6. New features regarding co-simulation Flux-Simulink

Introduction

FLUX and Matlab Simulink are software tools that are renowned in their respective fields of application. They are now linked for direct co-simulation through a new library, called «Coupling with Flux ».

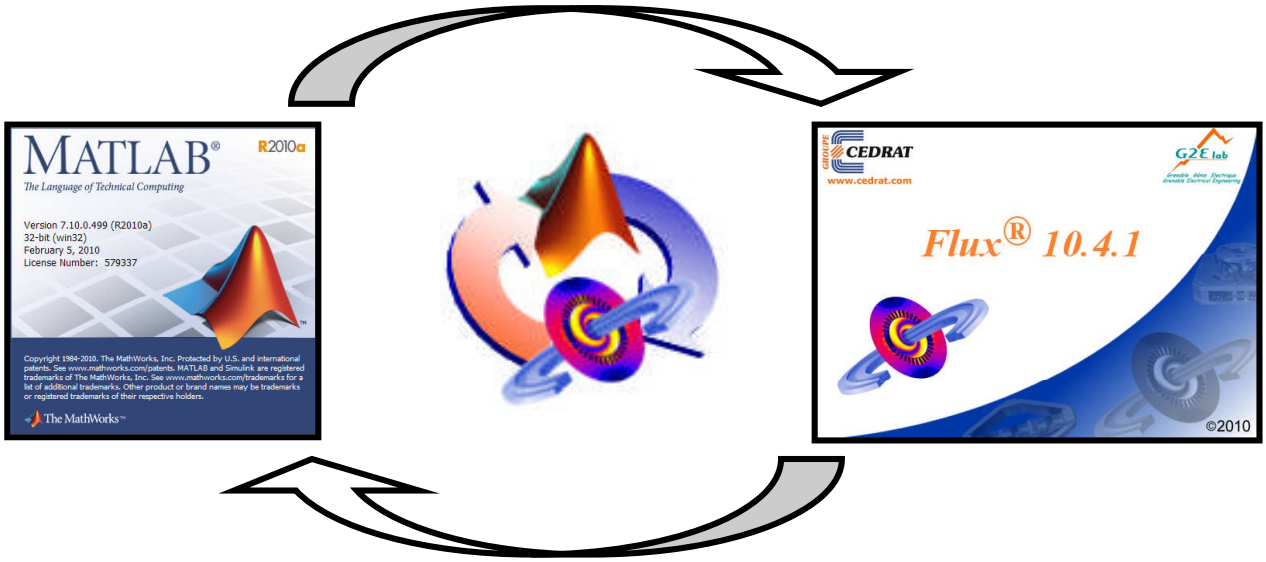
Contents

This chapter contains the following topics:

6.1. Co-simulation Flux-Simulink: About

Introduction

Prior to this Flux version, Cedrat offered a coupling between Flux and Matlab Simulink only for the historical version of Flux2D.
Starting with V 10.4, Flux offers a new coupling with Matlab Simulink, compatible with the new Flux2D version, with Flux 3D and with Flux Skewed. This coupling is available for all the transient applications.



Implementation

The procedure for coupling Flux and Matlab Simulink is as follows:

Stage	Software	Description
1	Flux	Preparation of the Flux project: • standard description: geometry, mesh and physics • specific description: creation of input and output parameters necessary to the coupling
2	Flux	Generation of component of the Flux – Matlab Simulink coupling
3	Supervisor Flux	Opening of Matlab–Simulink starting from Flux supervisor
4	Matlab	Opening of Simulink
5	Simulink	Preparation of Simulink (*mdl) model: • adding and definition of Flux – Simulink coupling library • adding, definition and connection of other necessary libraries around the coupling block
6	Simulink	Configuration of the simulation parameters
7	Simulink	Launching of the simulation
8	Flux / Simulink	Post processing of results

6.2. Co-simulation Flux-Simulink: Preparation of the Flux project

Introduction

Co-simulation requires that the standard description (geometry, mesh, physics) of the Flux project has been done. To prepare the coupling between Flux and Simulink, it is necessary to define, in Flux, the desired input and output parameters, in order to generate a coupling component file.

