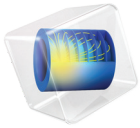

LiveLink™ *for* Excel®

User's Guide

6.0

COMSOL

LiveLink™ *for* Excel® User's Guide

Version: COMSOL 6.0

Contact Information

Visit the Contact COMSOL page at www.comsol.com/contact to submit general inquiries or search for an address and phone number. You can also visit the Worldwide Sales Offices page at www.comsol.com/contact/offices for address and contact information.

If you need to contact Support, an online request form is located at the COMSOL Access page at www.comsol.com/support/case. Other useful links include:

- Support Center: www.comsol.com/support
- Product Download: www.comsol.com/product-download
- Product Updates: www.comsol.com/support/updates
- COMSOL Blog: www.comsol.com/blogs
- Discussion Forum: www.comsol.com/forum
- Events: www.comsol.com/events
- COMSOL Video Gallery: www.comsol.com/videos
- Support Knowledge Base: www.comsol.com/support/knowledgebase

Part number: CM023401

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Chapter 2: Working With Models From Worksheets

Chapter 3: Loading and Saving Workbook Files

Chapter 4: Using Visual Basic® for Applications

1

Introduction

This guide introduces you to LiveLink™ *for* Excel®, which extends your COMSOL modeling environment with an interface between COMSOL Multiphysics® and Excel®.

In this chapter:

About This Product

LiveLink™ *for* Excel® extends your modeling capabilities by running COMSOL Multiphysics® simulations from an Excel workbook. Model definitions and results can easily be synchronized between your workbook and the simulation. In addition, LiveLink™ *for* Excel® adds the capability to create a COMSOL material library from data stored in a worksheet, and it enables support for saving and loading Excel® files for parameter and variable lists in the COMSOL Desktop®.

Read this section for an overview of:

- Interacting with a Model from a Worksheet
- Exporting Data to a Material Library
- Sharing a Model Between Excel® and the COMSOL Desktop®
- Loading and Saving Workbook Files in the COMSOL Desktop®
- Automating Using Visual Basic® for Application (VBA)

Connecting Excel to a COMSOL Multiphysics Server is only supported on Windows®.

Interacting with a Model from a Worksheet

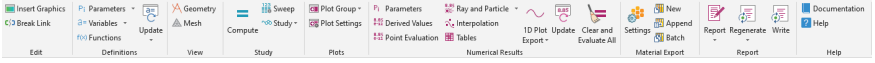


Figure 1-1: The COMSOL ribbon tab.

Using the tools on the COMSOL tab in the Excel® user interface (Figure 1-1) you can extract or modify model definitions, extract simulation results, and recompute a simulation. This allows you, for instance, to implement a simplified interface to a model (Figure 1-2) where you can access only the most important simulation parameters, and results from Excel.

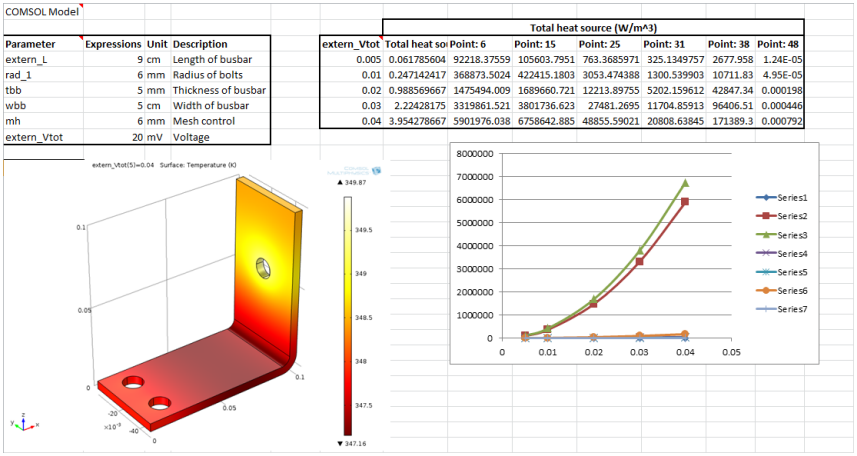


Figure 1-2: Overview of a worksheet linked to a COMSOL model.

While you work with COMSOL models you can still interact with 3D graphics in a separate dedicated window. You can insert COMSOL graphics into your worksheet as graphics images. This makes it possible to share your workbooks with people who do not have access to COMSOL Multiphysics.

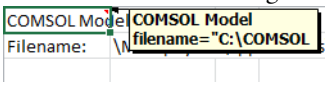
As soon as you open a model in Excel, a COMSOL Multiphysics Server starts in graphics mode where the model is loaded. The data transfer between Excel and the COMSOL Multiphysics Server is performed using a TCP/IP communication protocol.

The first time you start a COMSOL Multiphysics Server you need to enter a user name and password. Once this information is entered, the client/server communication is established. The information is stored in the user preferences, so that subsequent starts do not require it to be entered again.

LINKING A WORKBOOK TO A MODEL

When importing information from a model to a workbook in Excel, there are links placed in certain cells to ensure that data can be kept associated to the appropriate nodes in the COMSOL model. These links are represented in the Excel worksheet by

a comment on the cell, visible as a red mark at the top right cell corner. Hold the cursor over the cell comment to get a short description of the link.



Removing an automatically generated comment breaks the link between that cell range and the associated model feature.

Exporting Data to a Material Library

With LiveLink™ you can create a material library accessible by COMSOL models from material data stored in an Excel file. Using an interface (see Figure 1-3) you can configure the export such that COMSOL recognizes the material properties. The Material Export supports Excel sheet containing constant or field dependent material property.

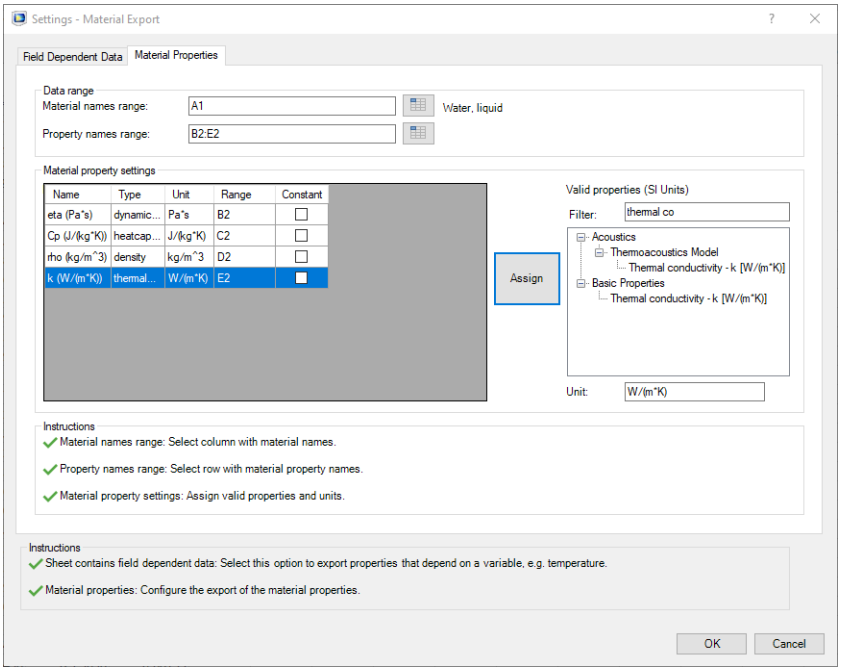


Figure 1-3: The Material export Settings dialog box.

Sharing a Model Between Excel® and the COMSOL Desktop®

You can share a model that is open in Excel with COMSOL Desktop by connecting COMSOL Desktop to the same COMSOL Multiphysics Server as Excel is connected to. This makes it possible to access the model settings simultaneously from Excel and from COMSOL desktop.

LiveLink™ *for* Excel® connects Excel with a COMSOL Multiphysics Server, started in graphics mode. This is called a graphics server. The graphics server does not support multiple clients connected at the same time. To share a model between the COMSOL Desktop and Excel you need to start a regular COMSOL Multiphysics Server when opening the model in Excel. See Managing Users Preferences to set the connection between Excel and a COMSOL Multiphysics Server without graphics.

Loading and Saving Workbook Files in the COMSOL Desktop®

LiveLink™ adds support to the COMSOL Desktop for the import and export files of the Excel workbook format (`.xlsx`). Use this functionality, for example, when saving data from a table to file. See Figure 1-4.

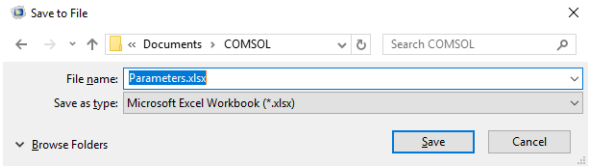


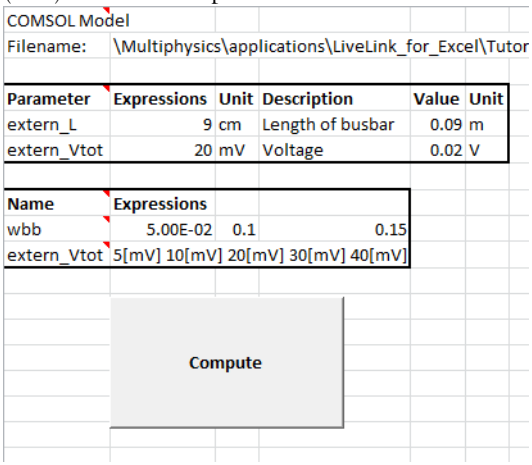
Figure 1-4: The Save to File dialog box.

Loading and saving workbook files is supported on all platforms even if Excel is not installed.

Automating Using Visual Basic® for Application (VBA)

Use VBA to control the content of Excel workbooks, create user interfaces, perform advanced calculations on worksheet linked to a COMSOL model. Using LiveLink™

also offers the possibility to use the COMSOL Application Programming Interface (API) in order to implement a model.



COMSOL Model

Filename: \Multiphysics\applications\LiveLink_for_Excel\Tutor

Parameter	Expressions	Unit	Description	Value	Unit
extern_L	9	cm	Length of busbar	0.09	m
extern_Vtot	20	mV	Voltage	0.02	V

Name	Expressions		
wbb	5.00E-02	0.1	0.15
extern_Vtot	5[mV] 10[mV]	20[mV]	30[mV] 40[mV]

You can save the model file for VBA format directly from the COMSOL Desktop.

Help and Documentation

A number of internet resources have more information about COMSOL, including licensing and technical information. The electronic documentation, topic-based (or context-based) help, and the application libraries are all accessed through the COMSOL Desktop.

If you are reading the documentation as a PDF file on your computer, the blue links do not work to open an application or content referenced in a different guide. However, if you are using the Help system in COMSOL Multiphysics, these links work to other modules (as long as you have a license), application examples, and documentation sets.

THE DOCUMENTATION AND ONLINE HELP

The *COMSOL Multiphysics Reference Manual* describes all core physics interfaces and functionality included with the COMSOL Multiphysics license. This book also has instructions about how to use COMSOL Multiphysics and how to access the electronic Documentation and Help content.

Opening Topic-Based Help

The Help window is useful as it is connected to many of the features on the GUI. To learn more about a node in the Model Builder, or a window on the Desktop, click to highlight a node or window, then press F1 to open the Help window, which then displays information about that feature (or click a node in the Model Builder followed by the **Help** button (). This is called *topic-based* (or *context) help*.

Win

To open the **Help** window:

- In the **Model Builder**, **Application Builder**, or **Physics Builder** click a node or window and then press F1.
- On any toolbar (for example, **Home**, **Definitions**, or **Geometry**), hover the mouse over a button (for example, **Add Physics** or **Build All**) and then press F1.
- From the **File** menu, click **Help** ().
- In the upper-right corner of the COMSOL Desktop, click the **Help**() button.

Mac

Linux

To open the **Help** window:

- In the **Model Builder** or **Physics Builder** click a node or window and then press F1.
- On the main toolbar, click the **Help** () button.
- From the main menu, select **Help>Help**.

Opening the Documentation Window

Win

To open the **Documentation** window:

- Press Ctrl+F1.
- From the **File** menu select **Help>Documentation** ().

Mac

Linux

To open the **Documentation** window:

- Press Ctrl+F1.
- On the main toolbar, click the **Documentation** () button.
- From the main menu, select **Help>Documentation**.

THE APPLICATION LIBRARIES WINDOW

Each application includes documentation with the theoretical background and step-by-step instructions to create a model application. The applications are available in COMSOL as MPH-files that you can open for further investigation. You can use the step-by-step instructions and the actual applications as a template for your own modeling and applications. In most models, SI units are used to describe the relevant properties, parameters, and dimensions in most examples, but other unit systems are available.

Once the Application Libraries window is opened, you can search by name or browse under a module folder name. Click to view a summary of the application and its properties, including options to open it or a PDF document.

The Application Libraries Window in the *COMSOL Multiphysics Reference Manual.*

Opening the Application Libraries Window

To open the **Application Libraries** window ( ):

Win	• From the **Home** toolbar, **Windows** menu, click ( ) **Applications Libraries**. • From the **File** menu select **Application Libraries**. To include the latest versions of model examples, from the **File>Help** menu, select ( ) **Update COMSOL Application Library**.

Mac Linux	Select **Application Libraries** from the main **File>** or **Windows>** menus. To include the latest versions of model examples, from the **Help** menu select ( ) **Update COMSOL Application Library**.

CONTACTING COMSOL BY EMAIL

For general product information, contact COMSOL at info@comsol.com.

To receive technical support from COMSOL for the COMSOL products, please contact your local COMSOL representative or send your questions to support@comsol.com. An automatic notification and case number is sent to you by email.

COMSOL WEBSITES

COMSOL website	www.comsol.com
Contact COMSOL	www.comsol.com/contact
COMSOL Access	www.comsol.com/access
Support Center	www.comsol.com/support
Product Download	www.comsol.com/product-download
Product Updates	www.comsol.com/support/updates
COMSOL Blog	www.comsol.com/blogs
Discussion Forum	www.comsol.com/community
Events	www.comsol.com/events
COMSOL Video Gallery	www.comsol.com/video
Support Knowledge Base	www.comsol.com/support/knowledgebase

2

Working With Models From Worksheets

Read this chapter for a description of the functionality provided by the LiveLink™ software inside the Excel® user interface. After installation the **COMSOL 6.0** tab is included on the ribbon in Excel. This is where you can access, modify, solve, and extract results from a simulation, or where you can configure data to create a material library.

In this chapter:

Overview of the COMSOL Tab

Switch to the **COMSOL 6.0** tab in Excel® to access LiveLink™ functionality to interact with the model from Excel.

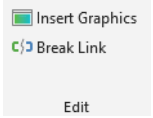
From here you can edit the model and view the geometry, the mesh, or the solution in an external 3D window. You can also compute the solution and extract data directly to the worksheet. From the COMSOL tab you can also access the material export settings to export the data stored in the worksheet to material data in the COMSOL format. The functionality provided by the buttons on the COMSOL tab is also available using Visual Basic® for Applications (VBA) as specific commands that can be run in a VBA script for automation.

The available tools are sorted into the following groups:

- Edit, where you can insert graphics into a worksheet, and manage links to a model.
- Definitions, where you can retrieve and update model definitions.
- View, where you can view the geometry and mesh.
- Study, you can compute the solution and access a parametric sweep.
- Plots, where you can display result plots.
- Numerical Results, where you can evaluate and extract data to the worksheet.
- Material Export, where you can create a material library.
- Report, where you can generate a report of the current model.
- Help, where you can access the documentation.

Edit

Use the buttons in the **Edit** group to manage the link between a cell range and the model, and insert a plot to the worksheet.



INSERT GRAPHICS

Click **Insert Graphics** () to import into the worksheet the currently displayed contents of the Graphics window using the COMSOL Multiphysics Server. The image can be exported from the graphics or directly taken as a screenshot. You can specify how you want the image and its size from the **Preferences** window.

See Managing Users Preferences to access the Preferences window.

See `InsertGraphics` to get more information about the corresponding command in VBA.

BREAK LINK

Click **Break Link** () to remove the comment added by the LiveLink™ interface from the selected cell range. This breaks the link between the cell range and the model.

See `BreakLink` to get more information about the corresponding command in VBA.

Click **Break Link > Break All Links** () to remove all the comments from the current worksheet. This breaks all the link between cell ranges and the model.

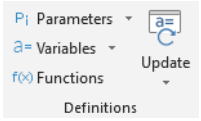
See `BreakAllLinks` to get more information about the corresponding command in VBA.

If you remove the comment on a cell that contains a material name or property configured for material export, the material or property is not exported to the material library, and the settings are lost.

Definitions

The **Definitions** group has the functionality to import model settings into the current worksheet, for example, parameters, variables, or functions. Select the cell range in the worksheet where you want to import the data, then click any of the buttons described below.

Importing data also creates a link between the worksheet and the model. You can edit the data and update the model with definitions from the modified cell.



PARAMETERS

Click **Parameters** ( ) to import all the global parameters from the open model.

See `Parameters` to get more information about the corresponding command in VBA.

Click **Parameters>Parameters Nodes**( ) to import only parameters listed in the selected parameter node. This is useful to filter the parameters to import in the worksheet.

See `Parameters` to get more information about the corresponding command in VBA.

Click **Parameters>Filter** ( ) to import only parameters with the prefix `extern` added to their name. This is useful if a model contains many parameters, and you only want to import a few into the Excel workbook. Just append the prefix `extern_` to the parameter names you want to use from the Excel worksheet.

L	extern_L	0.09 m
htc	5[W/m^2/K]	5 W/(m²·K)
extern_Vtot	20[mV]	0.02 V
extern_L	9[cm]	0.09 m

You can modify the expression, unit, and description of a parameter in the worksheet. To add a new parameter, enter it below the last parameter imported from the model.

Any change to the list is transferred to the COMSOL model during the update operation, which is by default done automatically. To manually control the model update with the modifications in the worksheet, see Update.

VARIABLES

Click **Variables** ( ) to import all the variables available in the open model.

See `Variables` to get more information about the corresponding command in VBA.

Click **Variables>Filter** ( ) to import only model variables with the prefix `extern` added to their name. This is useful if a model contains many variables and you only

want to import a few into the Excel workbook. If that is the case then just supply the variable names you want to use from Excel with the prefix `extern_`.

L	extern_L	0.09 m
htc	5[W/m^2/K]	5 W/(m²·K)
extern_Vtot	20[mV]	0.02 V
extern_L	9[cm]	0.09 m

Click **Variables>Select** ( ) to import only variables from a selected Variables node in the model.

You can modify the expression and description of imported variables in the worksheet. Any change to the list is transferred to the COMSOL model during the update operation, which is by default done automatically. To control manually the model update with the modifications in the worksheet, see Update.

FUNCTIONS

Click **Functions** (f(x)) to import function definitions from the open model.

The function import only supports one of the following type: Analytic, Interpolation, Step or Random.

You can edit in the worksheet the imported function definitions.

Any change to the list is transferred to the COMSOL model during the update operation, which is by default done automatically. To control manually the model update with the modifications in the worksheet, see Update.

See `Functions` to get more information about the corresponding command in VBA.

UPDATE

By default the update of parameters, variables, or functions is performed automatically as the cell is edited. This section describes how you can update manually the model with the value defined in the cell.

To set manual update for the model parameters, see Managing Users Preferences.

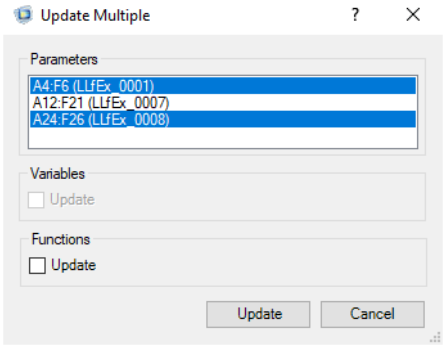
Click **Update** ( ) to update the open model with definitions found in the range of cells including the selected cell. The update requires that there is a link to the model within the cell range. The model is not updated if the open model does not correspond

to the model referenced in the link. Using this button you can update parameters, variables, and functions.

See `UpdateDefinitions` to get more information about the corresponding command in VBA.

Click **Update>Update All** () to update the model with all model definitions found in the current worksheet. Only cell ranges containing a link to a model are used for the update.

Click **Update>Update Multiple** () when you want to select which parameter table to update with the other model definitions found in the current worksheet. This opens the Update Multiple window where you can select which parameter table to update.



In the Parameters section, select the parameter table (defined in the specified cell range) to update the model with the definitions found in the current worksheet.

If you have imported model definition using the function and variables table you can select **Update** to update the model with the value in the worksheet.

View

Using the buttons in the **View** group you can display the model geometry or mesh in the graphics COMSOL Multiphysics Server window.

GEOMETRY

Click **Geometry** ( ) to display the model geometry in the graphics COMSOL Multiphysics Server window. In case the model contains multiple geometry nodes you can select the geometry to view from the menu. To change the level of detail for the displayed geometry see Managing Users Preferences.

See `InsertGeometryGraphics` to get more information about the corresponding command in VBA.

MESH

Click **Mesh** ( ) to display the mesh in the graphics COMSOL Multiphysics Server window. In case the model file contains multiple mesh nodes you can select the mesh node to view from the menu.

See `InsertMeshGraphics` to get more information about the corresponding command in VBA.

Study

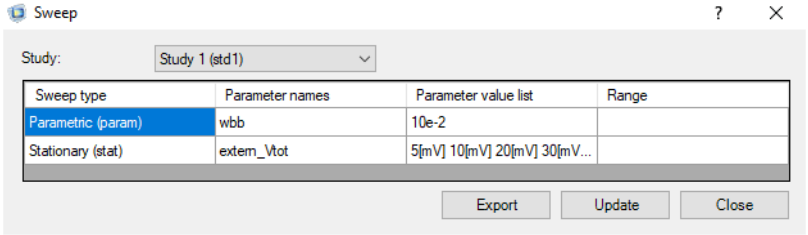
The **Study** group provides access to parametric sweep settings, and allows you to compute the solution for a selected study from the model.

