency for the source and can be switched on via *Manual tuning* option in *Heating details* dialogue in *QW-Editor*. After return loss calculation *QW-Simulator* will wait for the user response setting new frequency value.
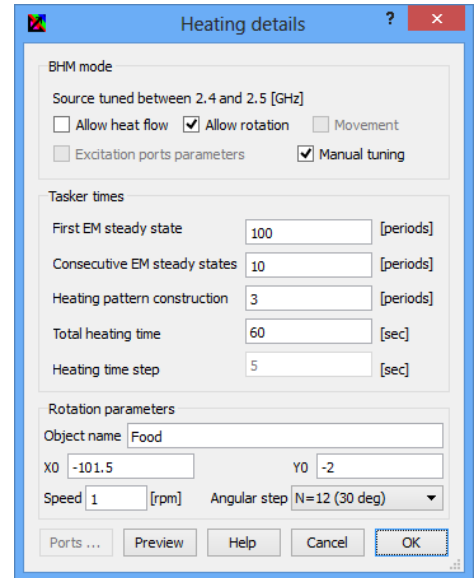
View Results window with S-Parameters will appear in BHM manual tuning mode. After clicking button the *Frequency* dialogue enabling frequency choice will appear. The user should choose the frequency and press OK button.
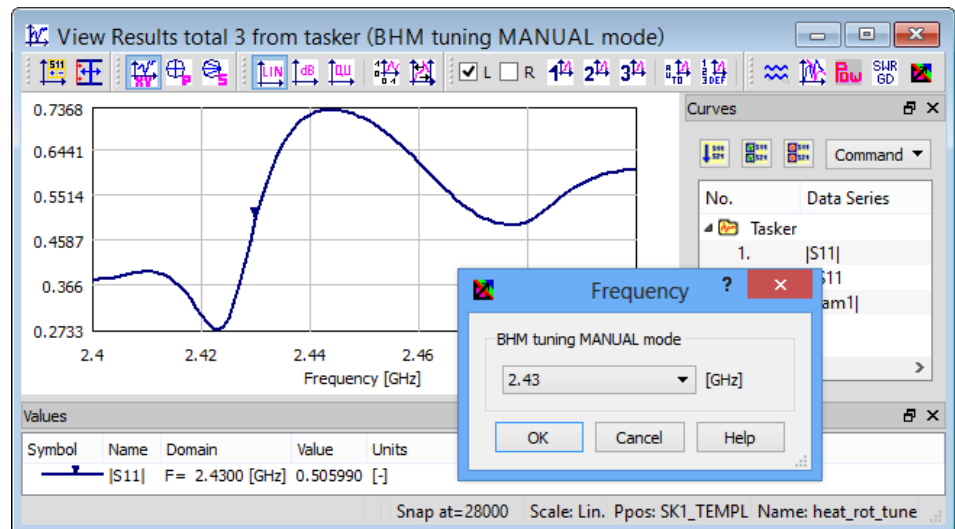
Additional messages are displayed in the *Simulation Log* window:

Manual BHM frequency tuning. Waiting for user choice in View Results window…
Manual BHM frequency tuning. User choice is F=2.43 [GHz], |S11|=0.50599 [-]
Simulator results file saved as C:/Users/Public/QWED/v2014x64/qw_examp/QW_3D/BHM/Heat/heat_ro
Starting from freeze file: C:/Users/Public/QWED/v2014x64/qw_examp/QW_3D/BHM/Heat/heat_rot_tu
Cell Descriptors Reading passed - 297, Cells number-82368
PMO file : C:/Users/Public/QWED/v2014x64/qw_examp/QW_3D/BHM/Heat/Food.pmf has been loaded
Circuit type: t3d
Number of Postprocessings: 1
Postprocessing [0]: SK1_TEMPL, (S-Parameters): From 2.4 GHz To 2.5 GHz Step 0.001 GHz
Excitation: name - templ1, Pulse type - band, Amplitude - 25, Delay - 0, Pulse duration - 2.30769 [ns] /
Change Excitation to sinusoidal 2.43 [GHz]