Flux Inputs

Several types of quantities can appear amongst the input parameters :
- electrical quantities (ex. resistance, voltage, current…)
- mechanical quantities (ex. torque, speed, position,…)
- geometric (air gap,…)

As the coupling between Flux and Matlab-Simulink uses multiphysics co-simulation, the input parameters must be defined as **I/O Parameters of multiphysics type**.

Flux Outputs

We can find the exact same quantity types as with the input parameters; namely the electrical, mechanical and geometric quantities.

The output parameters **must not** be of the multiphysics type.

An output parameter can be :
- a geometric parameter
- a I/O non multiphysics parameter
- a predefined parameter of a mechanical assembly
- a sensor

The coupling component

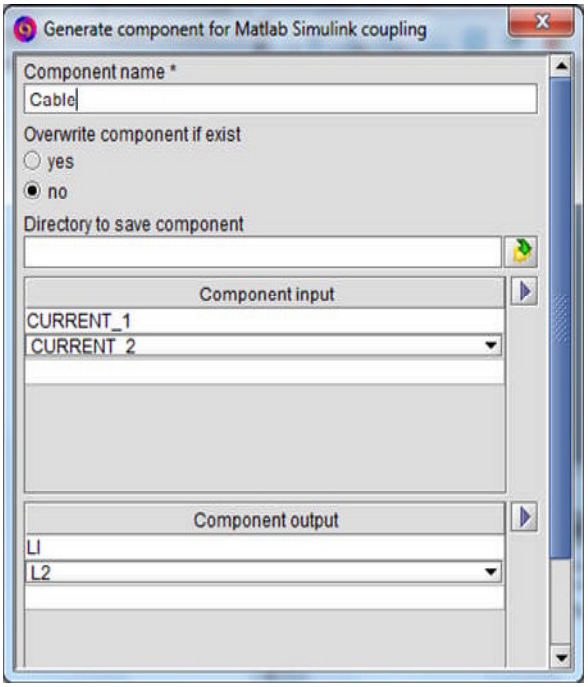
The coupling component file is necessary in order to ensure the transfer of information from the Flux project to Simulink. This component data is described in the *.F2MS file.

Once the necessary input and output parameters for the coupling have become available, the user must generate a component :
- by clicking on the **Generate component for Matlab Simulink coupling** in the **Solve** module

The dialogue box "**Generate component for Matlab Simulink coupling**" is presented below :

Continued on next page

The coupling component (continued)



Having generated the coupling component :

- A file **[ComponentName].F2MS** is created by default in the current directory.
- A Flux project **[ComponentName]F2MS.FLU** is created and it should have the same name as the .FLU accessed from Simulink during the solving process.

Upon launching of the solving process via Simulink, the corresponding project Flux is registered with the following name :
[ComponentName]F2MS_SOLVED.FLU

***.F2MS file**

This file contains the information necessary for Simulink to be able to automatically detect:

- the version of Flux
- the version of F2MS
- the dimension
- the inputs and the outputs

Solving Scenario

No solving scenario defined in Flux will be taken into consideration by Simulink. It is Simulink that manages the time steps of the simulation imposing them to Flux during the co–simulation.

6.3. Co-simulation Flux-Simulink: Preparation of the Simulink model

Introduction

Now that the preparation for the Flux project has been done, the preparation of the Simulink model can be carried out.
Upon the opening of Matlab Simulink via the Flux supervisor (compulsorily), the new library **« Coupling with Flux »** is added to the Simulink library.
The user must prepare **the Simulink model** by adding and characterizing the coupling library and equally the necessary libraries for the construction of the desired model.

Simulink library

The new library of Flux –Matlab Simulink coupling is added to the list of old libraries listed for the historical Flux2D.
The next figure shows the location of the new library added in the Simulink library.