COMPUTE

Click **Compute** ( ) to solve the model linked with the current workbook. The first study node in the model is computed by default.

SWEEP

Click **Sweep** ( ) to open the **Sweep** dialog box where you can view and edit the parametric sweep settings in the model.



From the **Study** list select the study to use. The list contains all sweep parameters defined in the model, including Auxiliary sweep.

The table lists the sweep parameters and the values. Edit the **Parameter value list** column to modify the sweep interval.

Click **Export** to export the parameter names values to the spreadsheet at the selected cell. The export also creates a link between the worksheet and the table in the Sweep window.

Click **Update** to update the model with parameters and values defined in the table. The table is automatically updated with the values from the worksheet when the cell range containing the sweep comment is selected.

Click **Close** to close the **Sweep** dialog box.

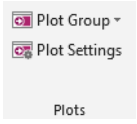
See `Sweep` to get more information about the corresponding command in VBA.

STUDY

Click **Study** () then select a study node from the model for computation. Selecting the study computes the solution.

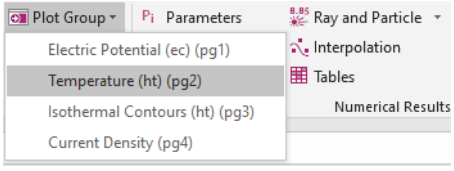
Plots

In the **Plots** group you access the plot settings, and display a selected plot group in the graphics COMSOL Multiphysics Server window.



PLOTS GROUPS

Click **Plot Groups** () and select a plot group from the menu to view it in the graphics COMSOL Multiphysics Server window. You cannot create new plots, only plot groups that are defined in the open model can be viewed.

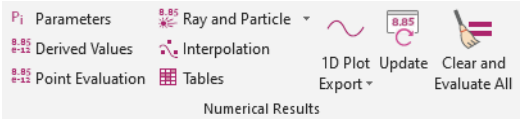


PLOT SETTINGS

To specify the parameter value, time, or eigenfrequency for which to display results for in the current plot group click **Plot Settings** ( ).

Numerical Results

With the tools in the **Numerical Results** group you can evaluate expressions and insert the evaluation results from a model table to the worksheet. In order to extract a numerical results first select an empty cell in the worksheet where to export the data in the worksheet.



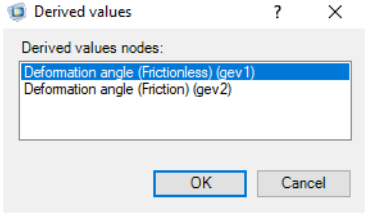
PARAMETERS

Click **Parameters** ( ) to insert result parameters in the worksheet. Result parameters can be used for calculating results without having to update or solve the model in contrast to parameters available in the **Definitions** section.

See `ResultsParameters` to get more information about the corresponding command in VBA.

DERIVED VALUES

Click **Derived Values** ( ) to open the **Derived Values** dialog box where you can select an expression to import to the worksheet.

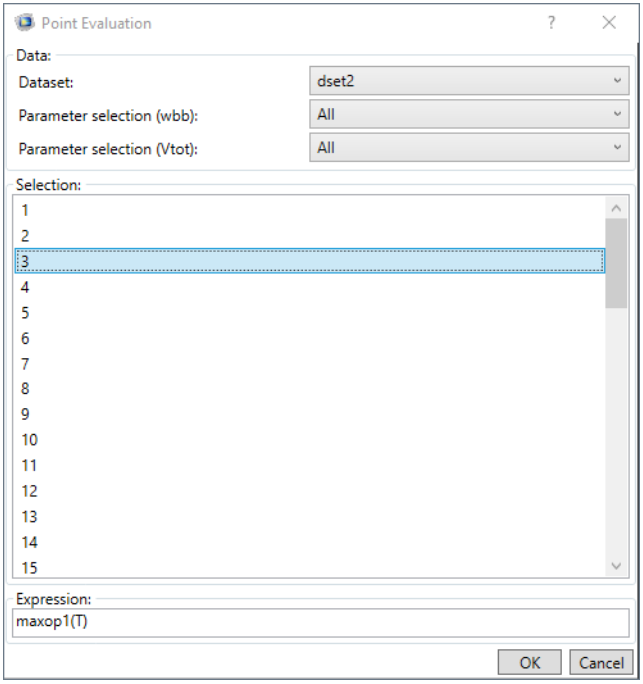


Expressions need to be defined under the Derived Values node of the model to be available in the list.

See `ResultsDerivedValue` to get more information about the corresponding command in VBA.

POINT EVALUATION

Click **Point Evaluation** (8.85 e-12) to open the **Point Evaluation** dialog box.

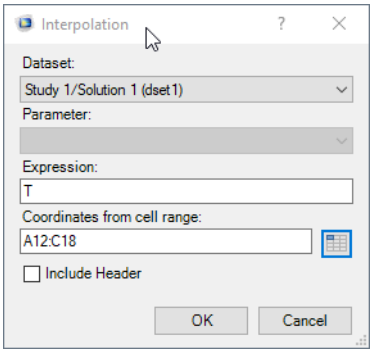


In the **Point Evaluation** window select the **Dataset** to evaluate on, and specify the points where the expression should be evaluated. Enter a valid expression into the **Expression** text field, then click **OK** for perform the evaluation. The results are inserted at the selected cell in the worksheet.

See `ResultsPointEvaluation` to get more information about the corresponding command in VBA.

INTERPOLATION

Click the **Interpolation** button ( ) to open the window with the same name.



From the **Dataset** list, choose the solution dataset from the model. For solution dataset of type parametric, also select the parameter value from the **Parameter** list. In the **Expression** text field enter the expression to evaluate. Finally, to enter the cell range that contains the coordinates for the interpolation points in the **Coordinates from cell range** text field, click the **Select range** button ( ). Click **OK** to evaluate and insert the results into the worksheet.

Format the point coordinate data on the worksheet such that the coordinates are listed in columns, with each row defining an evaluation point as in the figure below:

x	y	z
0	0	0
2.50E-02	0	0
5.00E-02	0	0
0	-1.25E-02	0
2.50E-02	-1.25E-02	0
5.00E-02	-1.25E-02	0

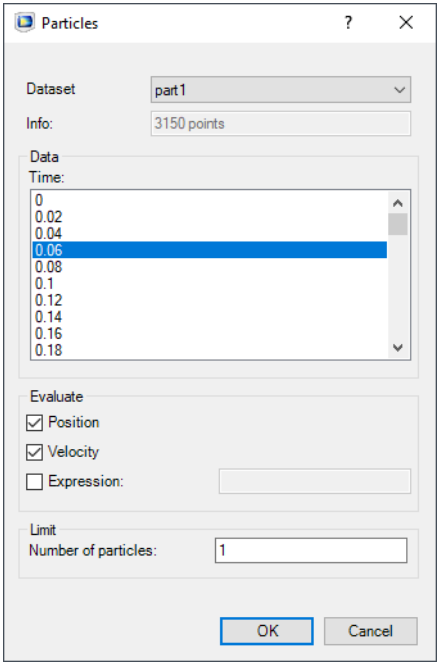
Select **Include Header** if you want to include automatic header with the evaluated data. In this case the data are shifted one row down and a header is included at the location of the cell comment.

See `ResultsInterpolation` to get more information about the corresponding command in VBA.

PARTICLE EVALUATION

Under **Ray and Particle** click **Particle Evaluation** ( ) to open the **Particles** dialog box where you can evaluate expressions along particle trajectories.

	The particle evaluation requires a license for the Particle Tracing Module.



Select a particle dataset from the **Dataset** list. From the **Evaluate** section select any of the following options:

- **Position**, to include in the evaluation the particle position along the trajectories.
- **Velocity**, to include in the evaluation the particle velocity along the trajectories.
- **Expression**, to include in the evaluation along particle trajectories the expression you specify.

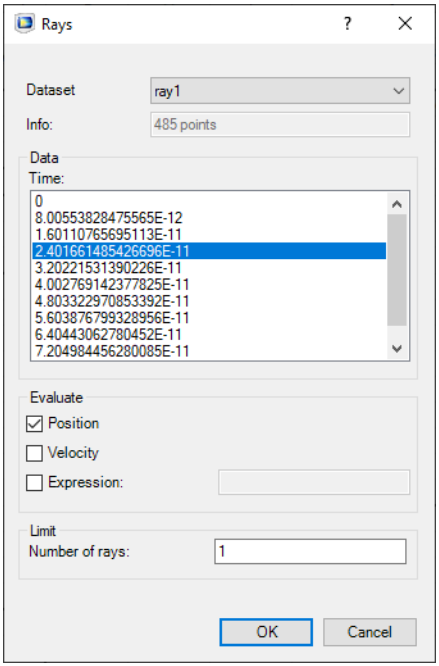
Reduce the evaluation output by entering the number of particles for the evaluation in the **Number of particle** text field. Click **OK** to perform the evaluation and to insert the results into the worksheet.

See `ResultsParticleEvaluation` to get more information about the corresponding command in VBA.

RAY EVALUATION

Under **Ray and Particle** click **Ray Evaluation** () to open the **Rays** dialog box where you can evaluate expressions along ray trajectories.

The ray evaluation requires a license for the Ray Tracing Module.



Select a ray dataset from the **Dataset** list. From the **Evaluate** section select any of the following options:

- **Position**, to include in the evaluation the ray position along the trajectories.
- **Velocity**, to include in the evaluation the ray velocity along the trajectories.
- **Expression**, to include in the evaluation along ray trajectories the expression you specify.

Reduce the evaluation output by entering the number of rays for the evaluation in the **Number of rays** text field. Click **OK** to perform the evaluation and to insert the results into the worksheet.

See `ResultsRayEvaluation` to get more information about the corresponding command in VBA.

TABLES

Click **Tables** ( ) to open the **Tables** dialog box and to select a table available from the model. Click **OK** to export the table data at the selected cell range.

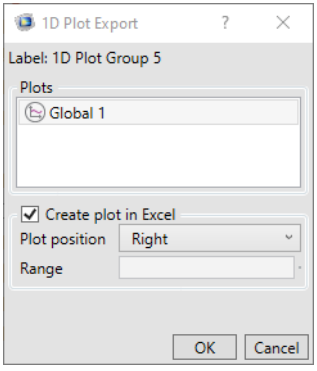
See `ResultsTable` to get more information about the corresponding command in VBA.

1D PLOT EXPORT

Excel does not have a chart type that supports general 2D and 3D plots that are commonly produced in COMSOL. However, 1D plots have data that can be extracted to Excel, and Excel can create plots of these data as well.

First select the cell in the worksheet where you want to import the plot data.

Then click **1D Plot Export** ( ) and select from one of the 1D plots that are defined in the model to open the 1D Plot Export dialog box. In this dialog box you set what to import into Excel:.



The **Plots** list contains all the plots defined under the plot group. By default, all plots are imported, but you can also select manually which plot to import.

While importing the data the plot is automatically generated in Excel and placed beside the imported data. Clear **Create plot in Excel** to not generate automatically the plot.

You can specify manually the plot position ion Excel, select one from the option **Left**, **Right**, **Top**, **Bottom** to place the chart beside the data. Select **Custom** to specify the cell where to place the top-left corner of the chart.

See `Export1DPlot` to get more information about the corresponding command in VBA.

UPDATE

Click **Update** ( ) to update all data evaluations on the current worksheet. Only cell ranges containing a valid link to the model are updated. Tables are not updated, if you have linked cells with tables in the COMSOL model, see Clear and Evaluate All to update the tables with their new values.

See `UpdateAllResults` to get more information about the corresponding command in VBA.

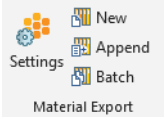
CLEAR AND EVALUATE ALL

Click **Clear and Evaluate All** ( ) to clear all table in the COMSOL model, evaluate all derived values, and then update both all data evaluations on the current worksheet and the tables.

See `ClearAndEvaluateAllResults` to get more information about the corresponding command in VBA.

Material Export

Use the **Material Export** group to export data from a worksheet to a material library.



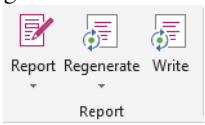
Click **Settings** ( ) to open the **Material Export** window where you can configure the export. For details, see Exporting Material Data.

After you configure the data click **New** ( ) to create a new material library or click **Append** ( ) to add the material definitions to an existing library.

Click **Batch** ( ) to open the **Material Export Batch** window where you can configure the batch export. For details, see Exporting the Material Library in Batch.

Report

Use the **Report** group to generate a report using the current model and write it in a given format.



Under **Report** ( ), select the type of report you want to generate. It can be a brief, intermediate, or complete report, depending the level of details you want.

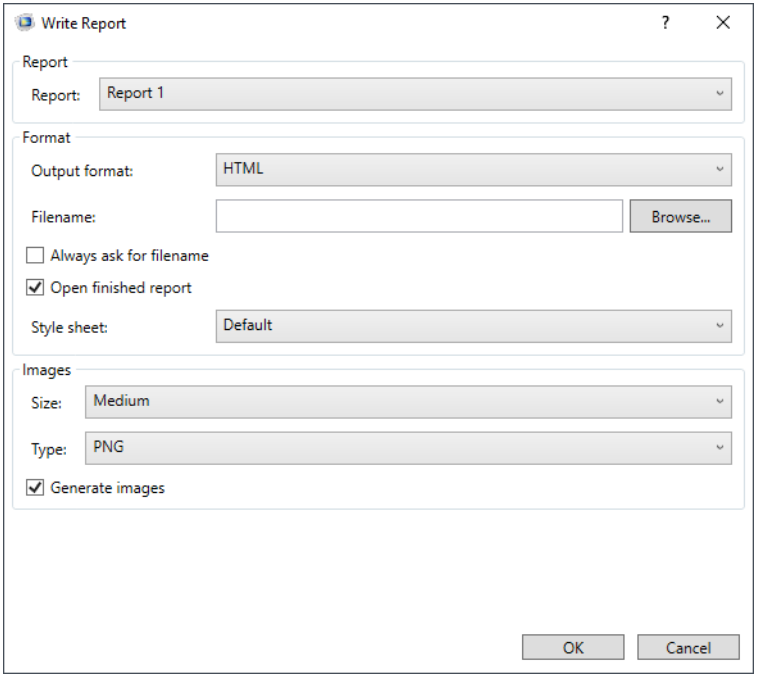
	Description of the built-in report types is in Reports and Presentations in the *COMSOL Multiphysics Reference Manual*.

You can also create a report based on user-defined templates available in the model.

When generating a new report in the model you are asked to enter the report node label in the **Generate Report** window.

Under **Regenerate** you select an already existing reports in the model to update with the current model settings.

Click **Write** to open the **Write Report** windows where you can set the file and image format of the report.



In the **Report** section, select which report to write. The settings in the window are automatically updated from the selected report properties.

In the **Format** section, you can choose between HTML and Microsoft Word® (.docx) format as output format.

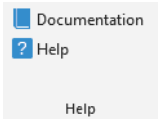
In the **Filename** field, enter the name of the report file. You can also browse to a folder to specify where to save the file. If no path is defined in the filename, the model path is used.

Select **Open finished report** if you want to visualize the report just after being generated.

You can choose between default and customized style sheets in the corresponding **Style sheet** list. When using a custom style sheet, browse to the style-sheet file, in the .css format, to use it.

In the **Images** section, you specify the images format to be included in the report. You can choose between five sizes, from extra small to extra large; the default image size is set to medium. In the **Type** list, you specify the image format to generate. You can choose between PNG, JPEG, or BMP.

Help



Click **Documentation** ( ) to open a browser with the COMSOL Multiphysics documentation.

See `OpenDocumentation` to get more information about the corresponding command in VBA.

Click **Help** ( ) to access the *LiveLink™ for Excel® User's Guide*.

See `OpenHelp` to get more information about the corresponding command in VBA.

Working With Models From Worksheets

In this section:

Accessing the Model Definitions

LiveLink™ has the functionality to import model definitions to a worksheet — for example, parameters, variables, and functions. You find the related tools grouped under **Definitions** on the **COMSOL** tab in the Excel® user interface.

PARAMETERS

To import all global parameters, select a cell in the worksheet and click the **Parameters** button. The parameters are inserted to the right and down from the selected cell. A link to the model, represented by a comment inserted in the selected cell, ensures that you can update the model with changes to the parameters in the worksheet. The imported data is formated as in Figure 2-1, with the parameter definitions organized into six columns.

Parameter	Expressions	Unit	Description	Value	Unit
param1	1	m	First parameter	1	m
param2	2	K	Second parameter	2	K
extern_param3	3	s	Third parameter	3	s

Figure 2-1: Model parameters after import to a worksheet.

The **Value** column is automatically updated with the expressions you enter. You can change this behavior in the Users Preferences window; see Managing Users Preferences.

The first **Unit** column is the unit to append to the expression, while the second Unit column is the unit for the parameter evaluation. You can change the formatting to

include the parameter unit together its expression in the users preferences; see Managing Users Preferences.

Parameter	Expressions	Description	Value
param1	1[m]	First parameter	1[m]
param2	2[K]	second parameter	2[K]
extern_param3	3[s]	Third parameter	3[s]

Figure 2-2: Model parameters after import to a worksheet without the unit column.

If you want to import and link only some of the parameters, you can create several parameters node in the COMSOL model. Then click **Parameters>Parameters Nodes**, to select and import the parameters defined in a parameters node only.

Parameter	Expressions	Unit	Description	Value	Unit
Parameters 2					
param2	2	K	Second parameter	2	K

Figure 2-3: Model parameters nodes import to a worksheet.

Alternatively define parameters with the prefix `extern_` in their name, and click **Parameters>Filter**, to import only these parameters.

Parameter	Expressions	Description	Value
extern_param3	3[s]	Third parameter	3[s]

Figure 2-4: Model parameters after filtered import to a worksheet.

VARIABLES

To import all model variables, select a cell in the worksheet and click the **Variables** button. Variables are inserted to the right and down from the selected cell. A link to the COMSOL model, represented by a comment inserted in the selected cell, ensures that the model can be updated with changes to the variables in the worksheet. After the import, the variable definitions are formatted as in Figure 2-5.

Name	Expressions	Description
var1	1	Global variable 1
var2	2	Global variable 2
select_var3	3	Global variable 3
bnd1	x	Boundary variable 1
bnd2	y	Boundary variable 2
extern_bnd3	x+y	Boundary variable 3

Figure 2-5: Model variables inserted into a worksheet.

Variables>Filter, to import only variables with names containing the prefix `extern_`.

Variables>Select, to import all the variables from the selected feature node only.

You can edit imported variables in your worksheet. To update the model with the modified definitions, see Updating Data in Cells Linked to the Model.

FUNCTIONS

To import function definitions from the model, select a cell in the worksheet and click the **Functions** button. The **Functions** dialog box opens, allowing you to select analytic or interpolation functions in the model. The imported data is inserted to the right and down from the selected cell. A link to the COMSOL model, represented by a comment inserted in the selected cell, ensures that the model can be updated with changes to the function in the worksheet.

For an analytic function the data is imported into two columns as in Figure 2-6.

Expression	x^2

Figure 2-6: Analytic function table format after import.

For an interpolation function the data is formatted as in Figure 2-7.

t	f(t)
1	1
2	4
3	9
4	16

Figure 2-7: Interpolation function table format after import.

You can edit imported model functions in your worksheet. To update the model with the modified definitions, see Updating Data in Cells Linked to the Model.

Computing the Solution

To solve the model directly from the Excel user interface, click the **Compute** button (=) from the **Study** group. Note that if the model contains several studies only the first study is computed. In this case you can also click the **Study** button (), and from the menu select the study to compute.

You have limited access to the solver settings from the **COMSOL** tab. It is recommended that you make sure that the model is suitably configured in the COMSOL Desktop before opening it in Excel.

Running a Model in Sweep

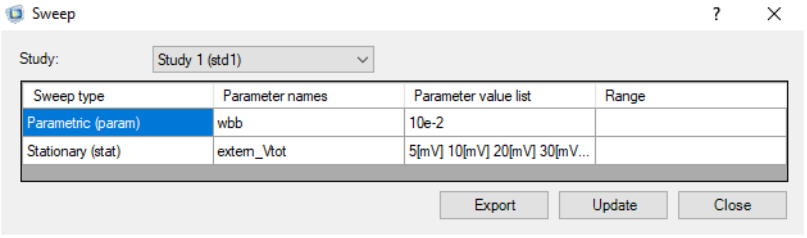
This section describes how to run a model in sweep using data value from the worksheet.

THE SWEEP DIALOG BOX

To access the sweep parameter value list, select **Sweep** () to open the **Sweep** dialog box.

If you plan to link cell ranges in the worksheet and the parameter list in the model, before you open the Sweep dialog box, first select the cell where the link is to be included.

The Sweep dialog box contains the list of the parameter name and value set in the parametric sweep node and in the auxiliary sweep settings available in the selected study.



In the **Study** list you can select the study where to define the parameter sweep value.

The **Parameter names** column lists the model parameters defined to run in sweep. The **Parameter value list** column contains the associated value. The **Range** column lists the cell range in the worksheet linked to the model parameters. You can directly edit the **Parameter value list** column. Click **Update** to update the modification in the model.

