

# QUICKWAVE 2017

SOFTWARE FOR ELECTROMAGNETIC DESIGN AND SIMULATIONS

QUICKWAVE-3D QUICKWAVE-V2D QW-MODELLER QW-ADDIN FOR AUTODESK<sup>®</sup> INVENTOR<sup>®</sup> SOFTWARE QW-BHM QW-GPUSIM QW-MULTIGPUSIM QW-OPTIMISERPLUS QPRONY

QuickWave 2017





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

The most visible change in *QuickWave 2017* is the Ribbon GUI that appears in the *QuickWave Editor* and in *QuickWave Simulator*. All commands in the Ribbon are organised in a series of tabs divided in sections with grouped commands and contain various types of buttons and controls. *QuickWave Editor* is equipped in the main Ribbon containing all commands needed for creating complete project for FDTD electromagnetic simulation with *QuickWave Simulator*. *QuickWave Simulator* is equipped with the main Ribbon and window dedicated Ribbons containing all commands needed for running electromagnetic simulation, checking the FDTD mesh, observing the electromagnetic fields and components and getting the simulation results. For the convenience of the users, we kept the possibility of using the previous Toolbars style. The choice can be made during the first run of *QuickWave Editor* and *QuickWave Simulator* or later with the use of readily accessible commands from the menu.

All main menus and windows' menus in *QuickWave Editor* and in *QuickWave Simulator* were organised thematically, what provide easy access to options and commands.

The new *QuickWave Help* system provides easier and faster access to the specific topics. The *QuickWave Help* system is divided into subcategories and is available from every window and dialog of *QuickWave Editor* and *QuickWave Simulator*.

The *Basic Heating Module* is now enhanced with a wide variety of options, allowing defining complete BHM process directly from *QuickWave Editor* interface, which include intuitive configuration of Rotation Axes, Movement Trajectories, declaring variable heating steps etc.

The effective and practically useful solution for simulation convergence monitoring has been introduced. It utilises monitoring of the electromagnetic (EM) energy in the calculation model and stopping the simulation when it decays to a certain level. This allows reducing the number of performed FDTD iterations and as a result the computing time, without reducing a computational accuracy. This solution is now available in *QuickWave* as *Energy Stop Criterion* feature.



# **RIBBON GUI IN QUICKWAVE EDITOR**

The Ribbon of *QuickWave Editor* groups all necessary menus and commands that guide the user during project preparation, setting of the simulation parameters, and simulation starting process.

The Ribbon Home tab is arranged in ten sections enabling basic file operations like loading and saving projects, adjusting the project content view to user's preferences, setting access to external applications or format converters, managing windows and refreshing the project after introducing modifications, staying up to date with *QuickWave* updates, accessing main help, support, QWED's website, *QuickWave End User Licence Agreement*, exiting the *QuickWave Editor* and accessing help for Home commands.

×	•		Home	A	Mode	el 🛛 👪	Simu	lation																				
5	N	ew	Open	Recent.	Save	Save As	UDO's	Preferences	Variables	Calculator	Set	Log	Tree	Info	Toolbars	2D	3D	Refresh	Arrange	Check	Configure	Help	Support	Website	EULA	<b>?</b> About	Exit	1000 Help
- Ha				Project		*	(	Configure 🚽	Info	Tools				View				Windows		L	Jpdates			Help			Exit	Help

The Ribbon Model tab is arranged in thirteen sections enabling basic file operations like loading and saving projects, defining basic project settings, drawing geometry from UDO scripts, setting excitation type and its parameters, boundary conditions, meshing, and accessing help for Model commands.