FREEZE EXTENDED FOR QW-BHM

Powerful *Freeze* option enables saving the actual state of the simulation in the purpose to restore this state or continue the calculations in the future. All *QW-Simulator* functions work in the same normal manner after *defreeze* operation. This feature is very convenient in many situations, typical when the user wants to:

- replace the calculations from one computer to another
- save calculations that are time consuming
- present a stable state of the calculations for a very large project without a necessity of running the simulation anew

Freeze operation can be applied to *BHM* scenarios, and now also including rotation and movement. However, it can only be invoked during regular FDTD iterations - not during the actual *BHM* processing. The *.sfr* file contains current electromagnetic fields, enthalpy, and temperature as well as copies of all the files needed for restoring the simulation, including *.pmo*, *.mv3*, *.ro3*, *.pr3*, *.pa3*, *.sh3* and *.ta3* files.
*Freeze* operation can not be applied for *BHM* scenarios with frequency tuning (automatic and manual).

QW-GPUSIM

QW-GPU Simulator is an OpenCL language implementation of *QW-Simulator* designated for massive parallel computing hardware, which can be executed on modern graphic cards (GPUs). Acceleration by approximately a factor of 14 for 3D examples and of 27 for V2D examples has been observed (on GTX TITAN GPU), with respect to multithread implementations run on comparably modern CPUs (I7 950).

To better accommodate workstations with multiple GPU devices we decided to rehash device choice method. In older versions of *QuickWave* in order to use two or more devices concurrently user needs to change preferences manually. Now it is changed to queue system. Every time *QW-GPUSim* launches it looks for the first device from the queue that is not already occupied by another instance of our program. If every device from the queue is occupied then search loops back and so on.

In *GPU* tab in *Preferences* dialogue there is a list of all devices available on the current machine. The order in the queue is given by the first *Preference* column. Devices on the list are always sorted by this column. Symbol "--" means that this device is not on the queue and will not be used while other preferences are available. Adding/removing device from the queue could be archived by using Add/Remove button. Buttons with up and down arrows allow user to shift order in the queue.
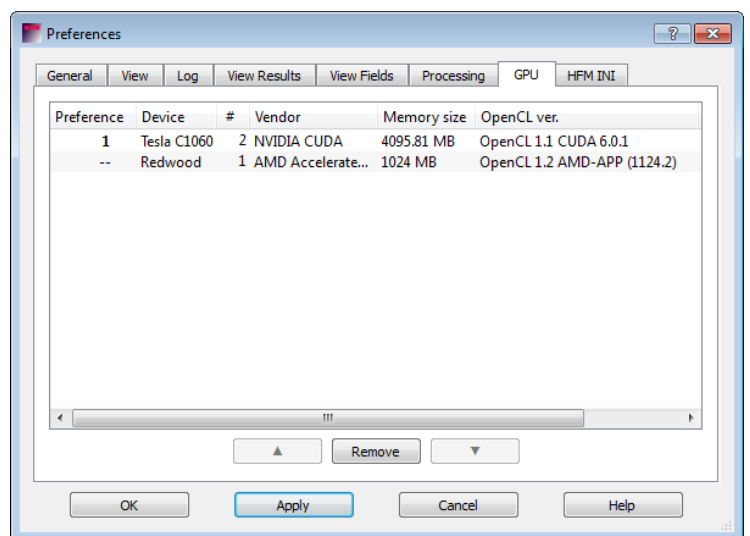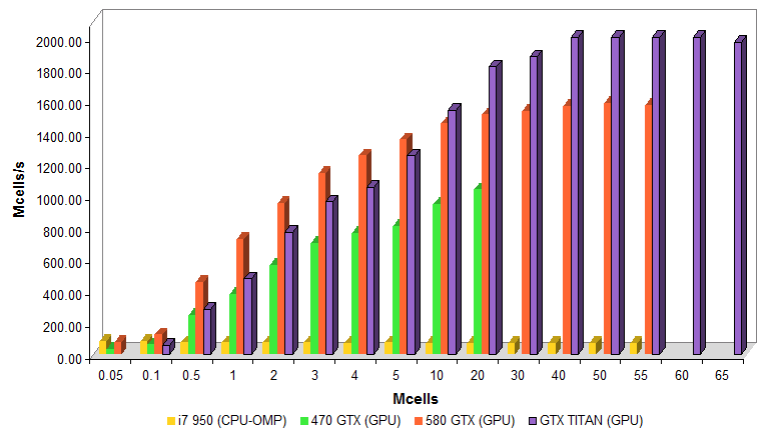
ANALYTICAL PORT TEMPLATE

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).