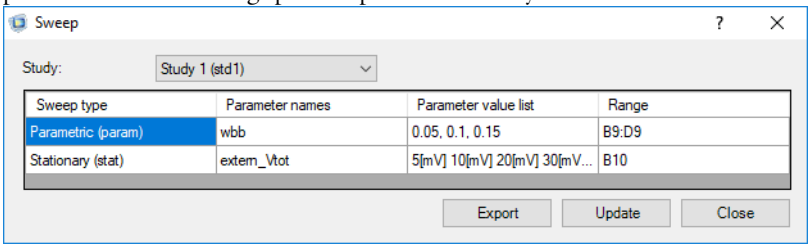
LINKING PARAMETER SWEEP VALUES WITH THE WORKSHEET

In the **Sweep** dialog box click **Export** to export the parameter sweep value list to the current worksheet. As part of the export, a link is created between the worksheet and the model. This is represented by a cell comment. In the worksheet, the parameter sweeps are stored in line from the cell containing the comment, the first column including the parameter names.

If the parameter value list only contains data separated by a space or a comma, the data are inserted in separate cells. If the parameter value list contains a string, such as a range function, or includes units, the data are exported to one unique cell.

Name	Expressions		
wbb	5.00E-02	1.00E-01	0.15
extern_Vtot	10[mV] 20[mV] 40[mV] 80[mV] 160[mV]		

After the export the **Range** column includes the cell range defining all the sweep parameter value list in the worksheet. Note that a cell comment is also created for each parameter name allowing specific update if necessary.



You can now edit the parameter value linked with the selected cell comment in the worksheet. Then close the **Sweep** dialog box. The parameter value has to be defined in the cells beside the one containing the parameter name.

UPDATING THE PARAMETER VALUE LIST TO THE MODEL

If the worksheet contains a link between a range and a parameter sweep list, select the cell with the comment and select **Sweep** (). The **Parameter value list** and the **Range** columns are automatically updated with the value from the worksheet. Click **Update** to update the model with the value defined in the worksheet.

It is not necessary to have links between the worksheet and the model to modify the sweep parameter value list, you can edit the value in the **Sweep** dialog box and click **Update**.

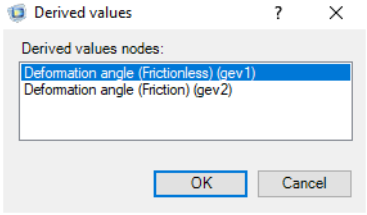
To update the model with the modified parameter value list, you need to select the cell with the comment and select **Sweep** (). The parameter value list now contains the value from the worksheet. Click **Update** to update the model with the value defined in the worksheet.

Evaluating the Results

With LiveLink™ *for* Excel® you can evaluate and insert simulation results into a worksheet. The tools needed for this are grouped under **Numerical Results** on the **COMSOL** tab in the Excel user interface. To perform the evaluations at least one solution dataset needs to be present in the model.

DERIVED VALUES

To evaluate data found in the Derived Value nodes defined in the model select the cell in the worksheet then click the **Derived Values** (8.85 e-12) button.



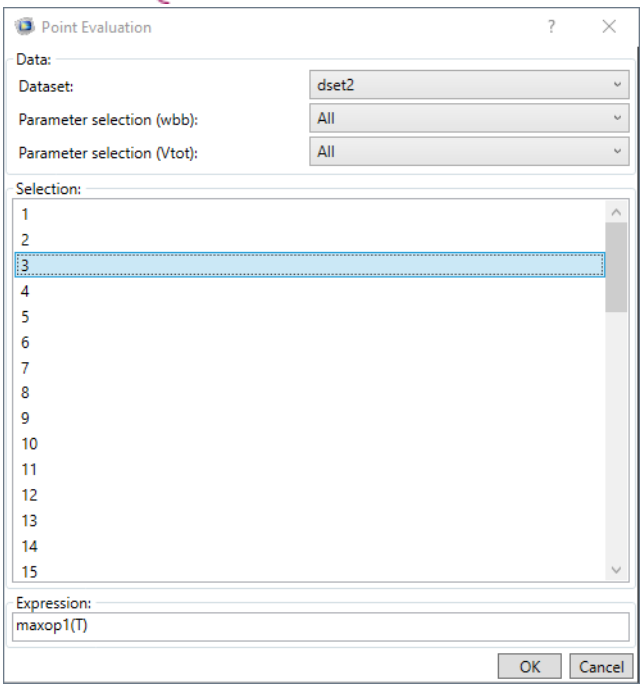
In the **Derived Values** dialog box, specify from which derived values node to import the data and click **OK**. The evaluated data is inserted to the right and down from the selected cell. A link to the model, represented by a comment inserted in the selected cell, assures that the evaluation can be updated with changes to the model solution.

POINT EVALUATION

To evaluate expressions on specified geometry vertices select a cell in the worksheet and click the **Point Evaluation** (8.85 e-12) button. In the **Point Evaluation** dialog box, select the solution dataset, one or more points, and specify the expression to evaluate. Click **OK** to import the data. The evaluated data is inserted to the right and down from the selected cell. A link to the model, represented by a comment inserted in the selected cell, assures that the point evaluation can be updated with changes to the model solution.

INTERPOLATION

To evaluate expressions at arbitrary location select a cell in the worksheet, click **Interpolation** to open the **Interpolation** dialog box.

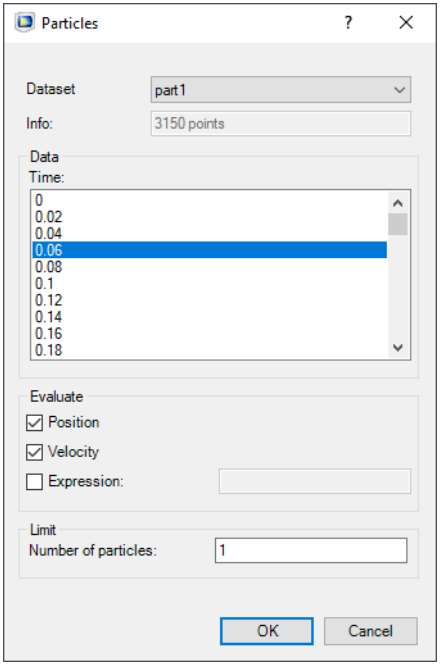


Select the solution dataset, if a parametric solution dataset specify the parameter value. Enter the expression to evaluate, and the cell range that contains the point coordinates for the evaluation. The coordinates need to be formated so there is one point per row, with the coordinates in different columns. The number of evaluation points correspond to the number of rows.

The evaluated data is inserted to the right and down from the selected cell. A link to the model, represented by a comment inserted in the selected cell, assures that the point evaluation can be updated with changes to the model solution.

PARTICLE EVALUATION

To evaluate expressions along particle trajectories, first select a cell in the worksheet then, under **Ray and Particle**, click the **Particles** ( ) button.

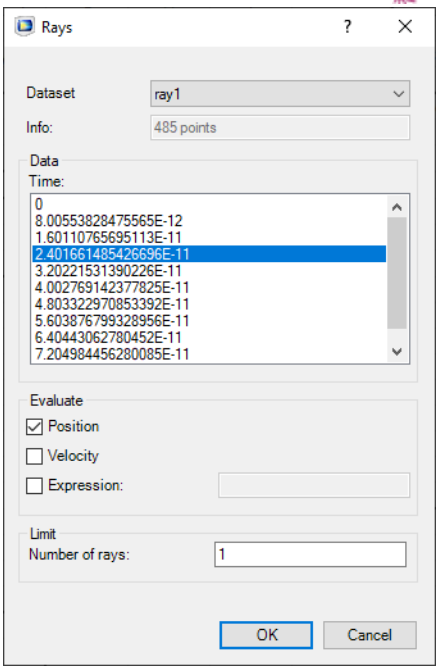


In the **Particles** dialog box, select a valid particle tracing solution dataset. Then specify the time for data evaluation in the Time list. Under Evaluate section you select what to extract in the worksheet: the position, the velocity and a specified expression. Finally you can define the number of particles for which you want to perform the evaluation. The amount of particles in the particle dataset is available in the Info field, under the Dataset menu list.

The evaluated data is inserted to the right and down from the selected cell. A link to the model, represented by a comment inserted in the selected cell, ensures that the point evaluation can be updated with changes to the model solution.

RAY EVALUATION

To evaluate expressions along ray trajectories, first select a cell in the worksheet then, under **Ray and Particle**, click the **Rays** ( ) button.



In the **Rays** dialog box, select a valid ray tracing solution dataset. Then specify the time for data evaluation in the **Time** list. Under **Evaluate**, you select what to extract in the worksheet: the position, the velocity, and a specified expression. Finally, you can define the number of rays for which you want to perform the evaluation. The amount of rays in the Ray dataset is available in the **Info** field under the **Dataset** list.

The evaluated data is inserted to the right and down from the selected cell. A link to the model, represented by a comment inserted in the selected cell, ensures that the point evaluation can be updated with changes to the model solution.

TABLES

To extract data from tables defined in the model, select a cell in the worksheet, click the **Tables** ( ) button, and from the dialog box select the table to insert into the worksheet. The size of selected table is display below the **Table name** list. The evaluated data is inserted to the right and down from the selected cell. A link to the model,

represented by a comment inserted in the selected cell, ensures that the point evaluation can be updated with changes to the model solution.

MODIFY THE EVALUATION SETTINGS

You can modify the settings for an existing data evaluation by following these steps:

- From a cell range containing evaluation results, select the cell that contains the link to the model.
- Click the button corresponding to the evaluation operation.
- Edit the settings for the evaluation.
- Click **OK** to perform the evaluation and replace the data in the cell range.

To update the existing evaluations after recomputing a solution, see Updating Data in Cells Linked to the Model.

Displaying the Results

To select a plot group to display in the graphics COMSOL Multiphysics Server window, click the **Plot Group** button () and from the menu list select an available plot group from the model.

Graphics display are enable with graphics server only, see Managing Users Preferences to enable graphics server.

If the plot group uses a solution dataset containing multiple solution parameters, you can specify the parameter you would like to view in the **Plot Settings** dialog box accessible by clicking the **Plot Settings** button ().

IMPORTING GRAPHICS

To import the current view of the graphics COMSOL Multiphysics Server window, click the **Insert Graphics** button () on the **Edit** group. The inserted graphics can either be a screenshot of the current graphics window or an export of the current plot. You can specify how to import the image and its size in the **Preferences** dialog box available from the **Edit** group.

UPDATING MODELS DEFINITIONS

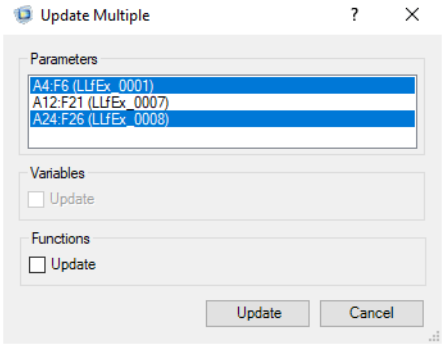
You can edit imported model definitions in the worksheet. The cell comment maintains the link between the data in the worksheet and the model, so that you can update the model with the new data.

	Imported parameters are updated automatically, see Managing Users Preferences to disable automatic update.

To perform an update select the cell with the comment and click the **Update** button ( ).

To update all model definitions in a worksheet, click the **Update all** button ( ). The **Update all** button is accessible in the menu under the **Update** button.

If you have multiple table that defines model definitions, click **Update multiple** button ( ) to specify which tables to use during the update in a separate dialog box.



In the **Update Multiple** dialog box you can select the parameter table defined with the cell range. You can also update model definitions with imported the variables and functions tables.

To solve the model after the update see Computing the Solution.

UPDATING SWEEP PARAMETER VALUE LIST

First select the cell with the comment representing the link to the sweep node in the model. In the **Study** group, click the **Sweep** button ( ). Select **Update** to update the parametric sweep node with the one stored in the worksheet.

UPDATING NUMERICAL RESULTS

In the **Numerical Results** group, click the **Update** button ( ) to update all results data found in a worksheet.

Click **Parameters** button ( ) to import results parameters from the model. These parameters allow you to update results analysis and postprocessing without recomputing the solution. Once you have edited the parameters in the worksheet, click the **Update** button ( ).

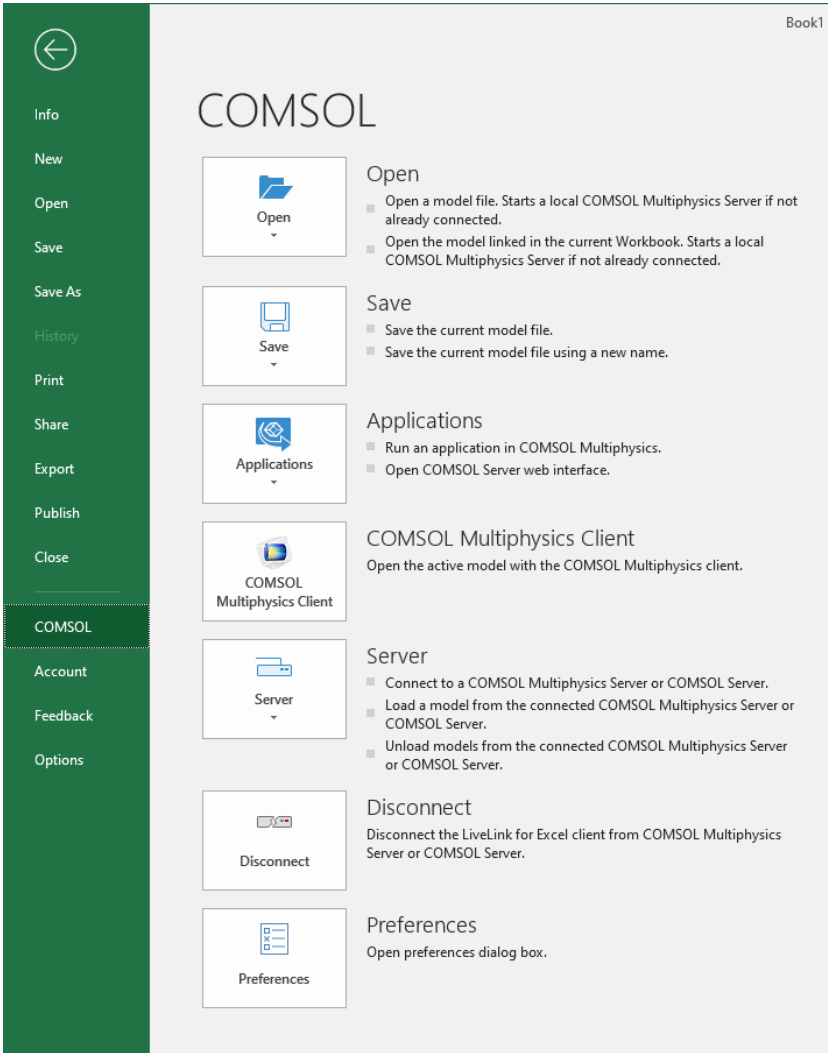
THE CELL COMMENT

For model definitions and numerical results imported into the worksheet the LiveLink™ *for* Excel® interface adds a comment to the cell selected at the time of the import. This cell comment is a link to the model ensuring that the data can be updated. The comment can also contain the evaluation settings to allow subsequent editing of the evaluation operation. Click **Break Link** ( ), or **Break All Links**, to remove a comment from a cell, or all comments from the current worksheet respectively.

The data in the cell range cannot be updated if the comment is missing.

The COMSOL Backstage View

Functionalities such as managing Model MPH-files, connecting with a COMSOL *server*, running COMSOL Apps, and setting users' preferences are grouped in the COMSOL backstage view. To access the COMSOL backstage view, go to the Excel File menu and click COMSOL.



The term *COMSOL server* designates either a COMSOL Multiphysics Server or COMSOL Server™ for running applications.

In this section:

Opening a Model MPH-File

To extract model definitions or results to an Excel® worksheet you need to link the workbook with a model loaded in a COMSOL *server*. You can directly open the model from Excel. If it is not already running, this starts a COMSOL Multiphysics Server in the background where the model is loaded. You can open any new Model MPH-file or open a model already linked in the workbook.

OPENING A NEW MODEL

Under the **File** Excel ribbon tab click **COMSOL** to access the COMSOL Backstage view.

Click **Open** (), and again **Open** (), then find the model MPH-file and click **OK**.

The model geometry, or a result plot when one is available in the model file, is displayed in an external graphics window. In Excel, the model name is inserted into the worksheet, see Figure 2-8.

COMSOL Model	
Filename:	C:\Users\user\Documents\example.mph

Figure 2-8: Spreadsheet after model import.

The model description and image, if contained in the model file, are also inserted. In addition, a comment is added to the cell selected before loading the model with the

text `COMSOL Model`. This comment is used by LiveLink™ interface to maintain the connection between the worksheet and the model on the COMSOL Multiphysics Server.

Only one model can be opened per workbook. Opening another model updates the link to point to the last opened model.

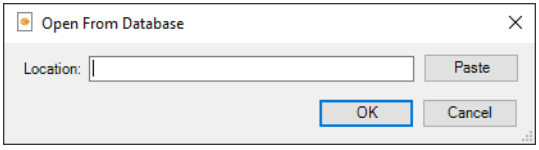
The comment is automatically updated if you save the model under a different name. Removing the comment breaks the link between the workbook and the model.

OPENING A LINKED MODEL IN THE WORKSHEET

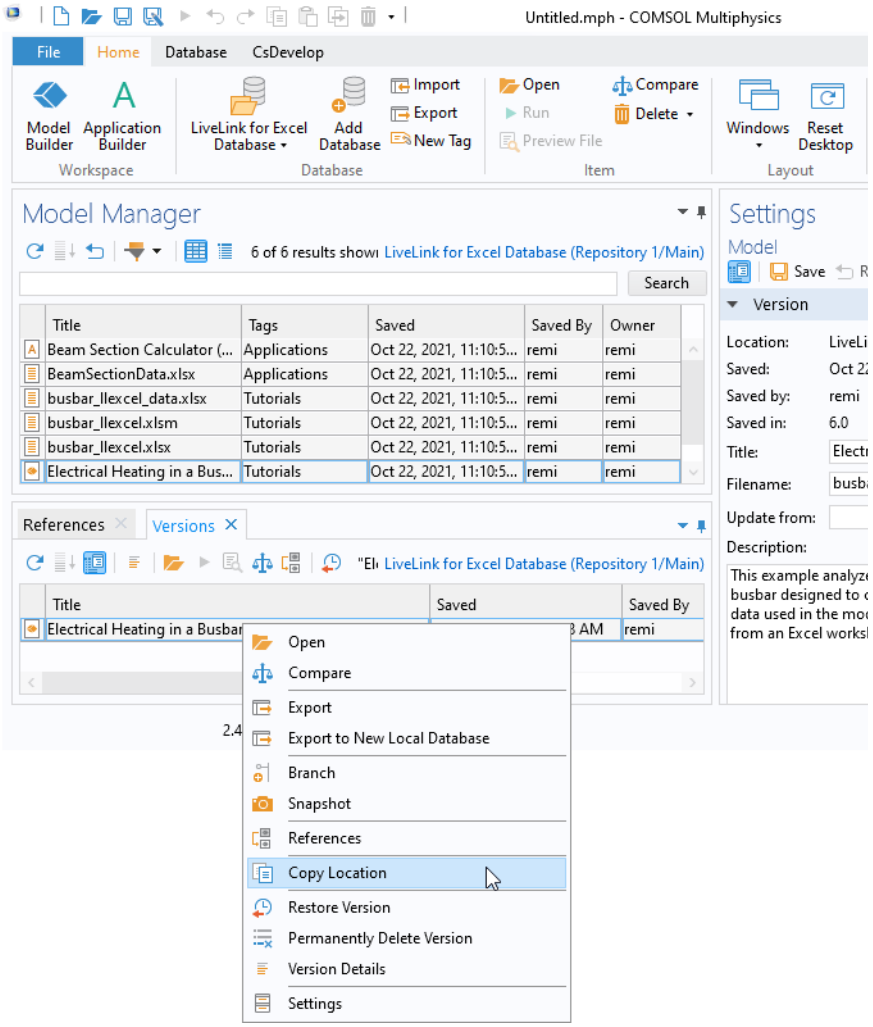
If the worksheet already contains a cell link with a model path you can open directly open the associated model. Under the **File** Excel ribbon tab click **COMSOL** to access the COMSOL Backstage view. Click **Open** ( ), and then **Open linked** ( ), this will open the file with the path defined in the cell comment link.

OPENING A MODEL FROM DATABASE

You can choose to open a model from a database. Under the **File** Excel ribbon tab click **COMSOL** to access the COMSOL Backstage view. Click **Open** ( ), and then **Open from database** ( ), this open a dialog window where you can enter the location of the model to work with.



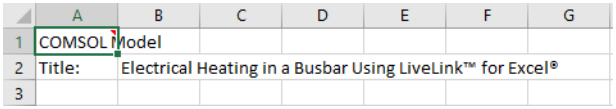
You can get the location from the Model Manager in the COMSOL Desktop. Select the model you interested, then in the Versions window right on the version you want to work with and select **Copy Location**.



Finally go back to Open From Database dialog, click **Paste** and then click **OK**.

This load the model in the COMSOL Multiphysics Server and a link is created in the worksheet.

Unlike a regular model import, the file path is not displayed below the cell comment that link the model. Instead you will see the model title.



OPENING RECENT MODEL

Under the **File** Excel ribbon tab click **COMSOL** to access the COMSOL Backstage view. Click **Open** ( ), and then **Recent** ( ), to get the list of the recent files open in a Multiphysics Server. Select the desired file and click **OK** to load the file in the server and establish the connection with the worksheet.