Element	Function
Flux_Link Library	Library that contains the Flux – Matlab Simulink couplings. This library is automatically accessible with **Simulink Library Browser** only if the opening of the Matlab Simulink has been made through the **Simulink** link in the Flux supervisor.
New Coupling Blocks	Permits the coupling between Flux and Simulink. This section is compatible with the new Flux2D, Flux3D and FluxSkew on the 32 and 64 Bits system.
Legacy Coupling Blocks	Permits the coupling between Flux and Simulink. This library is compatible only with the historical Flux2D version on the 32 Bits system.

Continued on next page

« Coupling with Flux » block

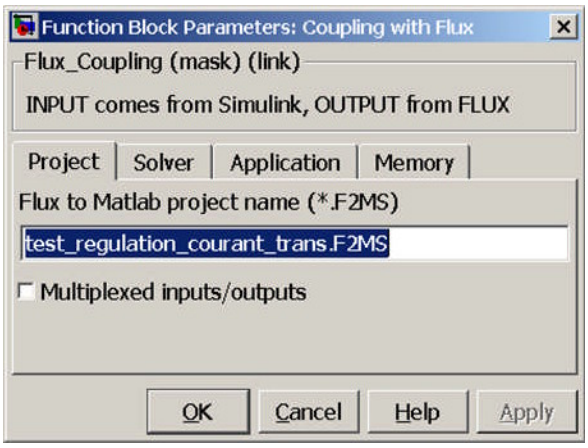
The new block «Coupling with Flux» available in Simulink has several properties which are classified in different tabs :

- Project
- Solver
- Application
- Memory

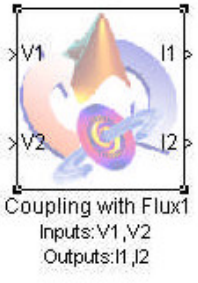
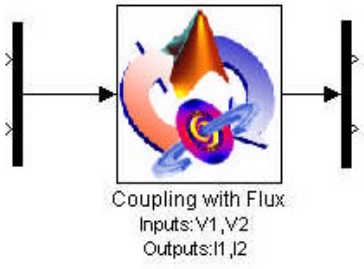
The content of each of these tabs is detailed in the following sections.

« Project » tab

Here is the content of the «Project» tab :



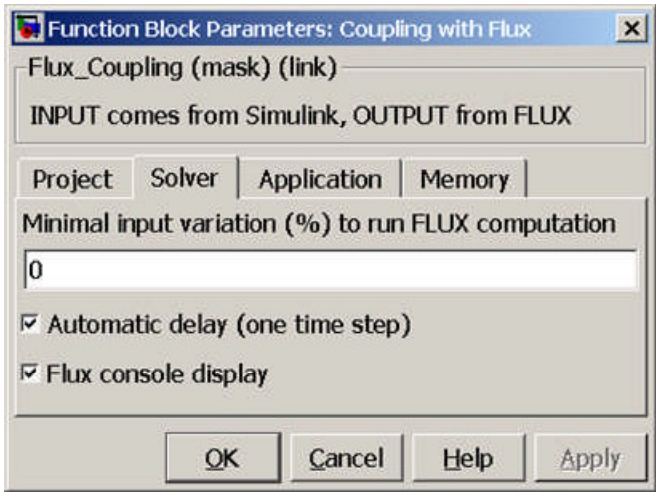
Element	Function
Flux to Matlab project name (*.F2MS)	Permits the user to fill in the **name of the project *.F2MS** (Flux to Matlab Simulink) that is the same as the Flux project name to ensure succesful coupling between the two software. Attention to correctly enter the **extension .F2MS**
Multiplexed inputs/outputs	Permits the user to choose the representation of the inputs/outputs: • an **individual representation** (singular input/output block) a connection for each input and output parameter . • a **« vector » representation** (multiple, itemized input/output block) a common connection for all the input and output parameters and one connection common to all the output parameters. The user will have to add: – a **Mux** input library, with the desired number of inputs. – a **Demux** output library, with the desired number of outputs.