Using *Analytical* mode generation the user should set a required mode (rectangular or circular): Rect_TE, Rect_TM, Circ_TE or Circ_TM and values of mode indices *m* and *n*. Note that for *Analytical* mode the software assumes that the size of the port matches the size of the waveguide and the waveguide is filled with air.
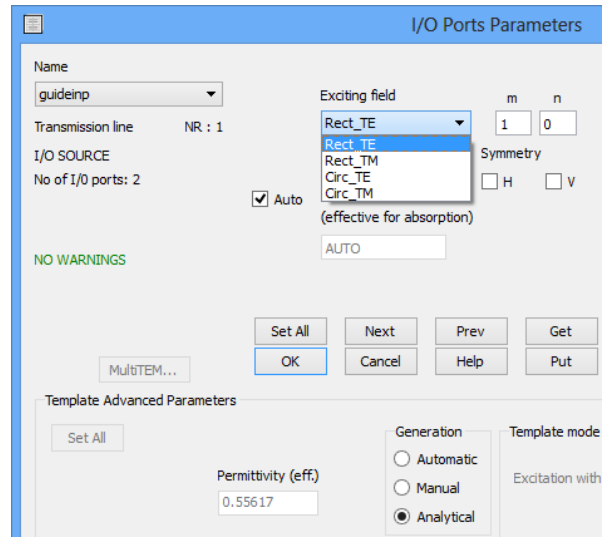
New UDO command (*TEMPA*) allows activating analytical template generation, setting template mode (rectangular TE or TM, circular TE or TM), indices of the mode, and matching frequency for port directly from UDO script.

MEDIUM INFO IN TEST MESH

The conformal FDTD meshing of the circuit is performed in the *QW-Editor* automatically but is controlled by the user. The user can choose the basic cell size, which determines the accuracy on one hand, and the computer time and memory needed for the simulations on the other hand.