OPENING A MODEL CONTAINING USER DEFINED PHYSICS INTERFACE

If the model contains a user defined physics interface created using the COMSOL Physics Builder, you need to save the compiled archive (`.jar`) in your user home folder `.comsol/v60/archives`. Any compressed archive (with extension `.jar`) is loaded next time the COMSOL Multiphysics Server starts.

OPENING A MODEL WITH A CLASS KIT LICENSE

For Class Kit License (CKL) type, you need to tart the COMSOL Multiphysics Server with the Classkit License, see the Managing Users Preferences to start the server with Classkit License.

Saving a Model MPH-File

Click **Save** ( ) to save the currently open model on the COMSOL Multiphysics Server. The model is saved in the MPH-file format. Then the link between the spreadsheet and the model is updated automatically.

Click **Save As** ( ) to save the currently open model file using a new name. The model is saved in the MPH-file format.hen the link between the spreadsheet and the model is updated automatically.

	Saving the Excel workbook does not automatically save the linked model.

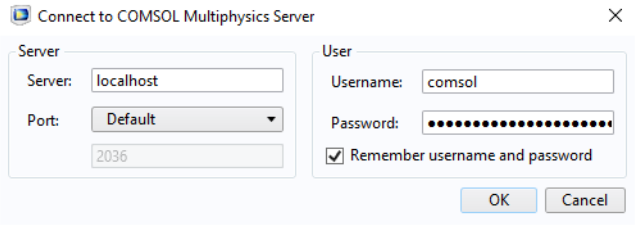
Saving file to a database is not supported.

Connecting Excel® to a COMSOL Server

The default settings using LiveLink™ *for* Excel® consist of starting a new COMSOL Multiphysics Server on the local machine the first time a model is loaded from the spreadsheet. You can specify a running COMSOL *server* to connect with Excel.

To specify the COMSOL *server* to be connected to Excel:

1. Start Excel and separately start a COMSOL *server*.
2. In Excel, go to **File** ribbon tab and select **COMSOL**.
3. In the COMSOL Backstage go to **Server** and click **Connect** ( ).The Connect to Server then pops-up.



4. In the **Server** text field enter the COMSOL *server* name (or server IP address). Enter `localhost` if the COMSOL *server* and Excel are running on the same machine.
5. In the **Port** menu list select **manual** if the COMSOL *server* is not listening to the default port number (2036). The port number is the one displayed in the COMSOL *server* window.
6. In the **User** and **Password** text field enter the login information requested by the COMSOL *server*.
7. Click **OK**.

When connecting Excel with a COMSOL Multiphysics Server not using graphics, you need to connect the server with a COMSOL Desktop to display graphics of the current model. See Connecting the COMSOL Desktop® with the COMSOL Multiphysics Server.

Disconnecting Excel® from a COMSOL Server

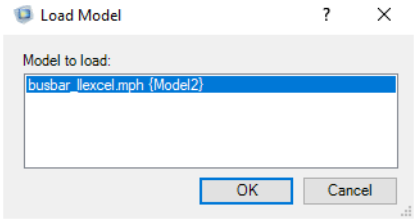
To disconnect Excel from a running COMSOL *server*, go to the **File** menu and select **COMSOL**. In the COMSOL backstage view, click **Disconnect** ( ).

Managing Model Loaded on a COMSOL Server

It is possible to import model that is loaded on a COMSOL *server* and to delete such models.

LOAD MODEL FROM SERVER

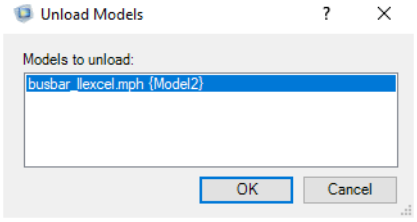
To load a model that is already loaded on a COMSOL *server* go to the Excel **File** menu and click **COMSOL**. In the COMSOL backstage view click **Server** ( )and then **Load Model** ( ).



In the Import Application from Server dialog box select in the list the application you want to open in the workbook and click **OK**.

UNLOAD MODEL FROM SERVER

To remove a model from a COMSOL *server* go to the Excel **File** menu and click **COMSOL**. In the COMSOL backstage view click **Server** ( )and then **Unload Models** ( ).



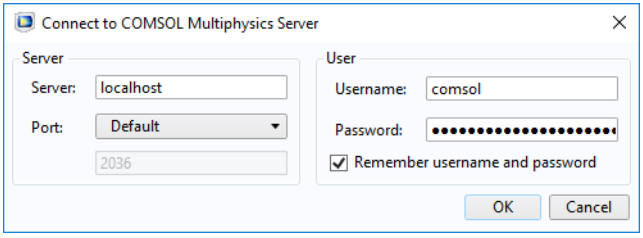
In the Remove Application from Server dialog box select in the list the application you want to remove from the COMSOL *server*.

Connecting the COMSOL Desktop® with the COMSOL Multiphysics Server

This section describes how to manually connect a COMSOL Desktop with a model open in Excel®. The COMSOL Multiphysics Server without graphics allows multiple clients connection, for example, Excel and a COMSOL Desktop. By default, Excel starts a COMSOL Multiphysics Server using graphics mode when opening a model. This server does not support multiple client connections. See Managing Users Preferences to use a COMSOL Multiphysics Server without graphics.

To display the model open from Excel in a COMSOL Desktop:

1. Start Excel and load a model in Excel as indicated in Opening a Model MPH-File.
2. In the COMSOL Desktop, from **File** menu (Windows users) or from the **Options** menu (Mac and Linux users), select **Client Server>Connect to Server** ( ).



You can now access the same application from both Excel and the COMSOL Desktop. Every change operated from Excel can be visualized from the COMSOL Desktop once the model is updated.

If you have already open an application in Excel and you want to open it also in the COMSOL Desktop, select **COMSOL Multiphysics Server>Import Application from Server** ( ) from the **File** menu (Windows users) or from the **Options** menu (Mac and Linux users). In the **Import Application from Server** window select the model to import.

If you want to open an application loaded in the COMSOL *server* in Excel, click the arrow beside the **Connect to Server** button and select **Import Application from Server** ( ).

Run Application

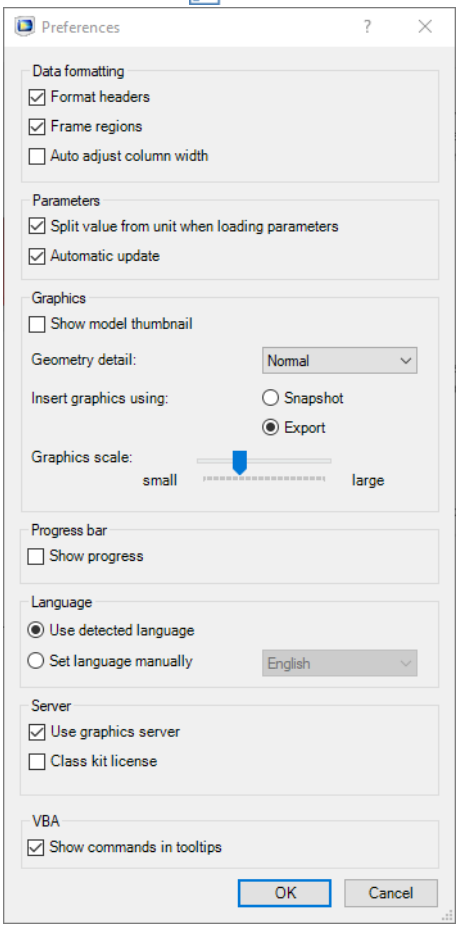
From Excel® you can launch apps created using the COMSOL Applications Builder, go to the File menu and select COMSOL. In the COMSOL backstage view under

Applications (), click **Run Application** (). Then browse to the MPH-file of the application to run and click Open.

You can also run apps that are loaded in the COMSOL Server. To open the COMSOL Server™ web interface from Excel, go to the File menu and select COMSOL. In the COMSOL backstage view under **Applications** (), click **COMSOL Server**(). Finally enter the credential to connect to the server.

Managing Users Preferences

Go to the **File** ribbon tab and click **COMSOL** to open the COMSOL Backstage view. Click **Preferences** () to open the **Preferences** dialog box.



Under **Data formatting**, select **Format headers** to create column or row headers with bold fonts. **Frame regions** adds a frame around the inserted data. Select the **Auto adjust column width** check box to automatically adjust cell width to fit the imported data.

Under **Parameters**, clear the **Split value from unit when loading parameters** check box if you want the value and unit of parameters to be inserted together as a string into a single cell. By default, the check box is selected so that the parameter values are formatted as numbers, and the parameter units are imported into a separate cell. Clear **Automatic update** if you do not want the parameters imported in Excel to have their values updated on the fly before computing the solution.

Under **Graphics**, select **Show model thumbnail** if you want the model image to be inserted into the worksheet when a model is loaded. In the **Geometry detail** list you can change the level of detail for geometry displayed in the graphics COMSOL Multiphysics Server window. Click **Snapshot** to insert the graphics as it looks like in the Graphics window (including background image). Click **Export** to insert the graphics without background image. Use the **Graphics scale** slider to change the size of the image to be inserted into the worksheet; see Insert Graphics.

Under **Progress bar**, select **Show progress** to display an external progress bar. The progress bar is shown when plotting the geometry or the mesh and when computing the solution.

Under **Language** select **Set language manually** radio button to manually define the Display and Screen Tip language, choose the language in the list box. **Select Use detected language** to use the language set in Excel.

Under **Server**, clear **Use a graphics server** if you want Excel® to not connect with a graphics COMSOL Multiphysics Server. A server in graphics mode displays the geometry, the mesh or plots in external graphics window. Only a server without graphics mode supports the connection of a COMSOL Desktop together with Excel via a model.

You need to restart the COMSOL Multiphysics Server to enable the changes.

Select **Class kit license** to connect Excel to a COMSOL Multiphysics Server that is running using a class kit license type.

In the **VBA** section, clear **Show commands in tooltips** if you don't want to see the corresponding VBA command in the button tooltips.

Exporting Material Data

To export material properties from a workbook in the Excel user interface to a COMSOL material library, use the tools from the **Material Export** group of the **COMSOL** tab.

LiveLink™ *for* Excel® supports both material properties stored in the spreadsheet as constant or as field dependent variables (as such as temperature dependent properties, B-H curve, and so forth). Depending on the original format, you have to specify the export settings in different windows.

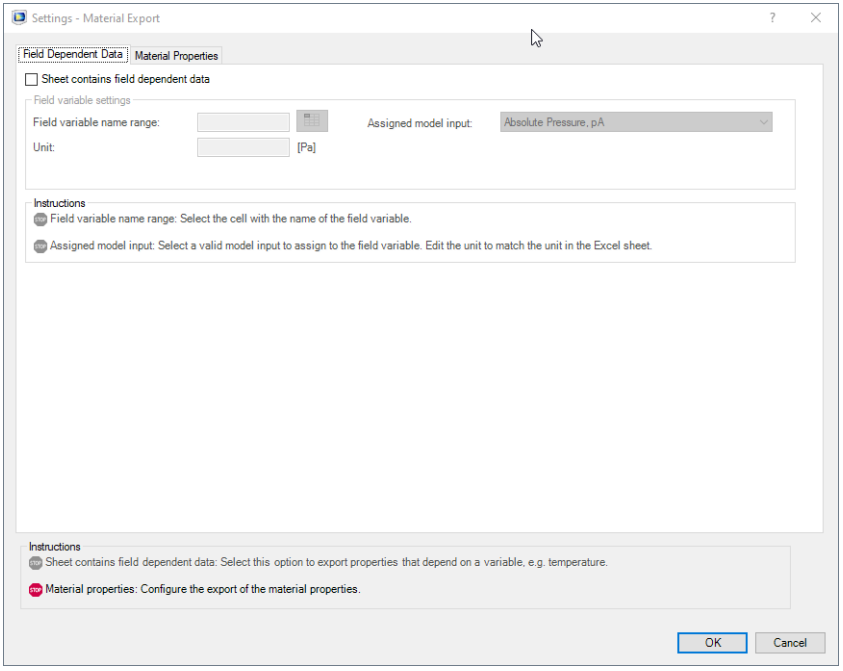
Automatically export the data to a new COMSOL material library or to an existing one. Perform the export for a single worksheet or in batch operations if the data are stored in different workbooks.

The Material Export Settings Window

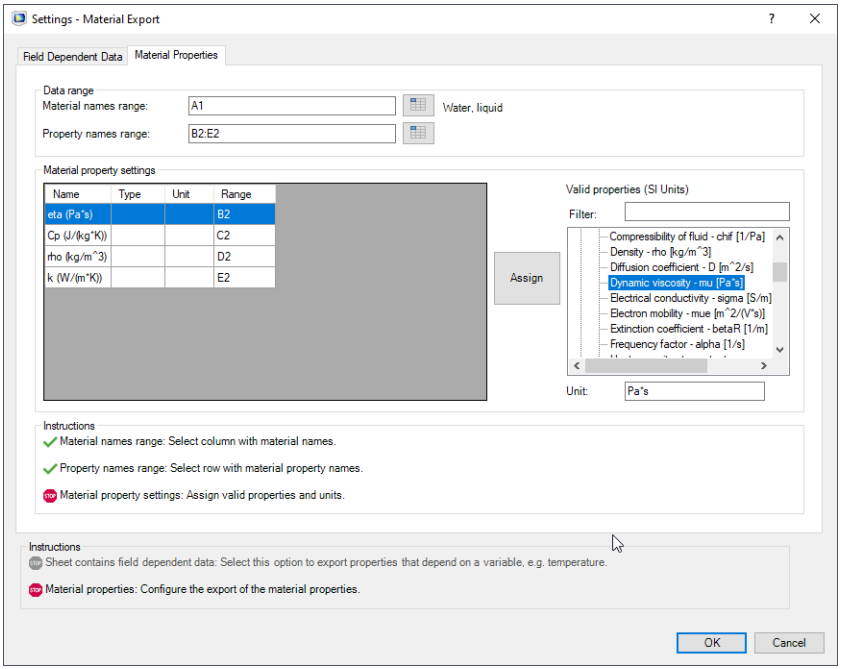
Click **Settings** ( ) in the **Material** group to open the **Material Export**. Specify the material and the properties to export to a COMSOL material library format. The material export procedure depends on the data format in the worksheet; the data can be defined as constant or as field variables.

EXPORT MATERIAL FROM DATA STORED AS CONSTANT

In the **Field dependent data** tab, specify the data format in the worksheet. If the worksheet contains only constant data formats, make sure that **Sheet contains field dependent data** check box is not selected.



In the **Material properties** tab, specify the material and the properties to be included in the export.



In **Material names range** select the cell range that contains the material names. The material names have to be stored in a column in the worksheet.

In **Property names range** select the cell range that contains the property names. The property names have to be stored in a row in the worksheet.

In the **Material property settings** section you assign properties recognized by COMSOL to the properties in the worksheet. Select a property name from the **Name** column, then select a property from the **Valid properties (SI Units)** list.

Click **Assign** to assign the selected valid property to the select name from the current worksheet.

In the **Filter** field you can enter a text that is used to filter the valid properties list, for instance, 'thermal conductivity' or 'sigma' in order to access the thermal conductivity or the electrical conductivity, respectively.

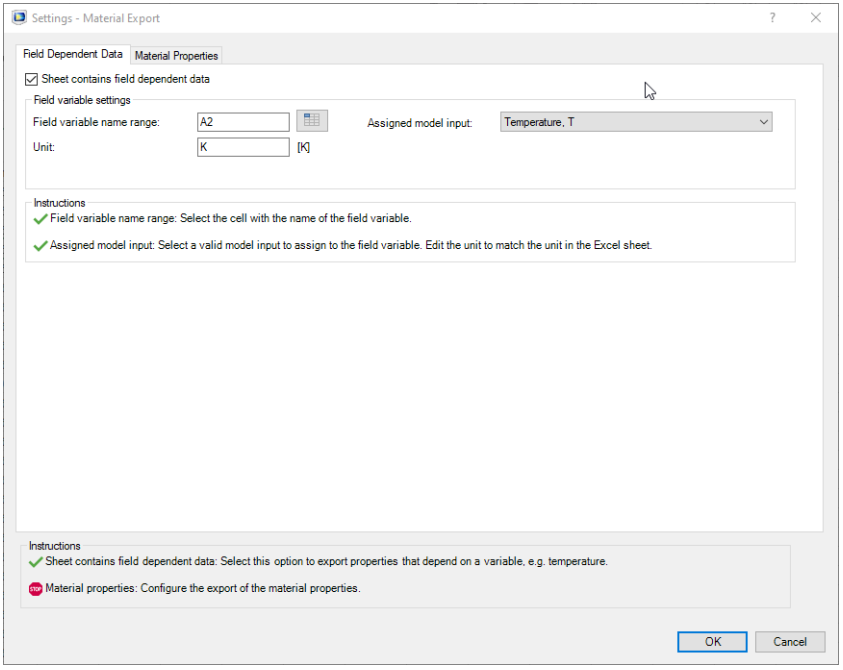
In the **Unit** column specify the unit in which the data is defined for the property. The default is SI units for all material properties.

Under the **Instructions** section in the dialog box you can follow the number of unassigned material properties for the selection. When you have completed the configuration all steps are marked with the icon ✓. If you have unassigned properties they will be indicated using the icon STOP.

Click **OK** to save the settings and to close the window.

EXPORT MATERIAL PROPERTIES FROM FIELD DEPENDENT DATA

In the **Field dependent data** tab select the **Sheet contains field dependent data** check box to specify the field variable settings.



In **Field variable name range** enter the cell number that contains the name of the field variable. The default data selection includes all data below the selected cell. You can manually specify the data cell range later in the **Material Properties** tab.

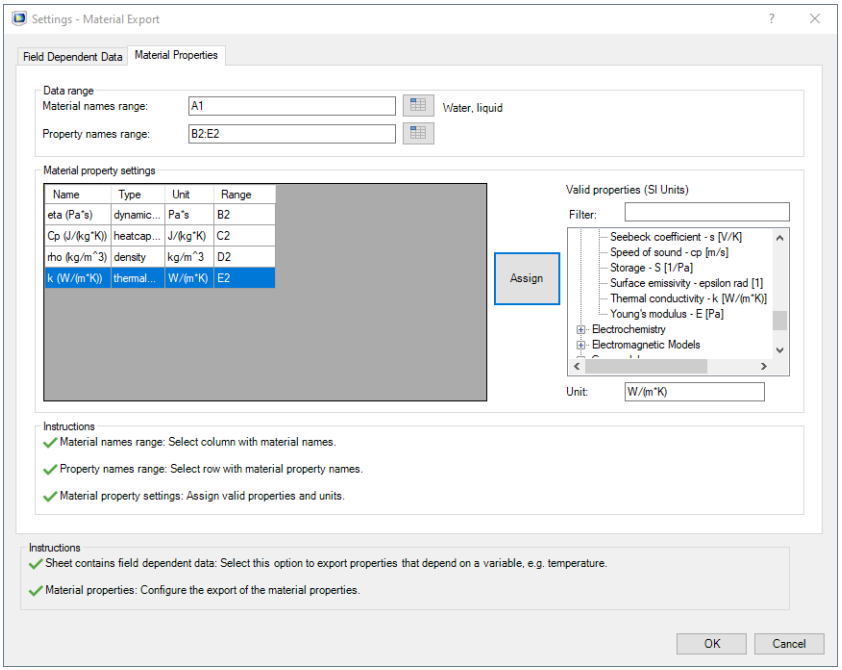
Once the field variable name is selected in the worksheet, in **Assigned model input** list select the model input in the COMSOL model that corresponds to the selected field variable name in the worksheet. The field dependent data is always stored in a single column. The field dependent data can correspond to the norm of the model input, for

instance with the following model input: the current density, the electric field, the magnetic field, the magnetic flux density, the stress tensor, and the velocity field.

In the **Unit** field enter the unit used in the worksheet if it differs from the default settings.

When you have completed the configuration all steps under the **Instructions** section are marked with the icon ✓.

In the **Material properties** tab specify the material and the properties to be included in the export.



In **Material names range** select the cell range that contains the material names. The material names have to be stored in a column in the worksheet.

In **Property names range** select the cell range that contains the property names. The property names have to be stored in a row in the worksheet.

In the **Material property settings** section assign properties recognized by COMSOL to the properties in the worksheet. Select a property name from the **Name** column, then select a property from the **Valid properties (SI Units)** list.

Click **Assign** to assign the selected valid property to the select name from the current worksheet.

In the **Filter** field you can enter a text that is used to filter the valid properties list, for instance 'thermal conductivity' or 'sigma' in order to access the thermal conductivity or the electrical conductivity, respectively.

In the **Unit** column specify the unit in which the data is defined for the property. The default is SI units for all material properties.

In the **Constant** column, select the radio button for the property you want to export as constant. If you select constant the value in the selected cell range in Property name value is used as property data to export in the material library.

In the **Range** column, enter the property data cell range to export. For constant data export select a unique cell. For field dependent data export specify the list of the data cell to export. The cell range has to be a unique column.

Under the **Instructions** section in the dialog box you can follow the number of unassigned material properties for the selection. When the configuration is completed, all steps are marked with the icon  .

Click **OK** to save the settings and close the window.

The Cell Comment

After you have configured the material data export according to the previous section the settings are stored in comments added to the cells that contain the material names and material property names. These comments enable you to edit the settings later, and you can also easily copy the comments to another worksheet with similar data to skip the steps of configuring the material export again. Do not remove the comments from the cells unless you want to prevent a certain material or property from being exported to the material library.