Individual input/output blocks	Vector Input/Output blocks
	

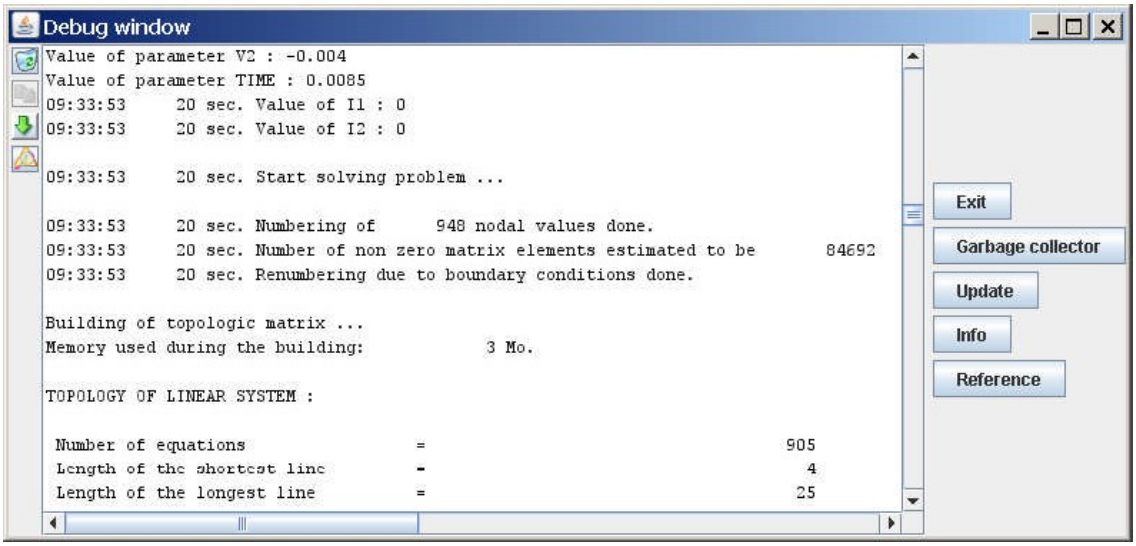
Continued on next page

« Solver » Tab

Here are the contents of the «Solver» tab:



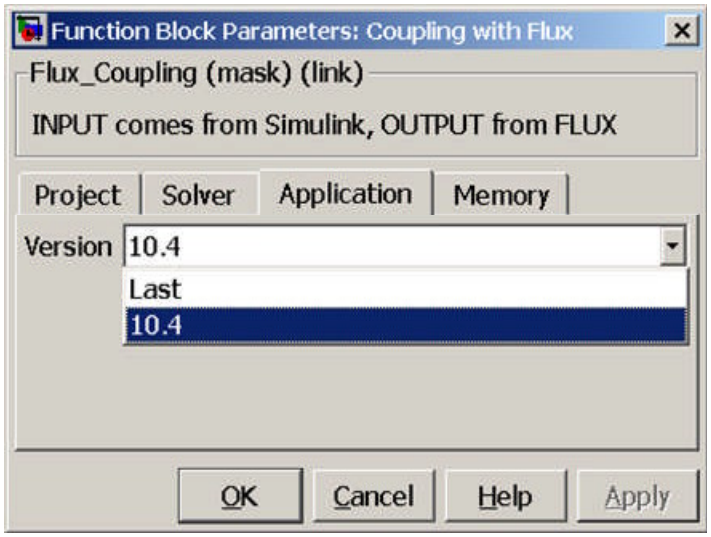
Element	Function
Minimal input variation (%) to run FLUX computation	Permits to define a percentage of variation of the input parameters between two calculation steps under which the Flux calculation will not be carried out. What matters is to be able to carry out several Simulink time steps, without systematically carrying out a Flux calculation.
Automatic delay (one time step)	Permits to Flux to calculate the output parameters with a delay of one step and to transmit them to Simulink for the calculation of the following step. This **automatic delay** mode is indispensable in case of retroaction between output and input to avoid the algebraic loops. However, if there is no retroaction, the automatic delay should not be activated, as this would imply a delay of one step upon the output parameters.
Flux console display	Permits to display a supplementary window in which the on going actions in Flux are entered. This is the equivalent of the **Historical zone** visible in Flux, zone placed below the geometric view.