×		Home		Moc	del	10	Simulatio	n																				
5	New	0pen	H Save	Circuit	Units	📌	Media	Library	Editor	DF Phase	<b>2D</b> 2D	SAT	DXF	SAT SAT	<b>I/O</b> I/O	Transmission Line .	Point.	Mane Wave	Lumped.	abc.		Monitor.	Snap.	Set .	AMIGO	Info	Help	)
Ribb		Project	-		Settings		Media		UDO		Drawing	In	nport/Exp	ort	I/O		Sources a	nd Loads		ABC	NTF	Monitor		FDTD	) Mesh		Help	6

The Ribbon Simulation tab is arranged in five sections enabling basic file operations like loading and saving projects, defining post-processings, choosing *QuickWave Simulator* type, exporting the current project to *QuickWave Simulator* and starting simulation, and for user's convenience accessing help for Simulation commands.

×		Home	A	Model	<u> </u>	Simulati	on											
E	New	0pen	H Save	Postprocessings					Monitor			Run	 Ex Options				QProny	Help
hhia		Project	*				Postproc	cessings			QW-Simulator			E	xport			Help

For the convenience of the users, we kept the possibility of using the previous Toolbars style. The choice can be made during the first run of *QuickWave Editor* or later with the use of readily accessible commands from the menu.



# RIBBON GUI IN QUICKWAVE SIMULATOR

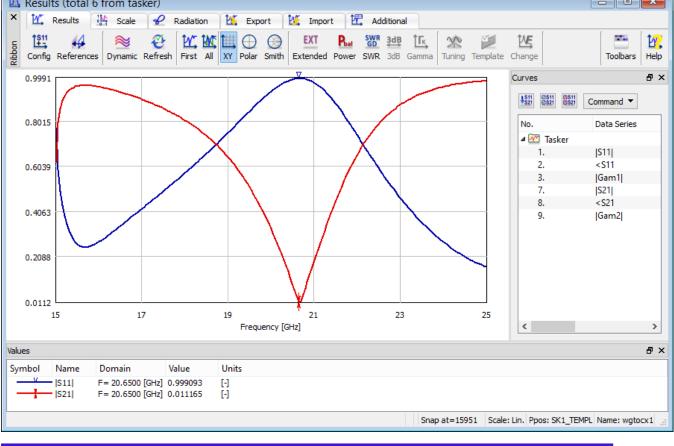
*QuickWave Simulator* is equipped with the main Ribbon and window dedicated Ribbons containing all menus and commands necessary for running electromagnetic simulation, checking the FDTD mesh and using mesh testing tools, viewing a wide variety of simulation results including electromagnetic fields, exporting the simulation results and loading the previously saved results.