Saving the Material Library

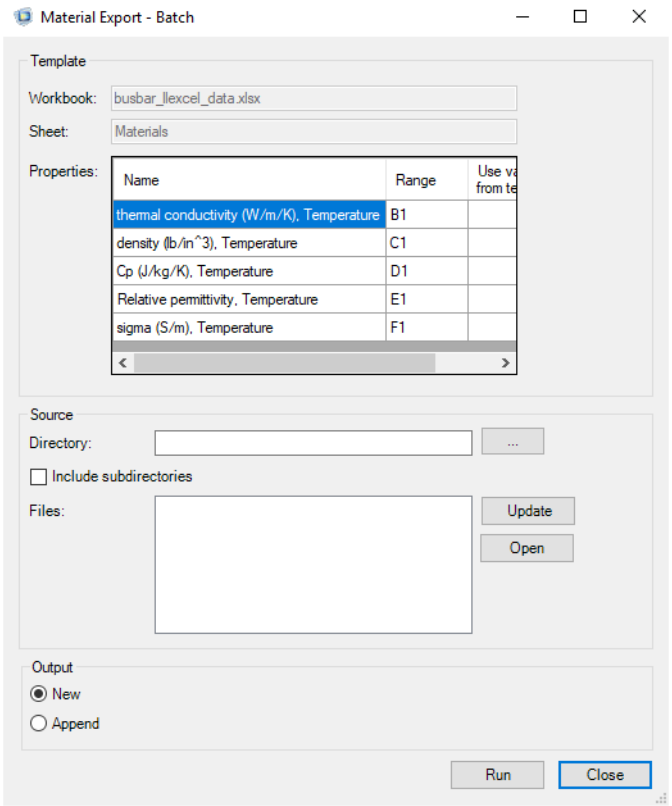
In the **Material Export** group select **Create** () to export the material properties to a new material library. In the **Save Material Library** window specify the filename and location. Click **OK** to export.

In the **Material Export** group select **Append** ( ) to export the material properties to an existing material library. In the **Append Material Library** window select an existing material library, and click **OK** to export.

	COMSOL automatically finds and imports material libraries saved in the materials folder of the COMSOL preferences directory. This is set as the default location when you create new material libraries or when you append data to existing material libraries.

Exporting the Material Library in Batch

In the **Material Export** group select **Batch** ( ) to open the **Material Export - Batch**.



In the **Template** section you find the settings defined for the material export. The **Properties** table lists the material, the property name, and the cell range to export.

Select **Use value from template** if the property is only defined in the template worksheet but should be included in all material during the batch export.

In the **Source** section define the worksheet to use during the export. First, in the **Directory** text field enter the path of the directory that contains the source Excel files. Select **Include subdirectories** to include workbooks stored under the main directory. Click **Update** to list the files to be used during the batch export. If you need to open one of the listed files, select the file in the list and click **Open**.

In the **Output** section you define where to export the material data. Select **New** to export the material data in a new material library. Select **Append** to export the material data to an existing material library.

3

Loading and Saving Workbook Files

LiveLink™ adds the Excel® workbook (.xlsx) format to the list of formats for loading and saving model definitions from the COMSOL Desktop®. Note that it is not required to have Excel installed on the machine where the COMSOL is running. If you are using Windows and have a supported version of Excel installed you will have some extra features that are not provided otherwise. Read this chapter for a description of how to load and save tabular data to a workbook.

In this chapter:

Importing and Exporting Model Definitions

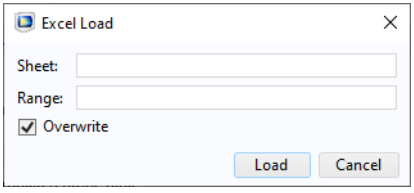
In this section:

Support for Excel® Files

The following model features support the saving or loading of Excel® files: Parameters, Variables, Interpolation, Piecewise, and the study step including continuation parameters.

Importing Data from a Workbook

To load data from a worksheet to a table in the **Settings** window of a feature, click the **Load from File** button ( ) below the table. In the file type list select **Microsoft Excel Workbook (*.xlsx)**. Select the desired file and click **Open**. Specify the sheet and cell range for the data.



Loading data from workbook files in a COMSOL Multiphysics model is also supported when Excel is not available.

In the **Sheet** text field enter the name of the worksheet containing the data. If no sheet name is defined, the first worksheet in the Excel file is selected by default.

In the **Range** field enter the cell range that holds the data. The range can be either defined using:

- the top-left cell number, to import all data up to the next empty cell.
- the cell range, to specify which cells are used for the import.
- empty cell range, to import the entire worksheet.

Also see Supported Formats.

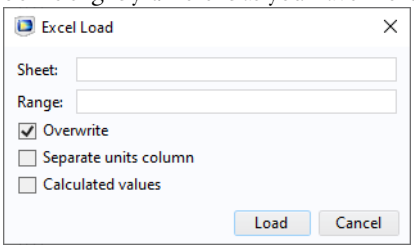
Clear the **Overwrite** check box to append the imported data to the end of the table. Note that you need to resolve conflicting data after the import.

Click **Load** to load the data to the table. Excel automatically starts in the background, if available. Excel will close after the import has been performed.

Excel usually locks the file when open it and hence the file cannot be loaded by other applications. Use Excel for reading the file to avoid this limitation.

IMPORTING MODEL PARAMETERS FROM A WORKBOOK

In case you want to import a list of parameters from a workbook, the Excel Load dialog box is slightly different as you have more import options.

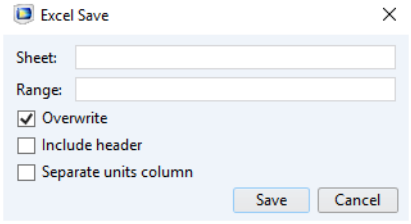


For parameters import select **Separate units column** if the worksheet contains the units in separate but adjacent columns. Select select **Calculated values** if the worksheet contains the parameters values in separate but adjacent columns.

Exporting Data to a Workbook

In the **Settings** window of the feature click the **Save to File** button ( ), usually located below the table. From the **Save as type** list select **Microsoft Excel Workbook (*.xlsx)**, then

specify the desired filename and click **Save**. Specify the sheet and cell range for the data export.



Saving data to workbook files from a COMSOL model is also supported when Excel is not available.

In the **Sheet** text field enter the worksheet name where to store the data. If no sheet name is defined, the first worksheet of the Excel workbook is selected by default.

In the **Range** field enter the cell range where data should be written. The range can be either defined using:

- a unique cell number defining the top cell in the worksheet.
- a cell range, to specify the cell where to save the data. Only the data within the specified cell range are exported.
- an empty cell range, all the data are saved starting from the cell A1.

Also see Supported Formats.

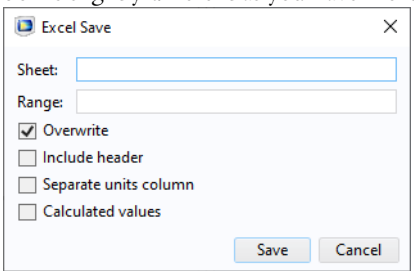
Clear the **Overwrite** check box if you want to append the data to the Excel file. Note that you can only append data to empty cells.

Select **Include headers** to export the table header row together with the data.

Click **Save** to save to export the data. Excel automatically starts in the background, if available. Excel will close after the export has been performed.

EXPORTING MODEL PARAMETERS TO A WORKBOOK

In case you want to export the model parameters to a workbook, the Excel Save dialog box is slightly different as you have more export options.



For parameters import select **Separate units column** to save the units in separate columns. Select select **Calculated values** to save the parameter values in separate columns.

Supported Formats

The format of the data to be imported or exported depends on the model definition that you are working with. It is recommended that you export a table to a file to check how the data is formatted, you can then format data similarly for the import.

The following is an overview of the data format for each feature that supports reading or writing of Excel files:

- **Parameters**: the first column in the cell range defines the parameter name, the second its expression, and the third optional column the parameter description.

extern_L	9[cm]	Length of busbar
rad_1	6[mm]	Radius of bolts
tbb	5[mm]	Thickness of busbar

  The parameter unit can also be defined in the file with an extra column included between the expression and the parameter description. For these data formats you need to select **Separate units column** in the Excel load dialog box.

extern_L	9	[cm]	Length of busbar
rad_1	6	[mm]	Radius of bolts
tbb	5	[mm]	Thickness of busbar

  Same as for the units, the parameters value can be included in a extra column. For these data formats you need to select **Calculated values** in the Excel load dialog box.

extern_L	9[cm]	0.09 m	Length of busbar
rad_1	6[mm]	0.006 m	Radius of bolts
tbb	5[mm]	0.005 m	Thickness of busbar

  If you want to include both units and parameters values, the units column must be placed between the expression and the parameters value columns. For these data formats you need to select both **Separate units column** and **Calculated values** in the Excel load dialog box.

extern_L	9	cm	0.09 m	Length of busbar
rad_1	6	mm	0.006 m	Radius of bolts
tbb	5	mm	0.005 m	Thickness of busbar

- **Variables**: the first column in the cell range defines the parameter name, the second its expression, and the third optional column the parameter description.

xi	abs(dest(x)-x)/D_i	
k	1-(2*xi^3+3*xi)/(2*(xi^2+1)^1.5)	Integral kernel
Q_source	4/(D_o^2-D_i^2)*epsilon*sigma_const*intop1(k*T^4)	Heat source

- **Interpolation** functions: the first cell column in the cell range defines the value of the input argument parameter t, and the second column defines the value of the function $f(t)$.

293	5.0136
303	8.5
313	9.3272
323	9.8918
333	10.3303
343	10.6921
353	11.0012
363	11.2717
373	11.5123

- **Piecewise** functions: the first column in the cell range defines the start of the interval, the second column defines the end of the interval, and the third column defines the expression for the function.

0	1	x
1	2	x^3

- **Parametric Sweep** and **Auxiliary Sweep**: the first column in the cell range defines the parameter name, and the second column contains the list of the parameters separated by space.

L	5e-2 10e-2 15e-2
Vtot	5e-2 10e-2 20e-2 30e-2 40e-2

Exchange Workbook Using the COMSOL® API

The COMSOL API provides commands to exchange file with the model, set the filename including the Excel extension (.XLSX) to specify workbook.

See the *COMSOL Multiphysics Programming Reference Manual* for the following feature:

- model.param() and model.result().param()
- model.variable()
- model.func()

In the case the client/server connection such as using COMSOL with MATLAB, the Excel file is available on the client machine.

IMPORTING WORKBOOK USING THE COMSOL API

To load an Excel file type:

```
model.feat.loadFile(<filename>, "sheet", <range>);
```

where *<filename>* is the Excel filename including the .XLSX extension. *<range>* is the top-left cell range from which to import the data.

EXPORTING WORKBOOK USING THE COMSOL API

To save an Excel file type:

```
model.feat.saveFile(<filename>,"sheet",<range>,header,overwrite);
```

where *<filename>* is the Excel filename including the .XLSX extension. *<range>* is the top-left cell range to which saving the data. *header* is a Boolean you set to *true*

to include the table header and `false` to not include the table header. `overwrite` is a Boolean you set to `true` to overwrite nonempty cells without warning and `false` to not overwrite non-empty cells without warning.

Exchange Workbook in the Application Builder

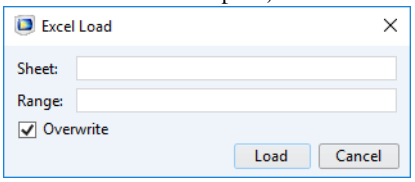
LiveLink™ also supports workbook exchange with the model in the Application Builder using either a Table form object or dedicated Language Elements.

EXCHANGE WORKBOOK USING A TABLE FORM OBJECT

In the Application Builder you can add a Table form object with the Load from file and/or Save to file toolbars.

See Table section in the *COMSOL Multiphysics Application Builder Reference Manual.*

When running the application to load data from an Excel workbook click **Load from file** button and select Microsoft Excel Workbook (*.xlsx) as File format. Once you have selected the file to import, the Excel Load window pops-up.

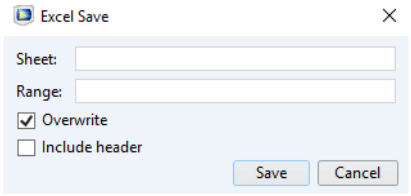


This is where you specify the worksheet and range where to import the data. In the **Range** field enter the top-left cell number or the cell range to load only the specified data within the cell range.

Clear **Overwrite** if you want to keep the data in the current table.

Click **Load** to import the table.

To save the data available in the table, click **Save to** file button and select Microsoft Excel Workbook (*.xlsx) as File format. Once you have selected the file where to save, the Excel Save window pops-up.



This is where you specify the worksheet and range where to export the data. In the **Range** field enter the top-left cell number or the cell range to save only the data that fit the specified cell range.

Clear **Overwrite** if you want to keep the non-empty cell in the file.

Select **Include header** if you want also to include the table header in the workbook.

Click **Save** to export the table.

EXCHANGE WORKBOOK USING THE METHOD EDITOR

LiveLink™ offers specific language elements in the Application Builder to exchange data between the application and an Excel workbook. These are `writeExcelFile` and `readExcelFile` to write to an Excel file and read the data from an Excel file, respectively.

Using the method editor, the file you are working can also be available on the server.

See File Schemes and File Handling section in the *COMSOL Multiphysics Application Builder Reference Manual*.

You will find below the commands to exchange data with an Excel workbook using the method editor available in the Application Builder.

```
writeExcelFile(String filename, String[][] data)
```

Writes the given string data to the first cell onwards in the first sheet of an Excel-file.

```
writeExcelFile(String filenname, String sheet, String cell,
   String[][] data)
```

Writes the given string data to the specified cell onwards on the specified sheet of an Excel-file.

The strings set in `data` can defines number, text, or Excel formulas as in the example below:

```
String [][] data = new String[][] {{"Mydata", "=SUM(4,7)", "5",
"=SUM(A1:C1)"}}
```

Formulas have to be entered following English number format.

```
String[][] readExcelFile(String filename)
```

Reads from the first cell onwards on the first sheet of an Excel-file into a String[][].

```
String[][] readExcelFile(String filename, String sheet,
   String cell)
```

Reads from the specified cell onwards on the specified sheet of an Excel-file into a `String[][]`.

See the application example Beam Section Calculator (using LiveLink™ *for* Excel®) in the LiveLink for Excel Application library.

4

Using Visual Basic® for Applications

LiveLink™ *for* Excel® supports Microsoft® Excel® built-in language, Visual Basic® for Applications (VBA), to access and modify the COMSOL model directly from a worksheet. Using Visual Basic for Application makes it possible to control the content of Excel workbooks, create user interfaces, and perform advanced calculations.

In this chapter:

Introduction

In this section:

Support for VBA

Visual Basic for Applications (VBA) is a macro language that is built into Excel. This language makes it possible to control the content of workbooks, create user interfaces and perform advanced calculations. Using LiveLink™ *for* Excel® you can also connect a COMSOL server from Excel and access all the features of the COMSOL Application Programming Interface (API).

The interface based on VBA is using the model structure and the methods (commands) for accessing the model settings and data provided by the COMSOL API, which programming syntax is similar. You can refer to the *COMSOL Programming Reference Manual* for more information.

The following parts of the documentation show the steps necessary to work with COMSOL models starting with a very simple example based on an existing model.

The *LiveLink™ for Excel® User's Guide Manual* assumes that you have some knowledge of VBA.

If you run the COMSOL API for use with VBA provided by LiveLink™, you cannot use the link between the worksheet and the model defined with a cell comment generated by the COMSOL tab.

See Updating and Solving a Model Using Excel® Macros to learn quickly the COMSOL API for use with VBA.

Introductory Example

Here is a small example that illustrates some of the possibilities that exist for using VBA for working with a COMSOL model. The examples requires that LiveLink™ *for* Excel® is properly installed and configured. Some knowledges in VBA are requested to get started; these are listed under Prerequisites.

To load or create a COMSOL model it is necessary to use the class ModelUtil, which is part of the COMSOL API. In addition to ModelUtil, there is another object that is part of LiveLink™ *for* Excel®, which is called ComsolUtil. This object provides extra utilities that are not already present in ModelUtil, such as the ability to start a COMSOL Multiphysics Server or access the ribbon functionalities (using the RibbonUtil object).

The example loads the busbar model from the Applications Libraries, creates a plot and extracts some numerical data and puts the data into an Excel sheet. Below is a detailed explanation of the different operations performed by the subroutine. At the end of the description, you will find the code used for this example, see Code for use with VBA. Copy and paste it in the VBA editor at your convenience.

1. In the Developer toolbar, click Visual Basic button to start the Microsoft Visual Basic for Applications interface.
2. From the Insert menu, select Module.
3. In the Module 1 editor start editing the subroutine:

```
Sub Example()
```

4. Create the utility objects dedicated for LiveLink™ *for* Excel®:

```
Set ComsolUtil = CreateObject("comsolcom.comsolutil")
Set ModelUtil = CreateObject("comsolcom.modelutil")
Set RibbonUtil = ComsolUtil.GetRibbonUtil
```

5. Open the model file `busbar.mph` from the COMSOL Multiphysics Applications Libraries

```
Range("A1").Select
Set model = RibbonUtil.OpenModel("busbar.mph")
```

You do not need to include the file path as long as you are opening a model from the COMSOL Application Libraries or the model is saved at the same location as the current workbook. Once the model is loaded a message is displayed on the COMSOL Multiphysics server window.

6 Write in the worksheet the coordinates to use for the data interpolation as in the figure below:

x	y	z
0	0	0
2.50E-02	0	0
5.00E-02	0	0
0	-1.25E-02	0
2.50E-02	-1.25E-02	0
5.00E-02	-1.25E-02	0
0	-2.50E-02	0
2.50E-02	-2.50E-02	0
5.00E-02	-2.50E-02	0

```
Range("A1").Value = x
Range("B1").Value = y
Range("C1").Value = z
Range("A2:C10").Value = 0
Range("A3").Value = 2.5e-2
Range("A4").Value = 5e-2
Range("B5").Value = -1.25e-2
Range("B8").Value = -2.5e-2
Range("A5:A7").Value = Range("A2:A4").Value
Range("A8:A10").Value = Range("A2:A4").Value
Range("B6:B7").Value = Range("B5").Value
Range("B9:B10").Value = Range("B8").Value
```

7 Collect the coordinate values from the Excel worksheet

```
Values = Range("A2:C10").Value
```

The Values variable is a 2D matrix. Note that this is a Nx3 array, which by default starts its indexing at 1. In the COMSOL model coordinates have to be entered as a 3xN array. Also, array indexing always start at 0.

8 Reformat the data collected in the worksheet in a usable way for the COMSOL model

```
Dim coords() As Double
ReDim coords(0 To 2, 0 To 8)
coords = ComsolUtil.ConvertToDoubleMatrix(Values, True)
```

9 Extract the temperature from the model using interpolation coordinates

```
Range("D3").Select
RibbonUtil.ResultsInterpolation "dset1", "T", "A4:C12", True
```

The above code creates a link between Excel and the COMSOL model, which defines an interpolation evaluation at the coordinates provided in the cell range A4:C12. You can reuse later this link to update the evaluation after you have computed a new set of solution.

10 End the subroutine

```
End Sub
```

11 To run the subroutine click Run Sub/User Form button or press F5

Once you have run the subroutine the ribbon is connected to the COMSOL Multiphysics Server. You don't need to open the model again.

Code for use with VBA

Below you find the full script of the example. You can copy it and paste it into the VBA editor. In the code below replace *<COMSOLPATH>* with your local COMSOL Multiphysics installation directory.

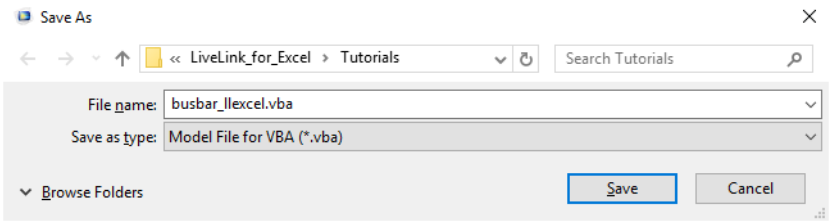
```
Sub Example()

Set ComsolUtil = CreateObject("comsolcom.comsolutil")
Set ModelUtil = CreateObject("comsolcom.modelutil")
Set RibbonUtil = ComsolUtil.GetRibbonUtil

Range("A1").Select
Set Model = RibbonUtil.OpenModel("busbar.mph")

Range("A3").Value = "X"
Range("B3").Value = "Y"
Range("C3").Value = "Z"
Range("A4:C12").Value = 0
Range("A5").Value = 2.5e-2
Range("A6").Value = 5e-2
Range("B7").Value = -1.25e-2
Range("B10").Value = -2.5e-2
Range("A7:A9").Value = Range("A4:A6").Value
Range("A10:A12").Value = Range("A4:A6").Value
Range("B8:B9").Value = Range("B7").Value
Range("B11:B12").Value = Range("B10").Value

Range("D3").Select
RibbonUtil.ResultsInterpolation "dset1", "T", "A4:C12", True

End Sub
```

Working with Models Using VBA

In this section:

Saving the Model File for VBA

You can save the COMSOL model as a file for VBA ready to use in an Excel ® macro. In the COMSOL Desktop go to **File** menu, choose **Save As**, and, in the **Save As** window, from the **Save as type** list select **Model File for VBA (*.vba)**.



The commands for each operation on the model are listed in the file in the order of they were performed, this way it is easy to get the corresponding command for a specific operation as it is the last one in the file.

If you do not want to save the entire model history and save only the commands that correspond to the current model status, in the File menu click **Compact History** prior to saving the model.

Important Notes About the Model Object

Consider the following information regarding the model object:

- All algorithms and data structures for the model are integrated in the model object.
- The model object is used by the COMSOL Desktop to represent your model. This means that the model object and the COMSOL Desktop behavior are virtually identical.
- The model object includes methods to set up and run *sequences of operations* to create geometry, meshes, and to solve your model.

