Simulink S-Function for RT-LAB

Document 1a

Creation of a S-Function From a Simulink Model and Protection of the Source Code

Version 1.2

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Contents

REVISION HISTORY

Version	Date	Responsible	Comment
1.0	2017-02-20	Daniel O'Brien	Initial version
1.1	2017-03-02	Daniel O'Brien	Minor improvements.
1.2	2017-09-06	Daniel O'Brien	• Add references toward the procedure for configuring a virtual machine. • Added "Constraints related to continuous states" section.

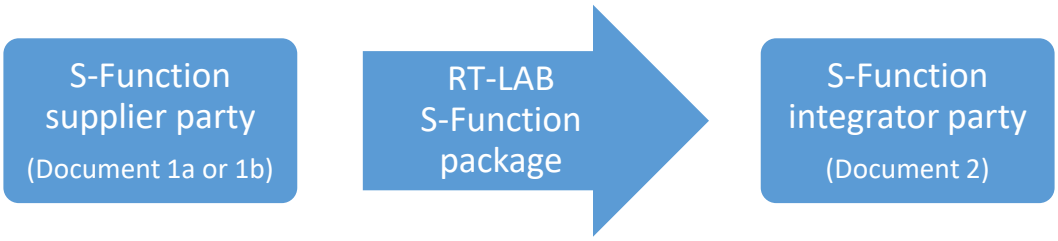
INTRODUCTION

This document presents a procedure to:

- Create a S-Function compatible with RT-LAB from:
  - a Simulink model
- Compile the source code of the S-Function in order to hide intellectual property

The result of this procedure is a package with everything needed for another party to integrate your S-Function in a model designed for real-time simulation in RT-LAB. For this purpose, there is a second document:

- Document 2 – Integration of an Existing S-Function in a Model for RT-LAB



REQUIRED MATERIAL

- Windows host PC
- Target:

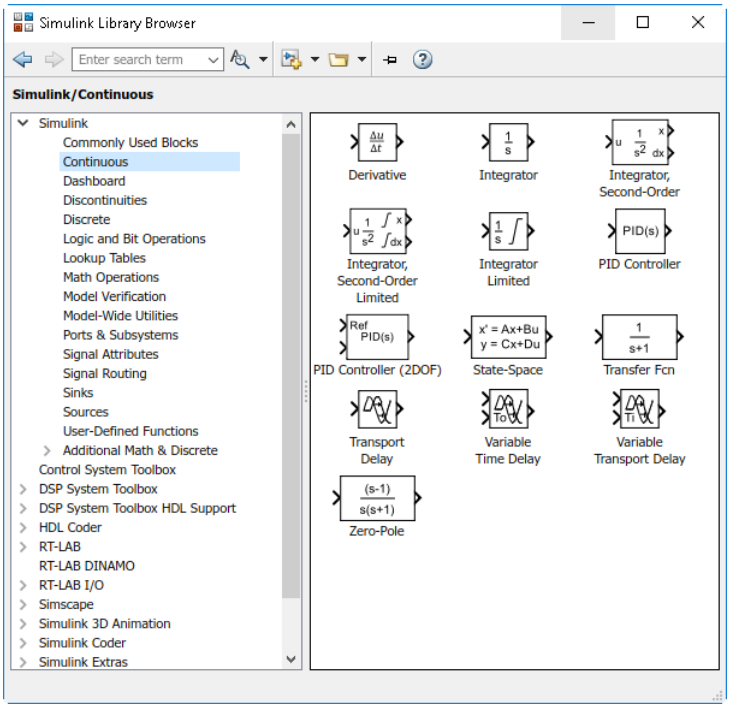
<table>
<tr><th></th><th>OPAL-RT Linux (x86-based)
(previously known as RedHat)</th><th>Windows
(localhost target in RT-LAB)</th></tr>
<tr><td rowspan="2">Requirements</td><td>OPAL-RT simulator
(OP5600, OP4510, …)
or
Vitual machine with
OPAL-RT Linux
(x86-based)***</td><td rowspan="2">Visual C++ 2010 compiler.
You may install
Microsoft Visual Studio 2010
or
Microsoft Visual C++ 2010
Express (free).</td></tr>
<tr><td>MobaXterm software
(for transferring files on
the target)</td></tr>
</table>

- MATLAB/Simulink
  - The Simulink Coder toolbox is required and any toolbox used in the Simulink model must be compatible with Simulink Coder.
  - The same version (ex: R2013b) and architecture (ex: 64-bit) of MATLAB/Simulink must be used by the supplier and the integrator of the S-Function.