× 🔄 Home 🕟 Run 🔯 Mesh 🗽 Results 😂 1D Fields 🎆 2D/3D Fields M Monitor 👰 Optimiser
🖻 😬 🚺 💽 🕘 🕺 📇 🕰 🖄 🗟 🚍 🛎 🖆 🖆 🏝 🎽 🖉 🖆 🚳 🥔 😭 😭 📾 🗞 ? 🖳 😫
Open         Recent_         Breakpoints         Preferences         Variables         Units         QW-Editor         Set         Tree         Log         Info         Toolbars         Cascade         Tile         Close All         Close All         Close All         Configure         Help         Support         Website         EULA         About         Exit         Help           5
Restore     Restore       Project +     Configure +     Info     Tools     View     Windows     Updates     Help     Exit     Help
🗙 🔚 Home 🕟 Run 🔯 Mesh 🗽 Results 😂 1D Fields 🎆 2D/3D Fields M Monitor 🔊 Optimiser
🖺 🖽 📡 🌔 🌔 🌔 🌔 🌔 🥥 🧔 💿 🥥 🤕 🍕 🎪 🍂 🖄 Slow Down: OFF 🗶 🎞
Open         Recent         Freeze Simulation         Start         Stop         Suspend         Resume         Step         Batch         Breakpoints         Create         Delete         Task         Post Saved         Test         View         Slow         Heating         Thermal         Z Changing         Frequency         Maveform         Help
Project         Freeze         Run Simulation         Breakpoints         Create         Next         Template         Slow Down         Manual BHM         Point Excitations         Change         Waveform         Help
🗙 💽 Home 🕟 Run 🔯 Mesh 🗽 Results 😂 1D Fields 🎆 2D/3D Fields M Monitor 👰 Optimiser
Open Run Mesh View Saved XY XZ YZ Isotropic Mesh Structure Inspect Geometry Media Dispersive Lumped Points Transmission Plane ABC NTF Fields Warnings LC Help
And Project +         Run +         Test Mesh         Display Options         Info         Test LC         Help
🗙 💽 Home 🕟 Run 🔯 Mesh 🗽 Results 🔅 1D Fields 🎆 2D/3D Fields M Monitor 🔊 Optimiser
Open Run Results View Cartesian Polar Smith Extended Power Cartesian Polar Rieke FD Power NTFFA Cartesian Polar 30 View Power Integral Average QProny Help saved Energy & of Power Temperature
Project + Run + Results S-Parameters SWR & GD FD-Probing Power NTFFA 2D Radiation Pattern 3D Radiation Pattern 3D Radiation Pattern + QProny Help
× 💽 Home 🕟 Run 🗱 Mesh 🕊 Results 🤃 1D Fields 🎊 2D/3D Fields M Monitor 👰 Optimiser
<ul> <li>Home D Run D Ruh L Results 20/3D Fields M Monitor O Optimiser</li> <li>Image: D Fields D Field</li></ul>
Open Run Fields View X Y Z Time E fields, H fields, H fields, H at Point Ip at Point He along Contour, Ic along Contour, SAR Temperature Enthalpy Energy Dynamic Total Waveform,
Project + Run + Fields Space/Time Domain Components Help
$\begin{array}{c c c c c c c c c c c c c c c c c c c $
Open Run Fields View Lines Points Art Art Thermal Thermal Vector Viewer Structure Efields, H fields, Poynting, Power, Js SAR I II Seff Help Effective Help
Open         Description         Components         Help
Open Run, Monitor View Lines Points Art Art Thermal Thermal Vector Structure Animation E fields, H fields, Power, E fields, H fields, Poynting, E fields, Poynting, Help
Saved         Saved         Lines         Filled         Discrete         Continuous         3D         Help           Project         Run         Monitor         Monitor         Display Options         Monitor Amplitude Components         Monitor Real Components         Monitor Imaginary Components         Help
×         E         Home         Image: New home
Image: Construction of the state stat
Set     Parameters

For the convenience of the users, we kept the possibility of using the previous Toolbars style. The choice can be made during the first run of *QuickWave Simulator* or later with the use of readily accessible commands from the menu.



# QuickWave 2017 🎆 2D/3D Fields Distribution /Vol Max × 🗜 Components 🏽 2D Surface 📃 2D Thermal 🗰 3D Vector 🖉 3D Viewer 🎆 Display 🖉 Structure 💸 Envelope 💸 Export 🚳 🏽 🥵 🚝 🐙 🏭 🗊 🗊 🗊 🕠 ¥ **%** л 0 6 75 16X Points Lines Art Filled Up Down Go To XY XZ YZ Amplify Adjust Attenuate Isotropic Scale. Width Preferences Palette 🗸 Next [VWmm^2] 8.746174e+07 0.000000e+00 Start at=17770/ 170 f\_exc: 193414.000 Plane: XY Layer=2(0.00001 mm)/2 Name: PhC\_wg\_bend 1/1 🛄 Results (total 6 from tasker) x



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# MORE CONVENIENT DIALOGUES IN QUICKWAVE EDITOR

The *QuickWave Editor* user interface has been enhanced with a set of new intuitive dialogues, for introducing and editing parameters of the ports, probes, Absorbing Boundary Conditions, field monitors, etc., for introducing mesh snapping planes or configuring the post-processings. The new dialogues allow the user to introduce project parameters modification in an easy and convenient way.