The Model Object in the *COMSOL Multiphysics Programming Reference Manual*.

The Model Utility Object

The model object has a large number of methods. The methods are structured in a tree-like way, similar to the nodes in the model tree in the *Model Builder* window on the COMSOL Desktop. The top-level methods just return references that support further methods. At a certain level the methods perform actions, such as adding data to the model object, performing computations, or returning data.

Detailed documentation about model object methods is in About General Commands in the *COMSOL Multiphysics Programming Reference Manual*.

You can access the model object methods using a ComsolUtil object. To create a ModelUtil object enter:

```
Set modelutil = CreateObject("comsolcom.modelutil")
```

See The COMSOL API section to get more information about the COMSOL API methods accessible from the ModelUtil object.

The COMSOL Utility and Ribbon Utility Objects

LiveLink™ offers dedicated method to interact with the COMSOL *server* from Excel. These methods are accessible using a ComsolUtil object.

To create a ComsolUtil object enter:

```
Set ComsolUtil = CreateObject("comsolcom.comsolutil")
```

See The COMSOL Utility Methods section to get more information about the methods available using the ModelUtil object.

In addition to the COMSOL Utility object you can create the COMSOL RibbonUtility object, which allows to access each operation available from the COMSOL ribbon using specific methods.

To create a RibbonUtil object enter:

```
Set RibbonUtil = ComsolUtil.GetRibbonUtil
```

See The COMSOL Ribbon Utility Methods section to get more information about the methods available using the ModelUtil object.

ComsolCom Version Control

It is possible to manually specify which ComsolCom version to run. To create a ComsolUtil and a ModelUtil object from a specific COMSOL version use the commands below:

```
Set ComsolUtil = CreateObject("comsolcom.comsolutil.<version>")
Set ModelUtil = CreateObject("comsolcom.modelutil.<version>")
```

where *<version>* is the COMSOL version number, for instance 6.0 for the current version.

Once you have set a COMSOL version to use, make sure LiveLink is installed with this version number.

If you don't want to specify the version number and use the highest COMSOL version available, use the commands below:

```
Set ComsolUtil = CreateObject("comsolcom.comsolutil")
Set ModelUtil = CreateObject("comsolcom.modelutil")
```

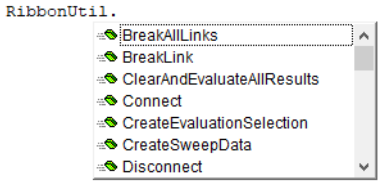
To be able to run the code created in the Visual Basic for Applications interface, you need to activate the ComsolCom references as static reference. To proceed, in the Microsoft Visual Basic for Applications window, go to **Tools** menu and click **References**. In the **Available References** list select **ComsolCom 6.0** and click **OK**.

Declaring Utility Object with Dim

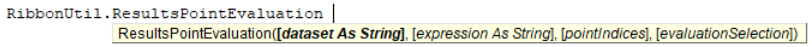
It is possible to declare variables of the ModelUtil, ComsolUtil, and RibbonUtil types using Dim, to proceed enter the command below:

```
Dim ModellUtil As ComsolCom.ModelUtil
Dim ComsolUtil As ComsolCom.ComsolUtil
Dim RibbonUtil As IRibbonUtil
```

Once these are declared automatic completion is accessible as shown below:



You also get indication how to use the method:



Error Handling

When working with script it can be useful to trap any errors that either originate from COMSOL or from your own code. The VBA editor has some settings that makes it possible to trap error in different ways, these tools are available in the Options window. The Options window is accessible from the Tools menu of the VBA editor.

In the Options menu you define the error handling settings in the General page, in the Error Trapping section you find:

- Break on All Errors: breaks code execution whenever there is an error. Shows a VBA dialog box with the error message.
- Break on Class Module: stops at the actual error (line of code) when a class module has been written in VBA.
- Break on Unhandled Errors: breaks code execution whenever there is an error but also allows you to trap the error (using the On Error statement). If you fail to trap an error you will get a dialog box from VBA.

EXAMPLE

In the VBA editor enter the code below. The code starts a COMSOL Multiphysics Server and connects it with Excel. Finally, it tries to load a model MPH-file that does not exist, as it is meant to fail.

```
Set ModelUtil = CreateObject("comsolcom.modelutil")
```

```
Set ComsolUtil = CreateObject("comsolcom.comsolutil")
Set RibbonUtil = ComsolUtil.GetRibbonUtil

Set model = RibbonUtil.OpenModel("c:\\foo.mph")

End Sub
```

Assuming that the file `foo.mph` does not exists and if the error trapping is set to Break on All Error, the following error message is returned:

```
Run-time error '-2146233088 (80131500'):

Failed to load model.
```

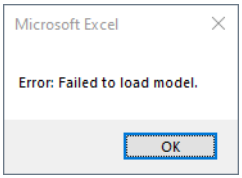
The numbers do not have any useful meaning, but sometimes you are able to decipher the message in the window. In this case the message says something about `The system cannot find the file specified`, which is expected. Click the End button to stop the VBA code from running.

When writing your own code, you may want to be able to handle errors differently so that you can show a nice dialog box about the problem or perhaps fix the problem on the fly. This is especially useful if you write code that other people will use. The On Error statement allow you to handle any error that may occur.

Update the code above such as:

```
Sub loadfile_error()

On Error GoTo errorhandler
Set ModelUtil = CreateObject("comsolcom.modelutil")
Set ComsolUtil = CreateObject("comsolcom.comsolutil")
Set RibbonUtil = ComsolUtil.GetRibbonUtil

Set model = RibbonUtil.OpenModel("c:\\foo.mph")
Exit Sub

errorhandler:
Call MsgBox("Error: " + Err.Description)
End Sub
```

Make sure the Error trapping option is set to Break on Unhandled Errors and run the script. You will now get the following dialog box:



In this example we are just showing an error message and an OK button. For more advanced error handling you may want to customize the error message further and provide different options to the user.

Running a script without the On Error statement but with the Error trapping option set to Break on Unhandled Errors may return message without sufficient information.

Starting and Connecting to a COMSOL Multiphysics Server

The most common approach to start and connect Excel to a COMSOL Multiphysics Server is by opening a model using `OpenModel()` from the RibbonUtil utilities. However, LiveLink™ *for* Excel® also provides methods for starting and connecting to a server manually.

Ordinarily you would run `StartComsolServer()` to start the COMSOL Multiphysics Server:

```
Boolean ComsolUtil.StartComsolServer(useGraphics As Boolean)
```

This command will start the COMSOL Multiphysics Server in graphics mode when `useGraphics` is set to `True` on the local computer. A port number, which is used for the communication between the COMSOL server and Excel, is automatically assigned by the COMSOL server. The default number is 2036, but if other COMSOL servers are running then a higher number has to be chosen. It also returns a Boolean to indicate if the COMSOL server has started (`True`) or failed to start (`False`).

To connect Excel to the COMSOL *server* using the default port number, simply use the command:

```
Void RibbonUtil.Connect([hostname As String], [portnumber As Int],
[login As String],[pwd As String])
```

where `hostname`, `portnumber`, `login`, and `pwd` are optional argument that set the connection credential: computer name, the port number the server is listening to, the user name and the password respectively. If you are already connected to a server and try to connect it again, nothing happens and you will remain connected. If however you try connect to a different server, it will disconnect automatically from the first one and connect to the specified one.

You can check if the RibbonUtil service is already connected to a server with the `IsConnected()` method:

```
Boolean RibbonUtil.IsConnected()
```

This returns `True` if already connected, `False` else.

To disconnect from the server use `Disconnect()`:

```
Void RibbonUtil.Disconnected()
```

Code for use with VBA

Below you find an example showing how to connect manually to a COMSOL Multiphysics server; feel free to copy and paste it to the VBA editor.

```
Sub ConnectServerExample()

Dim ComsolUtil As ComsolUtil
Dim RibbonUtil As IRibbonUtil

Set ComsolUtil = CreateObject("comsolcom.comsolutil")
Set RibbonUtil = ComsolUtil.GetRibbonUtil

If Not RibbonUtil.IsConnected Then
' Start a Multiphysics server
ok = ComsolUtil.StartComsolServer(True)
' Return an error if started properly
If ok = False Then
MsgBox "no server " & ComsolUtil.get_errormessage
Exit Sub
End If
' Get the port number used
port = ComsolUtil.get_port
' Connect to the server using the specified port number
RibbonUtil.Connect "localhost", port
End If
End Sub
```

Updating and Solving a Model Using Excel® Macros

In this section you will find several examples that illustrate some of the possible work flows when using VBA with a COMSOL model.

Some knowledge in VBA are required to run the examples. For more information please refer to the section Prerequisites.

This example reuses the worksheet described in the section Working with COMSOL® Models in Excel® in the *Introduction to LiveLink™ for Excel® manual*. The steps below show how to write commands that automatically update the model with the settings in the worksheet, compute the solution and update the results data extracted in the worksheet.

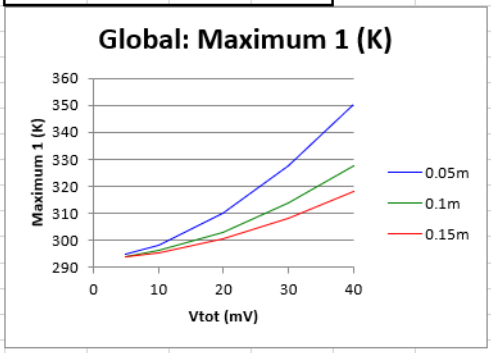
When writing a subroutine in VBA the cell comment generated using the COMSOL toolbar are not usable. Enter the full command using the COMSOL API to reproduce the same behavior.

To get ready with the examples follow the steps below.

1. Start Excel, in the **File** tab, click **Open**.
2. In your COMSOL Multiphysics installation directory, find the folder `models/LiveLink_for_Excel/Tutorials`.

3 Select the file `busbar_llexcel.xlsx` and click the **Open** button.

	A	B	C	D	E	F	G	H	I	J
1	COMSOL Model									
2	Filename:	Multiphysics\applications\LiveLink_for_Excel\Tutorials\busbar_llexcel.mph								
3										
4	Paramete	Expressio	Unit	Descriptic	Value	Unit				
5	Parameters 2									
6	L	9	cm	Length	0.09	m				
7										
8	Name	Expressions								
9	wbb	5.00E-02	0.1	0.15						
10	Vtot	5	10	20	30	40				
11										
12										
13	wbb (m)	Vtot (mV)	Max (T)		Vtot (mV)	Maximum	Maximum	Maximum 1 (K)		
14	0.05	5	294.7635		5	294.7635	294.0778	293.8078		
15	0.05	10	298.3922		10	298.3922	296.3628	295.5113		
16	0.05	20	310.0511		20	310.0511	303.1653	300.652		
17	0.05	30	327.7516		30	327.7516	313.7691	308.218		
18	0.05	40	350.2578		40	350.2578	327.4482	318.3603		
19	0.1	5	294.0778							
20	0.1	10	296.3628							
21	0.1	20	303.1653							
22	0.1	30	313.7691							
23	0.1	40	327.4482							
24	0.15	5	293.8078							
25	0.15	10	295.5113							
26	0.15	20	300.652							
27	0.15	30	308.218							
28	0.15	40	318.3603							
29										
30										
31										
32										



You can see in cell range B2, the full name of the model MPH-file that is linked to the workbook. In the first worksheet you can assign value to model parameters and parameters sweep. It also contains the value of the maximum temperature in the busbar for the different parameter sweep values. The second worksheet contains the joule heating data interpolated at point coordinates defined in cell range A3 to C20.

4 Go to the Excel **File** menu and select **COMSOL**. In the COMSOL backstage view click **Open** button and select **Open linked**. You will be asked if you want to replace the contents of the destination cell, click OK.

Note: When opening the linked model for this file, COMSOL will automatically search for the model busbar_llexcel.mph in the Application Library folder. If you don't have this model you need to specify the location. Find the folder `applications/LiveLink_for_Excel/Tutorials`. Select the file `busbar_llexcel.mph` and click the Open button.

The COMSOL Multiphysics Server starts and loads the model file busbar_llexcel.mph that is linked to the worksheet.

5 In Excel press Alt+F11 keys to open the VBA editor.

6 In the VBA editor, go to **Insert** menu and select **Module**.

7 In the editor type:

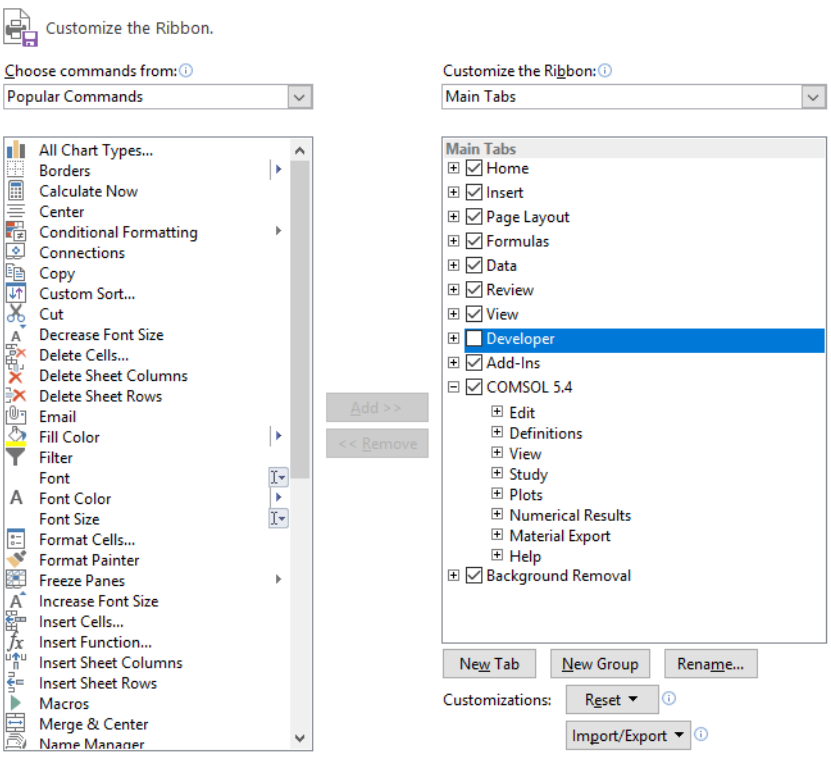
```
Sub busbarUpdate()
```

and press Enter key to get the end subroutine line automatically added to the script.

To run the macro a convenient way is to create a button. To proceed you need first to enable the Developer tab in the Excel ribbon.

8 In Excel, go to the **File** tab and select **Options**.

9 In the **Excel Options** window, select **Customize Ribbon** and on the right side of the window under **Main Tabs** select **Developer**.



10 Click **OK**.

11 Go to the **Developer** tab and click **Insert**.

12 Under **Form Controls** select **Button (Form Control)** and draw the button in the worksheet.

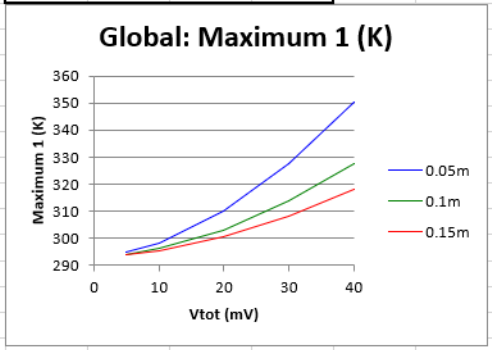
13 In the **Assign Macro** window that just pops-up, under the **Macro name** list select **busbarUpdate**. Click **OK**.

14 You now have a button in the worksheet that runs the macro you will write in the example below. You can remove the inserted image and change the text in the button so that the worksheet looks like in the image below.

	A	B	C	D	E	F	G	H	I	J
1	COMSOL Model									
2	Filename:	Multiphysics\applications\LiveLink_for_Excel\Tutorials\busbar_llexcel.mph								
3										
4	Paramete	Expressio	Unit		Descriptic	Value	Unit			
5	Parameters 2									
6	L	9	cm		Length	0.09	m			
7										
8	Name	Expressions								
9	wbb	5.00E-02	0.1	0.15						
10	Vtot	5	10	20	30	40				
11										
12										
13	wbb (m)	Vtot (mV)	Max (T)							
14	0.05	5	294.7635							
15	0.05	10	298.3922							
16	0.05	20	310.0511							
17	0.05	30	327.7516							
18	0.05	40	350.2578							
19	0.1	5	294.0778							
20	0.1	10	296.3628							
21	0.1	20	303.1653							
22	0.1	30	313.7691							
23	0.1	40	327.4482							
24	0.15	5	293.8078							
25	0.15	10	295.5113							
26	0.15	20	300.652							
27	0.15	30	308.218							
28	0.15	40	318.3603							
29										
30										
31										
32										

Vtot (mV)	Maximum	Maximum	Maximum 1 (K)
5	294.7635	294.0778	293.8078
10	298.3922	296.3628	295.5113
20	310.0511	303.1653	300.652
30	327.7516	313.7691	308.218
40	350.2578	327.4482	318.3603

Update



The worksheet including the full example code is available at XLSM-format in the LiveLink™ *for* Excel® Applications Libraries `LiveLink_for_Excel/Tutorials/busbar_llexcel.xlsm`

In order to work with a COMSOL model it is necessary to use the class ModelUtil, which is part of the COMSOL API. In addition to ModelUtil there is a new object that is part of LiveLink™ *for* Excel®, which is called ComsolUtil. This object provides

extra utilities - such as the ability to start a COMSOL Multiphysics Server and create the RibbonUtil object where you can access the ribbon functionalities.

15 Make sure you have set the COMSOL references in the VBA project, in the Visual Basic for Applications window, under Tools select References. In the Available References list, select ComsolCom 6.0 and click OK.

Type the command at the line after the subroutine declaration line `Sub busbarUpdate()`.

16 Load the ComsolUtil, the ModelUtil, and the RibbonUtil objects.

```
Dim ModelUtil As ModelUtil
Dim ComsolUtil As ComsolUtil
Dim RibbonUtil As IRibbonUtil

Set ModelUtil = CreateObject("comsolcom.modelutil")
Set ComsolUtil = CreateObject("comsolcom.comsolutil")
Set RibbonUtil = ComsolUtil.GetRibbonUtil
```

17 To allow long running jobs enter the command:

```
ComsolUtil.TimeOuthandler True
```

18 Open the linked model only if the ribbon is not connected to the COMSOL *server*.

```
If Not RibbonUtil.IsConnected Then
    RibbonUtil.OpenLinkedModel
End If
```

19 Set a link with the model, with the tag `Model`, available on the COMSOL *server*.

```
Set Model = ModelUtil.model("Model")
```

The cell range A6 to D6 define both the value and the unit for the model parameter L.

20 To update the model parameter defined in the cell range A4 enter:

```
Sheets("Sheet1").Activate
Range("A4").Select
RibbonUtil.UpdateDefinitions
```

The worksheet contains values for the busbar width (`wbb`) and the applied voltage (`Vtot`) as sweep parameter. In this example, the sweep parameters cannot have more than 5 value each.

21 Keep only the fifth first column for both sweep parameters:

```
Range("G9:J10").Clear
```

22 To update the parametric sweep parameters defined in the cell range A8 enter:

```
Range("A8").Select
RibbonUtil.Sweep "std1", ,True
```

23 To enable the progress bar and compute enter:

```
ModelUtil.ShowProgress True
Model.get_study("std1").Run
```

24 Display the third plot group and insert the corresponding image in L4.

```
Model.get_result("pg3").Run
Range("L4").Select
RibbonUtil.InsertGraphics "pg3"
```

25 Update all numerical results in sheet 1:

```
RibbonUtil.UpdateAllResults
```

In the step below, you will implement the code to perform the interpolation operation as it is currently done in Sheet2.

26 You need first to retrieve the value for each parametric sweep, that will be used to loop over when performing the interpolation evaluation.

```
Vtot = Range("B10:F10").Value
For I = 0 To 4
    If Not IsEmpty(Range("B9").Offset(, I).Value) Then
        wbbLength = I + 1
    End If
    If Not IsEmpty(Range("B10").Offset(, I).Value) Then
        VtotLength = I + 1
    End If
Next
wbb = Range(Cells(9, 2), Cells(9, 2 + wbbLength)).Value
Vtot = Range(Cells(10, 2), Cells(10, 2 + VtotLength)).Value
```

27 Clear Sheet 2, except the cell that contain the coordinates for the interpolation.

```
Sheets("Sheet2").Activate
Range("D1:AB20").Delete
```

28 Loop over the parameter wbb and interpolate the total heat at the specified coordinates:

```
For I = 0 To wbbLength - 1
    Range("D3").Offset(, I * VtotLength).Select
    RibbonUtil.ResultsInterpolation "dset2", "ht.Qtot", "A3:C20",
, "wbb", wbb(1, I + 1)
Next
```

29 Enter the commands below to improve the cell format:

```
For I = 0 To wbbLength - 1
    Idx = I * wbbLength
    Title = "Qtot [W] (wbb = " & wbb(1, I + 1) & "m)"
    Cell1 = 4 + VtotLength * I
    Cell2 = 4 + (I + 1) * VtotLength - 1
```

```
    Cells(1, Cell1) = Title
    Cells(1, Cell1).Font.Bold = True
    Cells(1, Cell1).HorizontalAlignment = xlCenter
    Range(Cells(1, Cell1), Cells(1, Cell2)).Merge
    Range(Cells(1, Cell1), Cells(1, Cell2)).Borders.Weight =
xlThick
    For j = 1 To VtotLength
        Idx2 = I * VtotLength + j - 1
        Title = "Vtot = " & Vtot(1, j) & "mV"
        Range("D2").Offset(, Idx2).Value = Title
        Range("D2").Offset(, Idx2).Font.Bold = True
        Range("D2").Offset(, Idx2).Borders.Weight = xlThick
    Next
Next
```

30 You can now close the Micorsoft Visual Basic for Applications window and test to run the subroutine by editing the model parameter L, cell B6, or the sweep parameters wbb and Vtot, cell B9 to F9 and B10 to F10 respectively. Click Update button to update the workbook with the current solution.