*** Procedure for configuring a virtual machine:
https://www.opal-rt.com/KMP/index.php?/article/AA-01281/8/HowTo/How-to-create-a-Virtual-machine-with-OPAL-RT-Linux.html

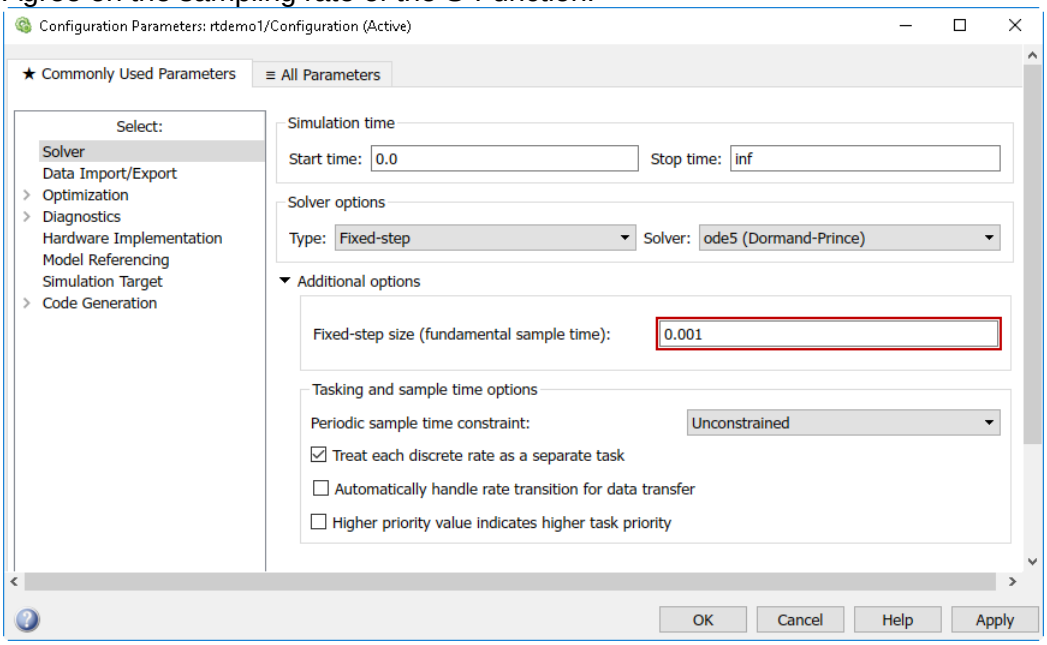
CONSTRAINTS RELATED TO CONTINUOUS STATES

When generating C code from a Simulink model that contains **continuous states**, the result will have traces of the *fixed-step size (fundamental sample time)* configured in the model. The most common continuous state blocks are located in the *Simulink/Continuous* and *Simulink/Discontinuities* libraries.