Test Mesh available in *QW-Simulator* is an important tool of verification if the mesh used in the simulation corresponds to the intentions of the user. The mesh is displayed layer by layer and for a cell pointed by a cursor, its position, cell type and filling media are shown in window status.
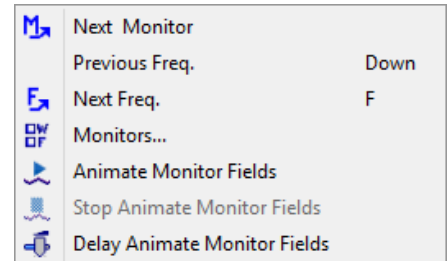
Medium Info dialogue shows the complete information about the medium under the mouse pointer. Now it also contains a full information for multipole (up to 3 poles) frequency dependent (Drude, Debye, Lorentz electric and magnetic dispersion) materials.
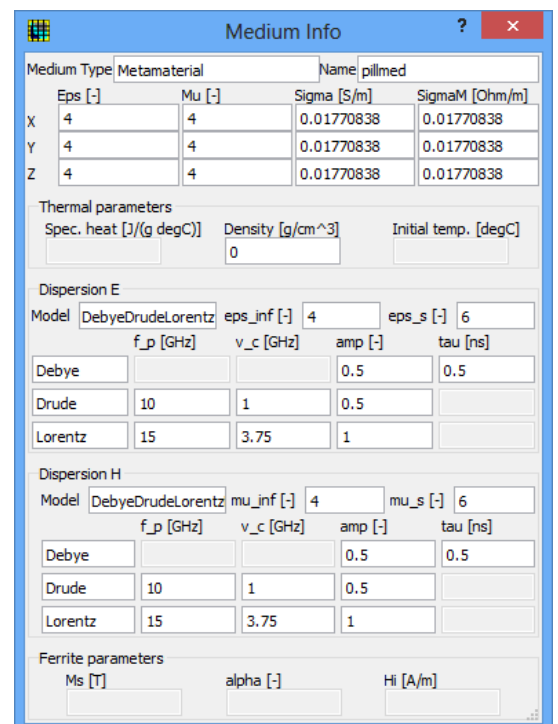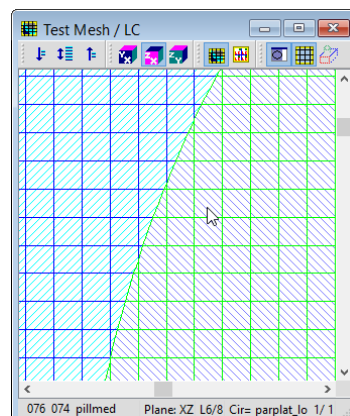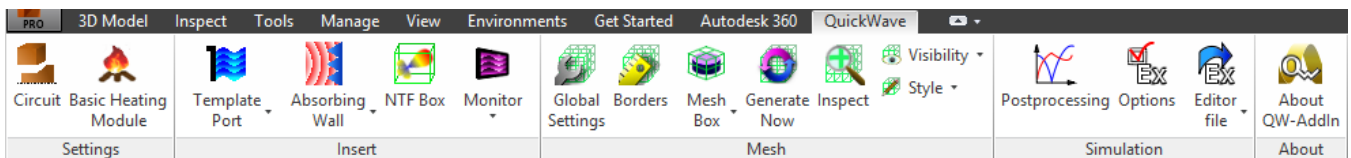
FIELDS MONITORING

FD-Monitors postprocessing allows monitoring the field distribution at multiple frequencies in one simulation (frequency domain monitoring) with a sparsity factor in space and time. The frequency domain fields are obtained from the time-domain ones via Fourier transform, which are calculated and stored from the beginning of the simulation. The frequency domain fields can be observed in the specified regions of the circuit called *monitors.* In *QW-Simulator*, magnitudes of these field components as well as real and imaginary parts of the Poynting vector (if available from the checked components) are accessible via *View-Fields Monitor* command. With *FD-Monitors* postprocessing we need to pre-define region and frequencies of interest, but then we obtain fields at multiple frequencies from one simulation with a pulse source (otherwise consecutive simulations, with harmonic excitation at consecutive frequencies would be needed).

Now the possibility of animation of the time domain field distribution (at chosen frequencies) for frequency domain monitoring is available.

M	Next Monitor	
	Previous Freq.	Down
F	Next Freq.	F
	Monitors...	
	Animate Monitor Fields	
	Stop Animate Monitor Fields	
	Delay Animate Monitor Fields	