Code for use with VBA

Below you find the complete VBA code; feel free to copy and paste it to the VBA editor.

```
Sub busbarUpdate()

Dim ModelUtil As ModelUtil
Dim ComsolUtil As ComsolUtil
Dim RibbonUtil As IRibbonUtil

Set ModelUtil = CreateObject("comsolcom.modelutil")
Set ComsolUtil = CreateObject("comsolcom.comsolutil")
Set RibbonUtil = ComsolUtil.GetRibbonUtil

ComsolUtil.TimeOuthandler True

If Not RibbonUtil.IsConnected Then
    RibbonUtil.OpenLinkedModel
End If

Set Model = ModelUtil.Model("Model")

Sheets("Sheet1").Activate
Range("A4").Select
RibbonUtil.UpdateDefinitions

Range("G9:J10").Clear

Range("A8").Select
```

```
RibbonUtil.Sweep "std1", , True

ModelUtil.ShowProgress True
Model.get_study("std1").Run


Model.get_result("pg3").Run
Range("L4").Select
RibbonUtil.InsertGraphics "pg3"


RibbonUtil.UpdateAllResults

Vtot = Range("B10:F10").Value
For I = 0 To 4
    If Not IsEmpty(Range("B9").Offset(, I).Value) Then
        wbbLength = I + 1
    End If
    If Not IsEmpty(Range("B10").Offset(, I).Value) Then
        VtotLength = I + 1
    End If
Next
wbb = Range(Cells(9, 2), Cells(9, 2 + wbbLength)).Value
Vtot = Range(Cells(10, 2), Cells(10, 2 + VtotLength)).Value

Sheets("Sheet2").Activate
Range("D1:AB20").Delete

For I = 0 To wbbLength - 1
    Range("D3").Offset(, I * VtotLength).Select
    RibbonUtil.ResultsInterpolation "dset2", "ht.Qtot", "A3:C20",
, "wbb", wbb(1, I + 1)
Next

For I = 0 To wbbLength - 1
    Idx = I * wbbLength
    Title = "Qtot [W] (wbb = " & wbb(1, I + 1) & "m)"
    Cell1 = 4 + VtotLength * I
    Cell2 = 4 + (I + 1) * VtotLength - 1
    Cells(1, Cell1) = Title
    Cells(1, Cell1).Font.Bold = True
    Cells(1, Cell1).HorizontalAlignment = xlCenter
    Range(Cells(1, Cell1), Cells(1, Cell2)).Merge
    Range(Cells(1, Cell1), Cells(1, Cell2)).Borders.Weight =
xlThick
    For j = 1 To VtotLength
        Idx2 = I * VtotLength + j - 1
        Title = "Vtot = " & Vtot(1, j) & "mV"
        Range("D2").Offset(, Idx2).Value = Title
        Range("D2").Offset(, Idx2).Font.Bold = True
```

```
        Range("D2").Offset(, Idx2).Borders.Weight = xlThick
    Next
Next

End Sub
```

Prerequisites

In this chapter you find the minimum you need to know in Visual Basic for Application (VBA) in order to run macro using LiveLink™ *for* Excel®.

This section is not intended to provide information about VBA but how to run a script in VBA using LiveLink™ *for* Excel®.

In this section:

Enabling the Developer Toolbar

VBA is installed with Excel, and the VBA editor is accessible just by pressing Alt+F11 keys within Excel. To run the subroutine directly from the worksheet you need to enable the Developer toolbar in the Excel ribbon. In the Developer toolbar you will find the different control tools that can be inserted in the worksheet.

The steps below describe how to activate the Developer toolbar in the Excel ribbon.

1 In Excel right-click on any tab of the ribbon and select **Customize the Ribbon...**.

2 In the **Excel Options** window, locate the **Main Tabs** list and select **Developer**.

3 Click **OK**.

The Developer tab is now available in the ribbon.

Manual Installation

When installing LiveLink™ the component necessary for supporting VBA is installed as well. For manual control, it is possible to manually register and unregister the `ComsolCom.dll` component.

REGISTER THE VBA SUPPORT COMPONENT

In order to register the VBA component you must open a Command Prompt as Administrator and run the following command:

```
C:\Windows\Microsoft.NET\Framework\v4.0.30319\RegAsm.exe
"<COMSOLPATH>\ext\LiveLink\Excel\ComsolCom.dll" /codebase /tlb
```

where *<COMSOLPATH>* is your COMSOL Multiphysics installation directory path.

UNREGISTER THE VBA SUPPORT COMPONENT

In order to unregister the VBA component you must open a Command Prompt as Administrator and run the following command:

```
C:\Windows\Microsoft.NET\Framework\v4.0.30319\RegAsm.exe
"<COMSOLPATH>\ext\LiveLink\Excel\ComsolCom.dll" /u /tlb
```

where *<COMSOLPATH>* is your COMSOL Multiphysics installation directory path.

Saving Excel Workbooks Containing Macros

If you have an Excel workbook that contains VBA code (or macros) you need to save it as an Excel Macro-Enabled Workbook, which has the ".xlsm" extension.

Depending on your security settings for your computer as well as the security settings for Microsoft Office you may receive a warning when opening an Excel XLSM-file.

Object and Methods

The interface based on VBA is using the same structure of the model and the same methods for accessing the model settings and data. Most of the COMSOL API method are available in VBA, some of them had to be renamed in order to fulfill the Component Object Model (COM) technology requirements.

In this section:

The COMSOL API

COMSOL provides an API based on Java that makes it possible to access COMSOL models settings and results. The COMSOL API consists on approximately 200 classes. These classes contain many methods each. All these methods are covered in the *COMSOL Programming Reference Manual.*

ADAPTING COMSOL API CODE IN VBA

The COMSOL Desktop supports saving model as JAVA-file, which is very convenient to learn the COMSOL API syntax. However, the code generated in the JAVA-file requires some adaption to be run in VBA. The difference between the code to be used with JAVA and with VBA consist in:

- Methods with the same name resulting in different operation has to be renamed, see the section Renamed Method
- The keyword `Call` has to be used on every line calling a method in the COMSOL API when the method do not return anything.
- The `set` method, in the COMSOL API, does return a reference to the object being changed. In VBA it does not return anything.
- Methods that involve three- or four-dimensional arrays are not supported in VBA. These methods are `faceDDX`, `faceDX`, `faceFF1`, and `faceFF2`.

The COMSOL API may change over time. Adding new methods to the COMSOL API may result in conflicts with the way that methods are named using COM. Hence as methods are adding to the API some method named will get the prefix get_ (or other changes will be applied in order to avoid conflicts).

Renamed Method

In the COMSOL API you can have methods with the same name resulting in different operation. To adapt the COMSOL API with the COM requirements some methods have to be renamed.

GETTING AND SETTING PROPERTY

In the COMSOL API you can get and set properties with the same method name. For instance the method `author()` can return the author name of a node in the model using the syntax:

```
String author()
```

But it can also set the author's name of the node in the model using the syntax:

```
ModelEntity author(String name)
```

As a standard, the methods used for getting the value of a property is renamed with the prefix "get_". The methods used for setting the value of a property are left with their name in the COMSOL API.

In the above example to run the first method in VBA you need to type:

```
string get_author()
```

While to run the second one, the same syntax is used:

```
ModelEntity author(string name)
```

Some of the method that requires name change depending on either they set or get properties are listed below:

```
string tag();
string label();
string comments();
String author();
string version();
string model();
```

RETRIEVING NODES IN THE MODEL

For working with the structure of the model tree there are a number of methods that are used to retrieve nodes. These methods also exist in two version with the same name here exemplified using the study method.

The COMSOL API syntax to return a list that contains all the studies in the model is the following:

```
StudyList study()
```

In case you have several studies in the model, you can return a particular study from the list of available studies. In the COMSOL API the syntax is:

```
Study study(String tag)
```

Is it customary in COM to denote the latter using a prefix "get_" to indicate that a single entry of a list is requested, while the first method keep the same name as in the COMSOL API.

In the above example to run the first method in VBA you need to type:

```
StudyList study()
```

While to run the second one, the same syntax is used:

```
Study get_study(String tag)
```

As a specific example, to set the selection of the mesh size node to a point in the COMSOL API you enter:

```
model.mesh("mesh").feature("size").selection().geom("geom",0)
```

while to run the same in VBA you need to change the command to the following one:

```
Call model.get_mesh("mesh").get_feature("size").Selection.geom("g
eom",0)
```

GETADJ() AND GETADJORIENT()

The method `getAdj()` returns an array or a vector depending on the number of arguments. The method that returns an array is renamed to `getAdj1` and the method that returns a vector is renamed into `getAdj2`.

Similar renaming has been performed in the method called `getAdjOrient`, the method that returns an array is renamed to `getAdjOrient1` and the method that returns a vector is renamed into `getAdjOrient2`.

Utility Methods

LiveLink™ *for* Excel® also provides utility classes, ComsolUtil and RibbonUtil, that is useful for specific operations with the COMSOL server, and runs COMSOL ribbon operation using VBA respectively.

In this section:

COMSOL UTILITY METHODS

METHOD	PURPOSE
`ConvertToDoubleMatrix`	Convert the incoming object to an array of doubles in COMSOL API format.
`ConvertToDoubleMatrixDecimal`	Convert the incoming object to an array of doubles in COMSOL API format.
`ConvertToDoubleVector`	Convert the incoming object to a vector of doubles in COMSOL API format.
`get_errormessage`	Return error messages in model.
`get_port`	Return the server port number.
`get_Version`	Return the ComsolCom interface version.
`GetRibbonUtil`	Return IRibbonUtil object.
`isGraphicsServer`	Return graphics server status.
`StartComsolServer`	Start a COMSOL Multiphysics Server.
`TimeOuthandler`	Set timeout handler to Excel.

RIBBON EDIT METHODS

METHOD	PURPOSE
`BreakAllLinks`	Break all links to the model.
`BreakLink`	Break link between a cell and the model.
`Connect`	Connect the COMSOL ribbon to the server.
`Disconnect`	Disconnect the COMSOL ribbon from the server.
`IsConnected`	Connection status between the COMSOL ribbon and the server.
`OpenLinkedModel`	Start a COMSOL Multiphysics Server.
`OpenModel`	Open a model object from a MPH-file.
`ReadModelLink`	Read model link.

RIBBON DEFINITIONS METHODS

METHOD	PURPOSE
`Parameters`	Import model parameters.
`Functions`	Import selected model functions.

METHOD	PURPOSE
UpdateAllDefinitions	Update all model definitions links.
UpdateDefinitions	Update selected model definitions link.
Variables	Import model variables.

RIBBON VIEW METHODS

METHOD	PURPOSE
InsertGraphics	Insert graphics in the worksheet.
InsertGeometryGraphics	Insert geometry graphics in the worksheet.
InsertMeshGraphics	Insert mesh graphics in the worksheet.

RIBBON STUDY METHODS

METHOD	PURPOSE
CreateSweepData	Return ISweepData object.
Sweep	Export or update parametric sweeps.

RIBBON RESULTS METHODS

METHOD	PURPOSE
Removes COMSOL related comments from the selected cells.	Update all evaluated data and results tables.
CreateEvaluationSelection	Return IEvaluationSelection object.
Export1DPlot	Export 1D plot data.
ResultsDerivedValue	Export derived values data.
ResultsParameters	Export results parameters.
ResultsParticleEvaluation	Export particle evaluation data.
ResultsPointEvaluation	Export point evaluation data.
ResultsTable	Export results table data.
ResultsRayEvaluation	Export ray evaluation data.
ResultsInterpolation	Export interpolated data.
UpdateAllResults	Update all evaluated data.

RIBBON HELP METHODS

METHOD	PURPOSE
`OpenDocumentation`	Open COMSOL Multiphysics documentation.
`OpenHelp`	Open LiveLink™ for Excel® help.

RIBBON PREFERENCES METHODS

FUNCTION	PURPOSE
GetRibbonPreferences	Return IRibbonPreferences object.
`AutomaticParameterUpdate`	Set automatic parameters update.

The COMSOL Utility Methods

Additionally to the COMSOL API, LiveLink™ *for* Excel® provides its own object ComsolUtil, which contains the method to handle operation between the COMSOL server and Excel.

To make all COMSOL utility methods available using VBA, enter:

```
Set ComsolUtil = CreateObject("comsolcom.comsolutil")
```

CONVERTTODOUBLEMATRIX

`ConvertToDoubleMatrix(obj, transpose As Boolean) As Double()` converts the incoming object to an array of doubles in COMSOL API format.

The input object `obj` is either a scalar or an array, with the type string, integer (long or short) or double. The returned array will have the start index as zero, as it is requested in the COMSOL API.

If the boolean `transpose` is true then the input array is transposed before the output is created.

Code for use in VBA

```
Sub Convert2DoubleMatrixExample()

' Fill in data
Range("A1").Value = x
Range("B1").Value = y
Range("C1").Value = Z
Range("A2:C10").Value = 0
Range("A3").Value = 0.025
Range("A4").Value = 0.05
Range("B5").Value = -0.0125
```

```
Range("B8").Value = -0.025
Range("A5:A7").Value = Range("A2:A4").Value
Range("A8:A10").Value = Range("A2:A4").Value
Range("B6:B7").Value = Range("B5").Value
Range("B9:B10").Value = Range("B8").Value
' Reformat the data collected in the worksheet in a usable way for
' the COMSOL model
Dim coords() As Double
ReDim coords(0 To 2, 0 To 8)
Set ComsolUtil = CreateObject("comsolcom.comsolutil")
coords = ComsolUtil.ConvertToDoubleMatrix(Range("A2:C10").Value,
True)
Range("E2:M4").Value = coords

End Sub
```

CONVERTTODOUBLEMATRIXDECIMAL

`ConvertToDoubleMatrixDecimal(obj, transpose As Boolean, dec As String) As Double()` converts the incoming object to an array of doubles in COMSOL API format.

The input object `obj` is either a scalar or an array, with the type string, integer (long or short) or double. The returned array will have the start index as zero, as it is requested in the COMSOL API.

If the boolean `transpose` is set to true then the input array is transposed before the output is created.

`dec` is a string that defines the decimal sign definition (usually "," or "."). Decimal sign definition is important to specify when converting strings to values.

CONVERTTODOUBLEVECTOR

`ConvertToDoubleVector(obj) As Double()` converts the incoming object to a vector of doubles.

The input object `obj` may be a scalar or a vector. The input may be of the type string, integer (long or short) or double. The returned vector will have the start index as zero, which makes it possible to send such vectors to COMSOL when vectors have to be supplied as an argument to a method in the COMSOL API.

GET_ERRORMESSAGE

`get_errormessage() As String` returns error message.

This returns any error message that was created by StartComsolServer() or other methods in ComsolUtil.

GET_PORT

`get_port() As Integer` returns the port number of the COMSOL Multiphysics server.

To return the port number the Multiphysics server has to be started StartComsolServer() in the same module.

GET_VERSION

`get_Version() As String` returns the version of the ComsolCom interface.

The version of the ComsolCom interface does not include the build number as it is for the COMSOL version. The current ComsolCom version number is `"6.0.0.0"`.

GETRIBBONUTIL

`GetRibbonUtil() As IRibbonUtil` returns the IRibbonUtil object to enable COMSOL ribbon utilities.

ISGRAPHICSSERVER

`isGraphicsServer() As Boolean` returns if the COMSOL Multiphysics server is started as a graphics server.

The method isGraphicsServer requires an established connection to a COMSOL server.

STARTCOMSOLSERVER

`StartComsolServer(usegraphics As Boolean) As Boolean` starts a COMSOL Multiphysics Server. The boolean `usegraphics` is true to start the graphics server.

The method StartComsolServer returns a boolean that indicates if the COMSOL server has started successfully or not, the value of the boolean being true or false respectively.

TIMEOUTHANDLER

`TimeOuthandler(on As Boolean)` applies a timeout handler to Excel.

Set `on` to `True` to apply a timeout handler to Excel in order to prevent any timeout when performing long running tasks (such as starting a server or solving large models).

The COMSOL Ribbon Utility Methods

COMSOL ribbon functionalities are also accessible using VBA commands. These commands help to manipulate the model, compute the solution and perform

postprocessing operations like showing results or extracting data to the worksheet. The VBA ribbon commands are accessible from the RibbonUtil object.

To make all COMSOL ribbon utility methods available using VBA, enter:

```
Set RibbonUtil = ComsolUtil.GetRibbonUtil()
```

This returns the RibbonUtil object that implements the VBA toolbar functionality methods.

GETRIBBONPREFERENCES

`GetRibbonPreferences() As IRibbonPreferences` returns the `IRibbonPreferences` object for handling ribbon preference operations.

AUTOMATICPARAMETERUPDATE

`AutomaticParameterUpdate(on As Boolean)` sets the automatic parameter update functionality. `on` is a boolean that specify if the automatic update is turn on (`true`) or not (`false`).

`AutomaticParameterUpdate` is accessible from the RibbonPreferences object.

BREAKALLLINKS

`BreakAllLinks()` break all links to model.

Removes all COMSOL related comments from the currently active worksheet.

BREAKLINK

`BreakLink()` breaks link to model.

Removes COMSOL related comments from the selected cells.

CLEARANDEVALUATEALLRESULTS

`ClearAndEvaluateAllResults()` clears all currently linked results table entries and then evaluate all linked derived values.

CONNECT

`Connect([hostname As String], [port As Integer], [username As String], [password As String])` connects the ribbon and the client for the API to a server. All arguments are optional where:

- `hostname` is the host name where the COMSOL *server* is running

- `port` is the port number the COMSOL *server* is listening to.
- `username` and `password` are the credentials requires when connected to a COMSOL *server* running on a different machine.

The `Connect` method also connect the ModelUtil object to access the API clients from a server.

CREATEEVALUATIONSELECTION

`CreateEvaluationSelection() As IEvaluationSelection` returns a `IEvaluationSelection` object to use in a point evaluation.

To set the parameter selection you can use one of the following approaches:

- `evalSelection.SetLoopLevelIndices(level As long, int[] levels)` sets the parameter selection using the loop level one based index `level` and the current level one based index `levels`.
- `evalSelection.SetLoopLevelEvaluation(int[N-1][M-1] levelArray)` sets the parameter selection using the integer array `levelArray`, where N is the number of loop levels in the solution and M the maximum number of current loop level indices to set.
- `evalSelection.SetLoopLevelEvaluation(Array(int[] level1, int[] level2,...))` sets the parameter selection using a dynamic array, where int1, int2,... are integer array that set the one based index for parameter 1, 2,..., respectively.

For transient studies you may want to evaluate point expression at interpolated time, use `SetInterpolation` to set the evalSelection object as in:

`evalSelection.SetInterpolation(t As Double)` where `t` is the time for evaluation.

See the section `ResultsPointEvaluation` from more information about point evaluation.

CREATESWEEPDATA

`CreateSweepData() As ISweepData` returns a ISweepData object that can be used in parametric sweep settings.

`void ISweepData.AddParameterSweep(sweepType As String, pName As String, pValues)` adds a parameter sweep. Provide an array of double values for the parameterValues argument.

DISCONNECT

`Disconnect()` disconnects the ribbon and API clients from a COMSOL *server*.

The COMSOL Multiphysics server also shuts down once the connection is broken.

EXPORT1DPLOT

`Export1DPlot(pgTag As String)` exports the 1D plot group `pgTag` data, and creates a line chart. The data are exported at the currently selected cell and the line chart is placed on the next cell available on the right side.

`void Export1DPlot(pgTag As String, featTag)` exports the data of the feature `featTag` of the 1D plot group `pgTag`, and create a line chart. `featTag` is either a string array or an object array.

`void Export1DPlot(pgTag As String, featTag, False)` exports the 1D plot data without creating the line chart.

`void Export1DPlot(pgTag As String, featTag,, plotPosition As String)` exports the 1D plot data and create a line chart at the position specified by `plotPosition`, which can either be `"right"`(default), `"left"`, `"bottom"`, or `"top"`.

`void Export1DPlot(pgTag As String, featTag,, "custom", cellRange As String)` exports the 1D plot data and create a line chart at the cell `cellRange`.

Code for use in VBA

```
Sub Export1DPlotExample()

Set ModelUtil = CreateObject("comsolcom.modelutil")
Set ComsolUtil = CreateObject("comsolcom.comsolutil")
Set RibbonUtil = ComsolUtil.GetRibbonUtil

Range("A1").Select
Set Model = RibbonUtil.OpenModel("busbar_llexcel.mph")

' Example 1: Export the 1D Plot data pg5 and create the chart
Range("A4").Value = "Export the 1D Plot data pg5 and create the
chart"
Range("A5").Select
RibbonUtil.Export1DPlot "pg6"

' Example 2: Do not include the chart
Range("A20").Value = "Do not include the chart"
Range("A21").Select
RibbonUtil.Export1DPlot "pg6", , False

' Example 3: Include the chart below the data
```

```
Range("A28").Value = "Include the chart below the data"
Range("E29").Select
RibbonUtil.Export1DPlot "pg6", , , "bottom"

' Example 4: Set manually the location of the chart
Range("A50").Value = "Set manually the location of the chart"
Range("A51").Select
RibbonUtil.Export1DPlot "pg6", , , "custom", "A57"

End Sub
```

FUNCTIONS

`Functions(fTag As String)` imports the model function defined with the tag `fTag` at the currently active cell.