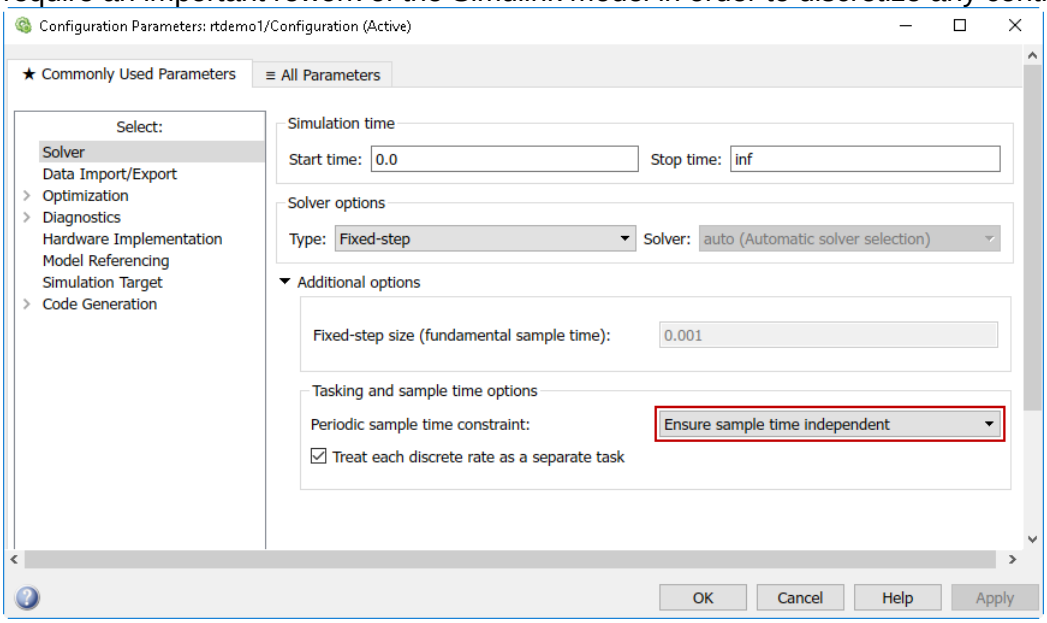


Therefore, in order for the integration of the S-Function to be successful, the supplier and the integrator must either:

A. Agree on the sampling rate of the S-Function.



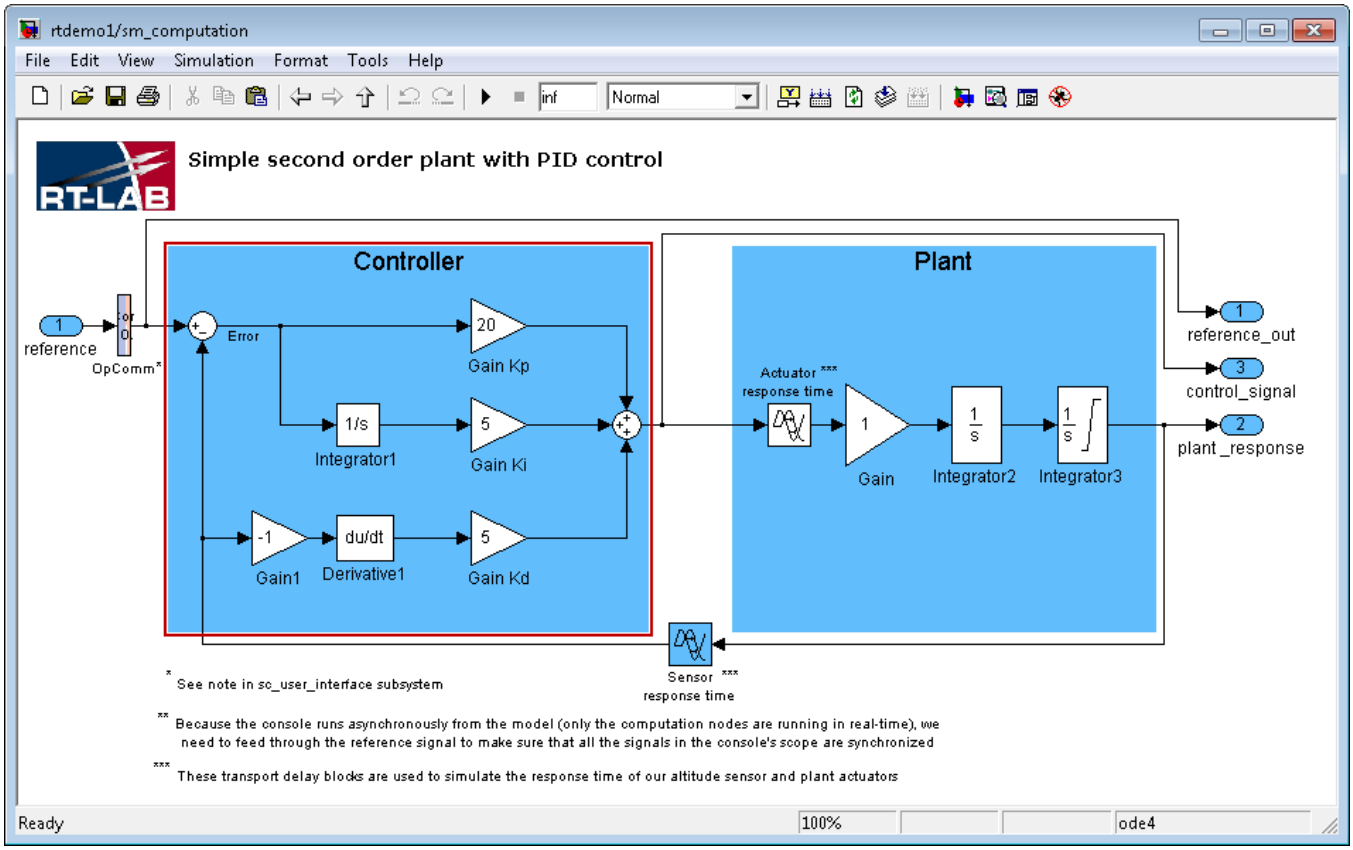
B. Configure the S-Function model to "*Ensure sample time independent*". This option will force the choice of the solver to *discrete* and blocks containing continuous states will be prohibited. This will most likely require an important rework of the Simulink model in order to discretize any continuous state logic.