Add ABC Box ? ×											
Port Name: murbox Type: MUR  Activity: PLUS											
Geometry Parameters           Image: Second state           Image: Second state           Image: Second state											
X: 10.00000   Y: 10.00000   Z: 10.00000   X to YZ											
Position     Ordinates     Dimensions											
Xmin: -20.00000 Xmax: 50.00000 Length: 70.00000											
Ymin:         -20.00000         Ymax:         30.00000         Width:         50.00000											
Zmin: -20.00000 Zmax: 34.00000 Height: 54.00000											
Refresh											
OK Apply Cancel Help:											
🚻 Near To Far ? 🗙											
Near To Far NTF Frequencies											
20 25         GHz           Frequency band         From: 5         To: 15         Step: 0.01         GHz											
NTF background medium (Eps, Mu, Sigma, SigmaM)											
OK Cancel Help											

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#### **QW-EDITOR LOG**

The *QuickWave Editor* user interface has been supplemented with the new *QW-Editor Log* window, which delivers a wide variety of information concerning the project that the user is working with. The displayed information include the warning/error messages issued by Parser – UDO scripts interpreter, the activated Export Options notice, information regarding post-processings that has been activated for the project, etc. and also warning/error information issued by Export procedures.

QW-Editor Log	Ð	×
QW-Editor started-Thu Mar 23 15:02:53 2017         Loading project C:/Users/Public/QWED/v2017x64/qw_examp/QW_3D/Standard/Antennas/Holen/holen1.pro         Project loaded from C:/Users/Public/QWED/v2017x64/qw_examp/QW_3D/Standard/Antennas/Holen/holen1.pro         Export start v2017;2017.03.17 Thu Mar 23 15:06:27 2017         Export to directory: C:\Users\Public/QWED\v2017x64\qw_examp\QW_3D\Standard\Antennas\Holen         Export options:         Suppress singularity corrections: No         Suppress density/SAR: No         Allow Template QS test: No         Allow BHM: No         Postprocessings:         S-Parameters: Yes         Near To Far: Yes         Export done Thu Mar 23 15:06:27 2017 export exit code = 0         Export OK		

#### **FDTD MESH TESTING TOOLS**

New set of testing tools is available for effective FDTD mesh grid. The testing tools allow inspecting the information regarding the effective FDTD mesh grid, including the position of the consecutive mesh lines along all three axis, the size of the following mesh cells, and additional information indicating if the cell is of minimum or maximum size generated for the project. Additional mechanism allowing finding the step in cell size between neighbouring FDTD cells, with user defined cell size ratio has been enabled. Moreover, the testing tools allow checking the position and dimensions of different simulation objects like, e.g. transmission line ports, MUR wall/box, NTF box, etc.

<i>i</i>	Transmission Line Port Info ? ×
Name inp Activity X plus Template file na Waveform	Type Source Permittivity (effective) me inp_holen1.tpl
pulse of spec Frequence f1: f2: Duration	trum f1 <f<f2 y 15 25 3 (GHz) 3</f<f2 
Amplitude	Delay [ns]





bcircuit	holen 1 (1/	1)			Min/Max cells size
X Y	Z				X: 1.00000/1.00000 Y: 0.94204/1.00000
Nb	Position	Size	Info	^	Z: 0.68858/1.00000
-	-21.63062	0.94204			
1	-20.68858	0.94204			Number of cells
2	-19.74654	0.94204	min		X: 48
3	-18.80450	0.94204			Y: 43
4	-17.86246	0.94204			Z: 43
5	-16.92041	0.94205			Geometry: 88752
6	-15.97837	0.94204			With boundaries: 107536
7	-15.03633	0.94204			RAM: ~ 10 M
8	-14.09429	0.94204			RAM: ~ 10 M
9	-13.15225	0.94204			Cell Size Step
10	-12.21021	0.94204			X to YZ
11	-11.26817	0.94204			
12	-10.32612	0.94205			🗌 X: 10.00 ≑
	-9.38408				☐ Y: 10.00 🜩
	-8.44204				
	-7.50000				Z: 10.00
	-6.50000		max		
17	-5.50000	1.00000		¥	