INSERTGRAPHICS

`InsertGraphics(pgTag As String)` inserts the graphics from the plot group `pgTag` at the currently active cell.

INSERTGEOMETRYGRAPHICS

`InsertGeometryGraphics(geomTag As String)` inserts the graphics of the geometry defined with the tag `geomTag` at the currently active cell.

INSERTMESHGRAPHICS

`InsertMeshGraphics(meshTag As String)` inserts the graphics of the mesh defined with the tag `meshTag` at the currently active cell.

ISCONNECTED

`IsConnected() As Boolean` returns the connection status between the COMSOL ribbon and the server: True when connected, else False.

OPENDOCUMENTATION

`OpenDocumentation()` opens COMSOL Multiphysics documentation.

OPENHELP

`OpenHelp()` opens LiveLink™ *for* Excel® help.

OPENLINKEDMODEL

`OpenLinkedModel() As ModelImpl` opens a mph model file from the model link in the active workbook and returns the Model object. The model link is updated when the model is opened.

`OpenLinkedModel(pwd As String) As ModelImpl` opens the password protected mph model file from the model link in the active workbook and returns the Model object. The model link is updated when the model is opened.

A model link is created and inserted in the active cell when the model is opened. If no connection is established for the ribbon a local COMSOL Multiphysics server is started and connected automatically.

If the model MPH-file is not found at the location specified in the cell comment, `OpenLinkedModel` searches in the same folder where the workbook is saved.

Example

```
Sub OpenLinkedModelExample()

Set ModelUtil = CreateObject("comsolcom.modelutil")
Set ComsolUtil = CreateObject("comsolcom.comsolutil")
Set RibbonUtil = ComsolUtil.GetRibbonUtil

Set Model = RibbonUtil.OpenLinkedModel()

End Sub
```

OPENMODEL

`OpenModel(filename As String) As ModelImpl` opens the model MPH-file `filename` and returns the Model object.

`OpenModel(filename As String, pwd As String) As ModelImpl` opens the password protected model MPH-file `filename` and returns the Model object.

A model link is created and inserted in the active cell when the model is opened. If no connection is established for the ribbon a local COMSOL Multiphysics server is started and connected automatically.

In case of the filename does not include the full path, the method `OpenModel` search for the model MPH-file in the following directories:

- the same folder as the workbook.
- the COMSOL application libraries root directory and its subfolders.

Code for use in VBA

```
Sub OpenModelExample()

Set ModelUtil = CreateObject("comsolcom.modelutil")
Set ComsolUtil = CreateObject("comsolcom.comsolutil")
Set RibbonUtil = ComsolUtil.GetRibbonUtil
Range("A1").Select
```

```
Set Model = RibbonUtil.OpenModel("busbar_llexcel")

End Sub
```

PARAMETERS

`Parameters()` imports all parameters from the model to a linked field with upper-left corner at the currently active cell.

`Parameters(pGroupTag As String)` imports parameters in the model in the parameter node group to linked field with upper-left corner at the currently active cell.

`Parameters(pGroupTag As String, paramCaseTag As String)` imports parameters in the model in the parameter node group and case to linked field with upper-left corner at the currently active cell.

Code for use in VBA

The following example opens the model busbar_llexcel from the Application library. Then, if the current cell is empty, returns all model parameters. If not, returns the first group parameters. You can copy the code below and paste it into the VBA editor.

```
Sub ParametersExample()

Set ModelUtil = CreateObject("comsolcom.modelutil")
Set ComsolUtil = CreateObject("comsolcom.comsolutil")
Set RibbonUtil = ComsolUtil.GetRibbonUtil

Set Model = RibbonUtil.OpenModel("busbar_llexcel")

' Example 1: Import all parameters
Range("A4").Value = "Import all parameters"
Range("A5").Select
RibbonUtil.Parameters

' Example 2: Import the group parameters par2 only
Range("A13").Value = "Import all parameters"
Range("A14").Select
RibbonUtil.Parameters "par2"

End Sub
```

READMODELLINK

`ReadModelLink() As String` returns the model file path found in the model link in the currently active worksheet.

If model link does not exist an empty string is returned.

Code for use in VBA

```
Sub ReadModelLinkExample()

Set ModelUtil = CreateObject("comsolcom.modelutil")
Set ComsolUtil = CreateObject("comsolcom.comsolutil")
Set RibbonUtil = ComsolUtil.GetRibbonUtil
Range("A1").Select
Set Model = RibbonUtil.OpenModel("busbar_llexcel")
Range("A5").Value =  RibbonUtil.ReadModelLink

End Sub
```

RESULTSDERIVEDVALUE

`ResultsDerivedValue(dtag As String)` evaluates the derived values defined with the tag `dtag` and returns the data at the currently selected cell.

RESULTSINTERPOLATION

`ResultsInterpolation(dset As String, expr As String, coord As String)` evaluates an expression at an arbitrary location. Insert the linked field at the current cell.

The arguments consist in:

- `dset`, the solution dataset tag.
- `expr`, the expression to evaluate.
- `coord`, the cell range where the interpolation coordinates are defined.

`ResultsInterpolation(dset As String, expr As String, coord As String, header As Boolean)` evaluates an expression at an arbitrary location and specify whether to include the header or not. When the boolean `header` is set to `False` the header is not included. Default value for header is `True`.

`void ResultsInterpolation(dset As String, expr As String, coord As String, header As Boolean, coord As String, pName As String, pValue As String)` evaluates expression at arbitrary location. `pName`, a string to define the solution parameters name and `pValue`, its values to use for the evaluation.

Code for use in VBA

```
Sub ExampleInterpolation()

Set ModelUtil = CreateObject("comsolcom.modelutil")
Set ComsolUtil = CreateObject("comsolcom.comsolutil")
Set RibbonUtil = ComsolUtil.GetRibbonUtil
```

```
Range("A1").Select
Set Model = RibbonUtil.OpenModel("busbar_llexcel")

Range("A4:C12").Value = 0
Range("A5").Value = 2.5e-2
Range("A6").Value = 5e-2
Range("A7:A9").Value = Range("A4:A6").Value
Range("A10:A12").Value = Range("A4:A6").Value
Range("B7:B9").Value = -1.25e-2
Range("B10:B12").Value = -1.25e-2

' Example 1: Data interpolation (T) at coordinates given in A4:C12
Range("A14").Value = "Data interpolation (T) at coordinates given
in A4:C12"
Range("A15").Select
RibbonUtil.ResultsInterpolation "dset1", "T", "A4:C12"

' Example 2: Data interpolation (T) at coordinates given in A4:C12,
' including header
Range("A25").Value = "Data interpolation (T) at coordinates given
in A4:C12, including header"
Range("A26").Select
RibbonUtil.ResultsInterpolation "dset1", "T", "A4:C12", True

' Example 3: Data interpolation (T) at coordinates given in A4:C12
' using the solution dataset dset2 and parameter wbb = 0.1
Range("A37").Value = "Data interpolation (T) at coordinates given
in A4:C12 using the solution dataset dset2 and parameter wbb = 0.1"
Range("A38").Select
RibbonUtil.ResultsInterpolation "dset2", "T", "A4:C12", True,
"wbb", "0.1"

End Sub
```

RESULTSPARAMETERS

`ResultsParameters()` import all results parameters from the model to a linked field with the upper-left corner at the currently active cell.

RESULTSPARTICLEEVALUATION

`ResultsParticleEvaluation(dset As String, pos As Boolean, vel As Boolean, expr As String, num As Long, [t As String])` evaluates an expression along particle trajectories. Insert the linked field at the current cell.

The following arguments are supported:

- `dset`, use to define the particle dataset tag.

- `pos`, use to specify whether to include the particle position coordinates (`true`) or not (`false`).
- `vel`, use to specify whether to include the particle velocity (`true`) or not (`false`).
- `expr`, use to define the expression to evaluate.
- `num`, use to define the number of particles to use for the evaluation.
- `t`, use to set the time step for evaluation.

The particle evaluation requires a license for the Particle Tracing Module.

Code for use in VBA

```
Sub ParticleEvalExample()

Set ModelUtil = CreateObject("comsolcom.modelutil")
Set ComsolUtil = CreateObject("comsolcom.comsolutil")
Set RibbonUtil = ComsolUtil.GetRibbonUtil

Range("A1").Select
Set Model = RibbonUtil.OpenModel("trapped_protons")

' Example 1: Particle position at t = 3s
Range("A3").Value = "Particle position at t = 3s"
Range("A4").Select
RibbonUtil.ResultsParticleEvaluation "part1", True, False, "", 1,
Array(3)

' Example 2: Particle position and velocity t = 3s
Range("A6").Value = "Particle position and velocity t = 3s"
Range("A7").Select
RibbonUtil.ResultsParticleEvaluation "part1", True, Ture, "", 1,
Array(3)

' Example 3: Particle position, velocity, and the expression
' cpt.mf1.normB at t = 3s
Range("A9").Value = "Particle position, velocity, and the
expression cpt.mf1.normB at t = 3s"
Range("A10").Select
RibbonUtil.ResultsParticleEvaluation "part1", True, True,
"cpt.mf1.normB", 1, Array(3)

' Example 4: Particle position at t = 0s and t = 3s
Range("A12").Value = "Particle position at t = 0s and t = 3s"
Range("A13").Select
RibbonUtil.ResultsParticleEvaluation "part1", True, False, "", 1,
Array(0, 3)
```

```
' Example 5
Range("A16").Value = "Particles position (two particles) at t = 3s"
Range("A17").Select
RibbonUtil.ResultsParticleEvaluation "part1", True, False, "", 2,
Array(3)

End Sub
```

RESULTSPOINTEVALUATION

`void ResultsPointEvaluation(dset As String, expr As String, ptInd, [evalSel As IEvaluationSelection])` evaluates an expression at a geometry point. Insert the linked field at the current cell.

The following arguments are available:

- `dset`, use to define the solution dataset tag.
- `expr`, use to define the expression to evaluate.
- `ptInd`, use to define the list of the point selection for the evaluation.
- `evalSel`, use to define the parameter selection.

The argument `evalSel` is optional, when it is not set the evaluation is performed for all parameters.

See the section `CreateEvaluationSelection` for more information about how to set the parameter/time for evaluation.

Code for use in VBA

The first example shows how to perform point evaluation. Copy the code and paste it in the VBA editor.

```
Sub PointEvalExample()

Set ModelUtil = CreateObject("comsolcom.modelutil")
Set ComsolUtil = CreateObject("comsolcom.comsolutil")
Set RibbonUtil = ComsolUtil.GetRibbonUtil

Range("A1").Select
Set Model = RibbonUtil.OpenModel("busbar_llexcel")

' Example 1: Evaluate the temperature T at point 1 for parameter
' values in the dataset dset1
Range("A4").Value = "Evaluate the temperature T at point 1 for
parameter values in the dataset dset1"
```

```
Range("A5").Select
RibbonUtil.ResultsPointEvaluation "dset1", "T", Array(1)

' Example 2: valuate the temperature T at points 1 and 5 for all
' solution steps in the dataset dset1
Range("A12").Value = "Evaluate the temperature T at points 1 and 5
for all solution steps in the dataset dset1"
Range("A13").Select
RibbonUtil.ResultsPointEvaluation "dset1", "T", Array(1, 5)

' Example 3: Evaluate the temperature T at point 1 for only the
' first parameter value in data set dset1
Range("A20").Value = "Evaluate the temperature T at point 1 for only
the first parameter value in data set dset1"
Range("A21").Select
Set evaluationSelection = RibbonUtil.CreateEvaluationSelection()
evaluationSelection.SetLoopLevelIndices 1, Array(1)
RibbonUtil.ResultsPointEvaluation "dset1", "T", Array(1),
evaluationSelection

' Example 4:Evaluate the temperature T at point 1 for the second
' and third values of parameter 1 (Vtot) and the first one of
' parameter 2 (wbb) in the dataset dset2
Range("A24").Value = "Evaluate the temperature T at point 1 for the
second and third values of parameter 1 (Vtot) and the first one of
parameter 2 (wbb) in the dataset dset2"
Range("A25").Select
Set evaluationSelection = RibbonUtil.CreateEvaluationSelection()
evaluationSelection.SetLoopLevelIndices 1, Array(2, 3)
evaluationSelection.SetLoopLevelIndices 2, Array(1)
RibbonUtil.ResultsPointEvaluation "dset2", "T", Array(1),
evaluationSelection

' Example 5: Evaluate the temperature T at point 1 for the second,
' third and fourth values of parameter 1 (Vtot) and the first one
' of parameter 2 (wbb) in the dataset dset2
Range("A29").Value = "Evaluate the temperature T at point 1 for the
second, third and fourth values of parameter 1 (Vtot) and the first
one of parameter 2 (wbb) in the dataset dset2"
Range("A30").Select
Set evaluationSelection = RibbonUtil.CreateEvaluationSelection()
Dim intA(1, 2) As Long
intA(0, 0) = 2
intA(0, 1) = 3
intA(0, 2) = 4
intA(1, 0) = 1
evaluationSelection.SetLoopLevelEvaluation intA
RibbonUtil.ResultsPointEvaluation "dset2", "T", Array(1),
evaluationSelection
```

```
' Example 6: Evaluate the temperature T at point 1 for the second
' and third values of parameter 1 (Vtot) and the first one of
' parameter 2 (wbb) in the dataset dset2
Range("A35").Value = "Evaluate the temperature T at point 1 for the
second and third values of parameter 1 (Vtot) and the first one of
parameter 2 (wbb) in the dataset dset2"
Range("A36").Select
Set evaluationSelection = RibbonUtil.CreateEvaluationSelection()
evaluationSelection.SetLoopLevelEvaluation Array(Array(2, 3),
Array(1))
RibbonUtil.ResultsPointEvaluation "dset2", "T", Array(1),
evaluationSelection

End Sub
```

The second example illustrates how to perform a point evaluation at interpolated time. Copy the code and paste it in the VBA editor.

```
Sub PointEvalInterpTimeExample()

Set ModelUtil = CreateObject("comsolcom.modelutil")
Set ComsolUtil = CreateObject("comsolcom.comsolutil")
Set RibbonUtil = ComsolUtil.GetRibbonUtil

Range("A1").Select
Set Model = RibbonUtil.OpenModel("pid_control")
Set std1 = Model.get_study("std1")
std1.Run

' Example 1: Evaluate the concentration c at point 17 and at
' 0.125s using the solution dataset dset2
Range("A4").Value = "Evaluate the concentration c at point 17 and
at 0.125s using the solution dataset dset2"
Range("A5").Select
Set evaluationSelection = RibbonUtil.CreateEvaluationSelection()
evaluationSelection.SetInterpolation Array(0.125)
RibbonUtil.ResultsPointEvaluation "dset2", "c", Array(17),
evaluationSelection

' Example 2: Evaluate the concentration c at point 17 and at
' 0.125s and 2.37s using the solution dataset dset2
Range("A9").Value = "Evaluate the concentration c at point 17 and
at 0.125s and 2.37s using the solution dataset dset2"
Range("A10").Select
Set evaluationSelection = RibbonUtil.CreateEvaluationSelection()
evaluationSelection.SetInterpolation Array("0.125 2.37")
RibbonUtil.ResultsPointEvaluation "dset2", "c", Array(17),
evaluationSelection

' Example 3: Evaluate the concentration c at point 17 and at
```

```
' 0.125s and the second value of parameter 2 (k_P_ctrl) using the
' solution dataset dset2
Range("A16").Value = "Evaluate the concentration c at point 17 and
at 0.125s and the second value of parameter 2 (k_P_ctrl) using the
solution dataset dset2"
Range("A17").Select
Set evaluationSelection = RibbonUtil.CreateEvaluationSelection()
evaluationSelection.SetInterpolation Array(0.125)
evaluationSelection.SetLoopLevelIndices 2, Array(2)
RibbonUtil.ResultsPointEvaluation "dset2", "c", Array(17),
evaluationSelection

End Sub
```

RESULTSRAYEVALUATION

`void ResultsRayEvaluation(dset As String, pos As Boolean, vel As Boolean, expr As String, num As Long, [t As String])` evaluates an expression along ray trajectories. Insert the linked field at the current cell.

The following arguments are available:

- `dset`, the ray dataset tag.
- `pos`, use to specify whether to include the ray position coordinates (`true`) or not (`false`).
- `vel`, use to specify whether to include the velocity (`true`) or not (`false`).
- `expr`, the list of expression to evaluate.
- `num`, the number of rays to use for the evaluation.
- `t`, the time step for evaluation if available.

The ray evaluation requires a license for the Ray Optics Module.

Code for use in VBA

```
Sub RayEvalExample()

Set ModelUtil = CreateObject("comsolcom.modelutil")
Set ComsolUtil = CreateObject("comsolcom.comsolutil")
Set RibbonUtil = ComsolUtil.GetRibbonUtil

Range("A1").Select
Set Model = RibbonUtil.OpenModel("luneburg_lens")

' Example 1: Ray position at t = 5.8374e-9s
```

```
Range("A3").Value = "Ray position at t = 5.8374e-9s"
Range("A4").Select
RibbonUtil.ResultsRayEvaluation "ray1", True, False, "", 1,
Array(5.8374e-9)

' Example 2: Ray position and velocity at t = 5.8374e-9s
Range("A6").Value = "Ray position and velocity at t = 5.8374e-9 s"
Range("A7").Select
RibbonUtil.ResultsRayEvaluation "ray1", True, True, "", 1,
Array(5.8374e-9)

' Example 3: Ray position, velocity, and evaluation of gop.rrel at t
= 5.8374e-9s
Range("A9").Value = "Ray position, velocity, and evaluation of
gop.rrel at t = 5.8374e-9s"
Range("A10").Select
RibbonUtil.ResultsRayEvaluation "ray1", True, True, "gop.rrel", 1,
Array(5.8374e-9)

' Example 4: Ray position at t = 3.836e-9s and t = 5.8374e-9s
Range("A12").Value = "Ray position at t = 3.836e-9s and
t = 5.8374e-9s"
Range("A13").Select
RibbonUtil.ResultsRayEvaluation "ray1", True, False, "", 1,
Array(3.836e-9, 5.8374e-9)

' Example 5: Rays position (two rays) at t = 5.8374e-9s
Range("A16").Value = "Rays position (two rays) at t = 5.8374e-9s"
Range("A17").Select
RibbonUtil.ResultsRayEvaluation "ray1", True, False, "", 2,
Array(5.8374e-9)

End Sub
```

RESULTSTABLE

`ResultsTable(tblTag As String)` exports the results table with the tag `tblTag` at the currently active cell.

SWEEP

`Sweep(stdTag As String, True)` exports the parametric sweeps from the study `stdTag` at the currently active cell. `study` is the study node tag from where to extract the parametric sweeps.

`Sweep(stdTag As String, True, False, sweepData As ISweepData)` exports parametric sweeps from the study `stdTag` using the sweep data information set in the object `ISweepData`.

`Sweep(stdTag As String, False, True)` updates parametric sweeps from the study `stdTag` using the sweep data information set in the currently active cell.

`Sweep(stdTag As String, False, True, sweepData As ISweepData)` updates parametric sweeps from the study `stdTag` using the sweep data information set in the object `ISweepData`.

See the section CreateSweepData for more information about how to set sweep data information.

Example

```
Sub SweepExample()

Set ModelUtil = CreateObject("comsolcom.modelutil")
Set ComsolUtil = CreateObject("comsolcom.comsolutil")
Set RibbonUtil = ComsolUtil.GetRibbonUtil

Range("A1").Select
Set Model = RibbonUtil.OpenModel("busbar_llexcel")

' Example 1: Export parametric sweep set in the model
Range("A4").Value = "Export parametric sweep set in the model"
Range("A5").Select
RibbonUtil.Sweep "std1", True

' Example 2: Export parametric sweeps using given parameter values
Range("A9").Value = "Export parametric sweep using given parameter
values"
Set sweepData = RibbonUtil.CreateSweepData
Dim param(0, 2) As Double
param(0, 0) = 0.1
param(0, 1) = 0.15
param(0, 2) = 0.2
sweepData.AddParameterSweep "param", "wbb", param
Range("A10").Select
RibbonUtil.Sweep "std1", True, , sweepData

' Example 3 :Update parametric sweeps using the parameter value
' linked in the current cell
Range("A14").Value = "Update parametric sweeps using the parameter
value linked in the current cell"
Range("E11").Value = 0.3
Range("A15").Select
RibbonUtil.Sweep "std1", , True

' Example 4: Update parametric sweeps using the parameter value
```

```
' linked in the cell A10 and modify parameter values for Vtot
Range("A19").Value = "Update parametric sweeps using the parameter
value linked in the current cell and given parameter values"
Range("E11").Value = 0.3
Set sweepData2 = RibbonUtil.CreateSweepData
Dim param2(0, 1) As Double
param2(0, 0) = 5
param2(0, 1) = 10
sweepData2.AddParameterSweep "stat", "Vtot", param2
Range("A10").Select
RibbonUtil.Sweep "std1", , True, sweepData2
Range("A20").Select
RibbonUtil.Sweep "std1", True

End Sub
```

UPDATEALLRESULTS

`UpdateAllResults()` updates all evaluated data in the current worksheet.

UPDATEDEFINITIONS

`UpdateDefinitions()` updates the model with linked definitions in the currently active cell.

UPDATEALLDEFINITIONS

`UpdateAllDefinitions()` updates the model with all linked definitions in the active worksheet.

VARIABLES

`Variables()` imports all variables from the model to linked field with upper-left corner at the currently active cell.

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