QW-ADDIN FOR AUTODESK® INVENTOR® SOFTWARE IMPROVEMENTS

QW-AddIn for Autodesk® Inventor® Software allows preparing complete project for simulation directly in the CAD environment. Internal Autodesk® Inventor's® *Parameters* mechanism allows creating parameterised geometry. Now *QW-AddIn for Autodesk® Inventor® Software* can be used in optimisation and parameters sweep with *QW-OptimiserPlus* as an Editor for modifying the project geometry.
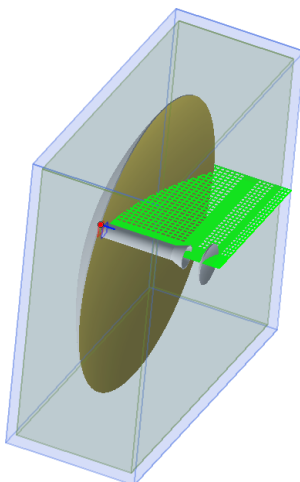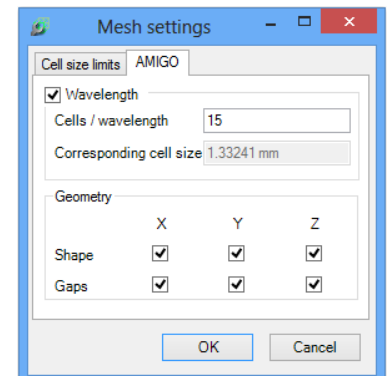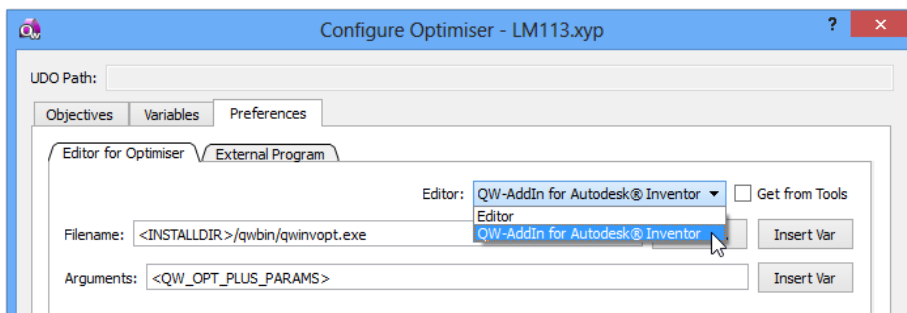
Automatic Meshing Intelligent Generation Option (*AMIGO*) optimises the meshing taking into account requested wavelength resolution in all media, while avoiding unnecessarily small cells. The shape of geometry is analysed in all X, Y and Z direction. Additionally the gaps are also taken into account.

QW-AddIn for Autodesk® Inventor® Software, next to *3D* projects, allows designing periodic structures and vector 2D (*V2D*) axisymetrical structures.

OTHER IMPROVEMENTS

1. Touchstone files in one or two port format can be loaded via *View->Saved Results* or *Load Reference* command in *View Results* window.
2. Comma-Separated Values (CSV) files can be loaded via *View->Saved Results* or *Load Reference* command in *View Results* window.
3. Export of the simulation results to Comma-Separated Values (CSV) file.
4. Pure data (*.txt and *.csv) only in Linear scale versus GHz were allowed. Now, new dialogue in *View Results* window allows indicating scale (Linear, Decibel, Quadratic) and domain (GHz or Hz) of the results that are loaded from file.
5. Managing list of reference data files in *View Results* window.
6. Domain for displayed results can be rescaled from GHz to Hz and vice versa via *Rescale Domain* command under cursor list context menu in *View Results* window.
7. Results in Polar and Smith displays can be displayed with domain limited scale.
8. The value of *Available Energy* from the source (in [nJ]) is displayed in the status bar of the *View Results* window while displaying *FD-Pavailable* results.
9. Saving the view of all opened windows (*View Results*, *View Fields*, *View Monitor*, *View Envelope*) to the *.png* files with new *Save_Opened_Windows_Picture* tasker command. The name of the separate files are set automatically as *<PROJECTFULLNAME>_<WINDOWTYPE>_<WINDOWNB> _it_<ITERATION>*.png,
10. The coordinate point (in FDTD cells) in which the fields are displayed can be changed one by one in each direction via commands in *Position* menu in *View Envelope* window.
11. Setting *Heat Flow Module* parameters available in *Preferences* dialogue.
12. Number of files that have been recently loaded and were remembered and visible in the *Recent files* menu can be defined for *QW-Editor* and *QW-Simulator* in *Preferences* dialogue.
13. New examples of *Salisbury* screen, one of the most popular absorbing structures.
14. Changing frequency band and step for *Dispersive Media Chart* via *Change Frequency Range...* command from context menu.
15. Number of periods for field pattern generation instead of number of iterations is set for template ports. New *TEMPDP* UDO command allowing specifying number of periods for port directly from UDO script.
16. Different types of project structure displays (useful for projects exported with sections from *QW-AddIn for Autodesk® Inventor® Software*) in *View Fields* window.
17. The content of the dump file, available in *View Fields* window, can be specified in *Preferences* dialogue.
18. Files list in *Project Tree* is refreshed after save any results.