ž.	Absorbing Boundary Condition	ons Info 🛛 📍 🗙
NameActivityabs_botZ plusabs_topZ minusabs_leftX plusabs_rightX minusabs_downY plusabs_upY minus	Type MUR MUR MUR MUR MUR MUR MUR	View Plane  XY O XZ O YZ Show Info Info Dynamic



# BHM IMPROVEMENTS

The Basic Heating Module is now enhanced with a wide variety of options, allowing defining complete BHM process directly from *QuickWave Editor* user interface, which include intuitive configuration of Rotation Axes, Movement Trajectories, declaring variable heating steps etc.

Network Add Rotation Axis ? ×
BHM Rotation Axis Name: rotaxis_1
Parameters
Coordinates
X: 40 Z: 0 Height: 200
Y: 50 Auto
Speed
Speed: 2 [rpm] Direction: Right 🕶
Assigned Objects
Food Assign
OK Apply Cancel Help

BHM Rotation Axes	? ×
Name         X         Y         Speed [rpm]         Assigned Objects           rotaxis_Food         -101.5         -50         1 (Right)         Food           rotaxis_FoodY         -101.5         50         1 (Right)         FoodY	Type Change to Rotation Axis ▼ Info Edit Add Copy Delete Select All
Close Help	.:



QuickWave 2	20	17
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BHM Movement Trajectory Name: movetraj_1								
Parameters Movement Type								
● XY ○ Z								
	dX	dY	dZ	Add				
1	27	52	0	Delete				
2	54	52	0	Up				
3	81	0	0	Op				
4	54	-52	0	Down				
5	27	-52	10	Import				
6	0	0	10	Export				
Assigned Objects Food Assign								

<b>₽</b> <sub>±</sub>	BHM	Movement Tr	rajecto	ries ? ×
Name	Туре	Assigned Obje	ects	Туре
movetraj_Food1 movetraj_Food2	Movement XY Movement XY			Change to Rotation Axis 🔻
moveraj_roouz	Wovement AT	10002		Info
				Edit
				Add
				Copy
				Delete
				Select All
		Close	Help	.:



#### QuickWave 2017

In this version, the user is also allowed to enable saving in each BHM step, parameters other than temperature, e.g. enthalpy, effective media parameters, etc.

BHM Mode BHM Options Sinusoidal excitation at fixed frequence Allow	eating Details ? × y 2.46 [GHz] Suspend simulation after Each BHM step RUM step Components ? ×			
□ Excitation ports parameters         Image: Save additional components         Image: Tasker times         First EM steady state       102         Consecutive EM steady states       30         Heating pattern construction       10         Heating time [sec]       101         Total       90         □ Variable steps       Not defined	Available components:         Temperature         Enthalpy         Effective permittivity X         Effective permittivity Y         Effective permittivity Z         Effective permeability X         Effective permeability X         Effective permeability Z         Effective conductivity X         Effective conductivity X         Effective conductivity Z         Effective magnetic loss X         Effective magnetic loss Z			
Single Object Rotation parameters Object name rot X0 0 Y0 0 OK	Specific heat       ✓         Options          Data Format:       QuickWave Default         Include in File:       ✓         Shape Data       FDTD Mesh         OK       Cancel         Help			

#### **AVERAGE TEMPERATURE**

For *QW-BHM* simulation, calculation of average temperature in the heated has been enabled. Two values of average temperature are available: *arithmetic average temperature* and *volume average temperature*. The *average temperature* is calculated separately for media with non-zero density (both lossy and lossless) and those with zero density (both lossy and lossless).



# **ENERGY STOP CRITERION**

The effective and practically useful solution for simulation convergence monitoring has been introduced. It is enabled for pulse excitation with a finite duration time and utilises monitoring of the electromagnetic (EM) energy in the calculation model and stopping the simulation automatically when it decays to a certain level. This allows reducing the number of performed FDTD iterations and as a result the computing time, without reducing computational accuracy. This solution is now available in *QuickWave* as Energy Stop Criterion feature, which is supplemented with several options additionally restricting the stop criterion, e.g. coupling the energy level with S-Parameters results fluctuations.