A big advantage of this option is that the choice of a discrete solver will make the real-time simulation application more performant in terms of computation time.

SECTION 1: S-FUNCTION CREATION

As an example, a S-Function will be created using the *Controller* part of the Simulink model rtdemo1.mdl provided with RT-LAB.



1. In MATLAB, type the following command in order to set a default compiler. You may choose any compiler detected by MATLAB.

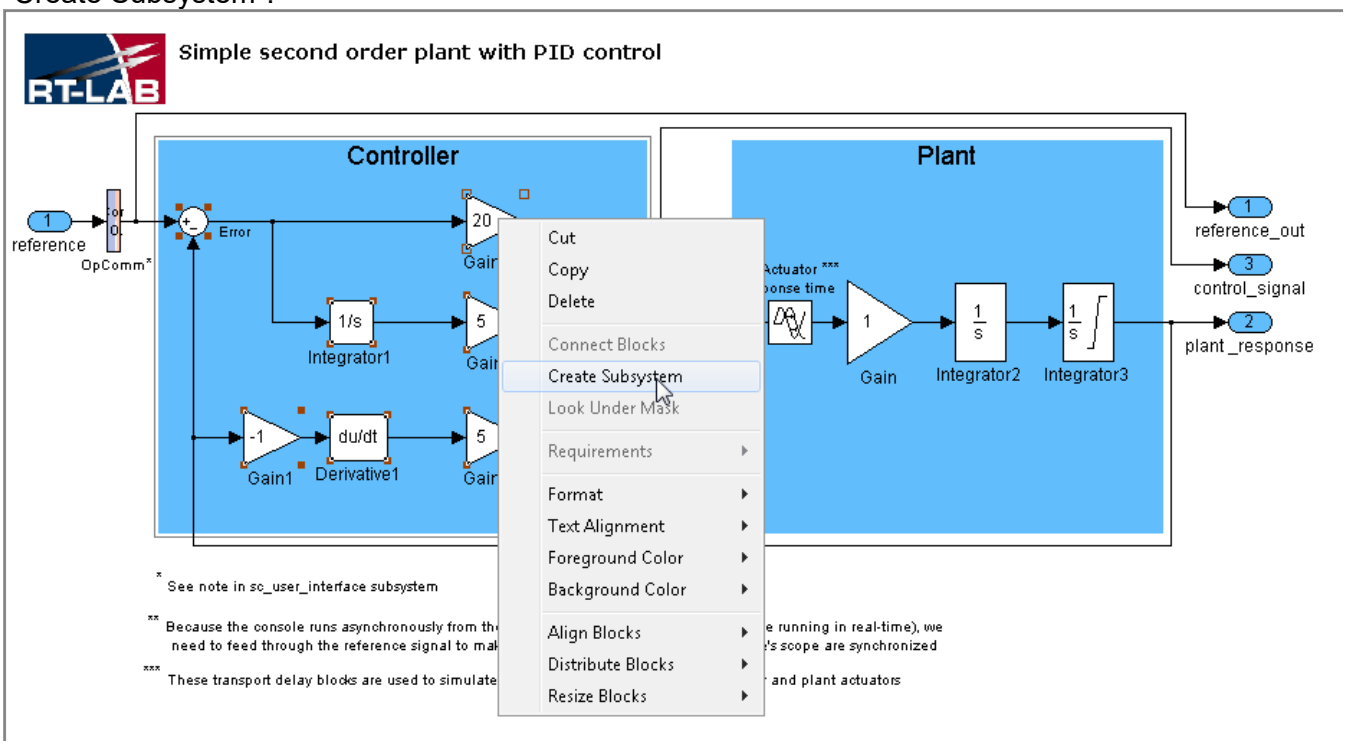
   ```
   mex -setup
   ```