Continued on next page

« Application » tab

Here are the contents of the « Application » tab:

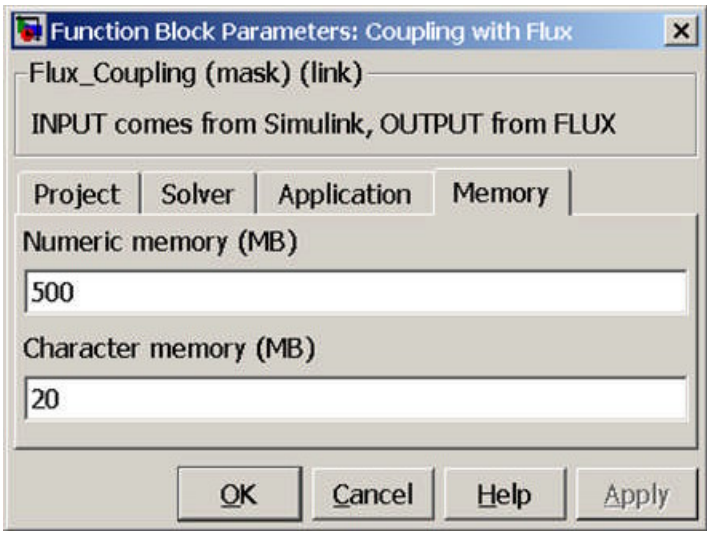


Element	Function
Version	Permits to choose the Flux version to be coupled with Simulink during the solving process. The user has a choice between : • **10.4** Flux version, which is the first version with which the new coupling Flux – Simulink is available. • **Last** version, which permits to choose the most recently installed version.

The information about the application (2D, 3D or Skew) are in the file *.F2MS and they are automatically taken into consideration.
The same for the static initialization. It is activated or not in the Flux project upon defining the application.

Continued on next page

« Memory » tab Here contents of the « Memory » tab:



Element	Function
Numeric memory	Permits to define the numeric memory allocated for Flux
Character memory	Permits to define the character memory allocated for Flux

Configuration of simulation parameters

The configuration of the simulation parameters is done only via Simulink , in the menu **Simulation → Configuration parameters**

6.4. Co-simulation Flux-Simulink: Example

Introduction

To permit to the user to implement the co-simulation between Flux and Matlab-Simulink, a detailed example, with the main stages to be implemented, is given in the following sections.

Example description

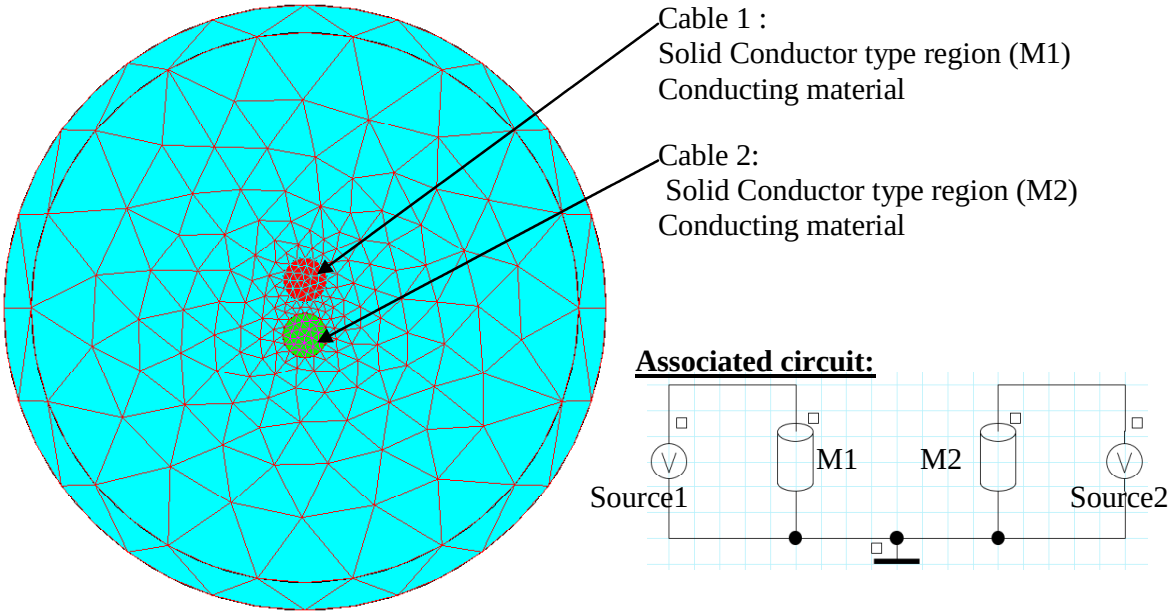
The example represents two cables, one supplied with sinusoidal voltage, the other with triangular voltage.