🖺 Energy Stop Criterio	'n	? ×						
✓ Enable Energy Stop Criterion								
Energy Level descent	-40	dB						
Energy Level report every	10	dB						
Energy Level probing every	1	periods						
S-Parameters stabilisation within	0.005							
Pulses number limit	20							
Save S-Parameters when stop criterion met								
Freeze simulation when stop criterion met								
$\checkmark$ Suspend simulation when stop criterion met								
<ul> <li>Continue after pulses number limit reached</li> </ul>								
OK Cancel Help								

# S-PARAMETERS CORRECTION AROUND 0 GHZ

The differential method of *S*-parameters extraction used in *QuickWave* converges slowly close to DC. This note is important for *TEM transmission lines*, where we may be interested in results close to DC. In the *QuickWave 2017* the algorithm for S-parameters extraction has been extended to assure higher accuracy results near DC range.

#### COLD PLASMA MATERIAL

The new Cold Plasma material has been introduced. Its complex relative permittivity (including series losses) is given by single-pole *Drude* dispersion model with user-specified parameters.

#### TOTAL ENERGY

The total energy accumulated in the circuit and its variation with the simulation time is now available for viewing at any simulation stage.

#### WAVEFORM

The excitation waveform of all sources included in the project is now available for viewing at any simulation stage. As previously, the excitation waveform may be observed as it is generated and injected into the circuit and additionally, the entire excitation waveform may be viewed at any simulation stage from file, which is saved automatically by the software.



#### FREEZE WITH SUBTASKS

Simulation freeze operation has been significantly extended and it is now available also while the certain subtasks e.g. *Save\_Full\_Volume\_Envelope* are in progress. After unfreezing the simulation, the subtasks that were previously in progress will continue their calculations.

# NTF FREQUENCY BAND

The radiation pattern and scattering pattern will be calculated at all frequencies specified by giving directly their values (as previously available) or by declaring the frequency range and frequency step between consecutive values.

# NEW HELP SYSTEM

The new *QuickWave Help* system provides easier and faster access to the specific topics. The *QuickWave Help* system is divided into subcategories and is available from every window and dialogue of *QuickWave Editor* and *QuickWave Simulator*.

# OTHER

- 1. *QW-BHM* module allows for rotating metal objects, what is a significant extension of *QW-BHM* functionalities.
- 2. *QW-BHM* module allows for suspending and/or freezing the simulation after each or user defined number of BHM step.
- 3. *QW-BHM* allows for setting variable duration of consecutive heating steps.
- 4. The preview of Rotation and Movement process for QW-BHM projects has been enabled.
- 5. The diagnostic run for TEM template ports has been introduced.
- 6. Stability Factor Multiplier has been enabled for modifications in QuickWave Editor
- 7. QuickWave Editor has been adjusted to operation with several monitors.
- 8. The parameters list of Save\_Volume\_Instantaneous and Save\_Full\_Volume\_Instantaneous subtasks has been extended with media effective parameters, e.g. EpsX, MuX, SigmaX, SigmaMX, Specific heat, etc.
- 9. Viewing previously saved Shape file (\*.sh3) has been enabled.
- 10. New results file for NTF post-processing, containing radiation efficiency, radiation resistance, power radiated, power injected, and current injected by the source, saved automatically upon NTF results export/save command.

#### SHORT-TERM LICENCES

Short-term licences involve time periods from 1 month to 6 months and are available for *QuickWave Professional* package, *QuickWave Standard* package, and all *QuickWave* optional modules. The new licences are protected with a software licencing procedure.

*qwStore* gives the possibility of getting quotation and purchasing short-term licence of your choice for *QuickWave* software.



QuickWave 2017



Design is as simple as it can be. Simulation is as fast as you want it to be. Results are as accurate as they should be.

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