If the cables are placed close enough, there will be a electromagnetic influence of one upon the other, and the currents will not be perfectly sinusoidal or triangular, respectively.

Therefore, the purpose of the study is to regulate the current in the cable supplied with sinusoidal voltage to obtain a sinusoidal current.

Flux project

The geometry, mesh and physics are given below.



Continued on next page

Preparation of I/O parameters in Flux

The input and output parameters are described as follows :

	name	Description	Type	Value / formula
Input parameters	V1	Supply voltage of the cable 1 associated to the voltage source **Source1**	I/O parameter, multiphysics	Reference value = 0
	V2	Supply voltage of the cable 2 associated to the voltage source **Source2**	I/O parameter, multiphysics	Reference value = 0
Output parameters	I1	Current in the cable 1 (current in the solid conductor **M1**)	I/O parameter defined by a space formula	I(M1)
	I2	Current in the cable 2 (current in the solid conductor **M2**)	I/O parameter defined by a space formula	I(M2)

Generation of component in Flux

To generate the component of the Flux – Matlab Simulink coupling:

Step	Action
1	Open the dialogue box : • Click on **Generate component for Matlab Simulink coupling** in the **Solve** module
2	Define the **name of component (**for example **CABLES)**
3	Choose the input parameters : • Select **V1** • Select **V2**
4	Choose the output parameters: • Select **I1** • Select **I2**
5	Validate by clicking on **OK**
→	A **CABLES.F2MS** file has been created**.** The Flux project has been duplicated and registered under the name : **CABLESF2MS.FLU**

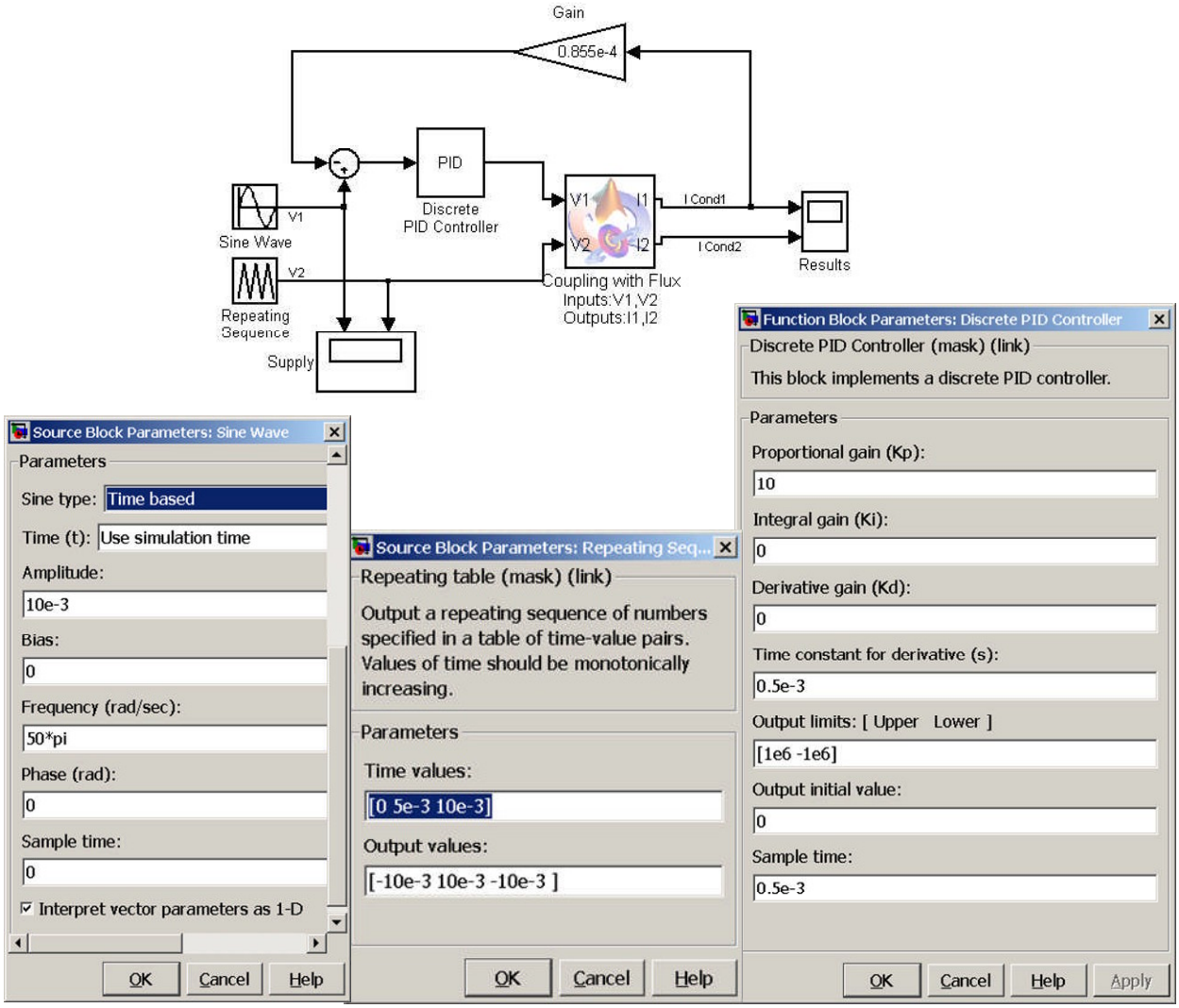
Continued on next page

Preparation of the Simulink model

To prepare the Simulink model :

Step	Action
1	Open Matlab : • Starting from the **Flux supervisor** in the **Solve** module, click on **Simulink**
2	Open Simulink by clicking on 
→	The Simulink library is open.
3	Make a new model : • Point on **New** and click on **Model** in the menu **File**
→	A blank window will appear
4	Register the model : • Click on **Save** in the menu **File** • Allocate a name (for example **model_cables**)
4	Place the section « Coupling with Flux » • Take the library **« Coupling with Flux »** in the library **Flux_Link** and place it in the window **model_cables**
5	Characterize the section « Coupling with Flux » : • double click on the section • in the tab **Project** : – allocate the name of the project **CABLES.F2MS** – tick or not **Multiplexed inputs/outputs** (in function of the desired representation) • in the tab **Solve** : – tick the case **Automatic delay** – tick the case **Flux console display** • validate the characterization of the library by clicking on **OK**
6	Place, characterize and connect the **other necessary libraries** according to the model in the figure below.
7	Save the model by clicking on **Save** in the menu **File**
→	The preparation of the Simulink model is complete.

Continued on next page



Simulation configuration

Configure the simulation parameters with a time interval from 0 to 0.6 s and the time step set at 0.001 s and launches the solving process.

During the solving process the actions carried out in Flux are visible in the **Flux console,** which has appeared in a new window, and the information on the solved steps are also displayed in the window "**Command Window**" of **Matlab**.

Continued on next page

Analysis of results

The results can be analyzed in Matlab – Simulink, as well as from Flux in the project **CABLESF2MS_SOLVED.FLU**

Graph results in Matlab-Simulink	Graph results in Flux