   Note: The `mex` command varies from one version of MATLAB to another. Please refer to MathWorks' documentation in order to properly configure a compiler.

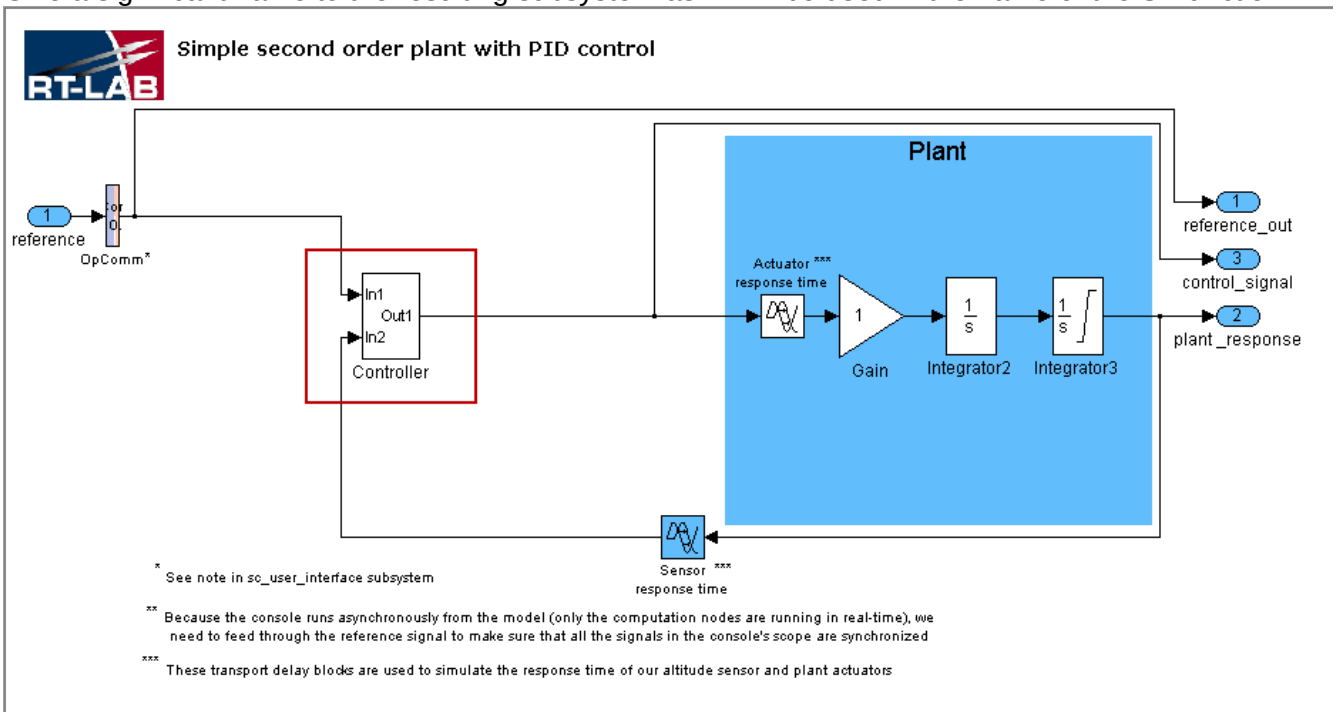
2. Change the current folder in MATLAB to the folder where the Simulink model is saved and open the model.

3. Copy the following files that are provided with the procedure next to the Simulink model or in a folder that is a MATLAB path.
   - create_rtlabsfcn.m
   - rtlabsfcn.tmf

4. Select blocks that you want to hide in an S-Function. Right-click on one of the blocks and select “Create Subsystem”.

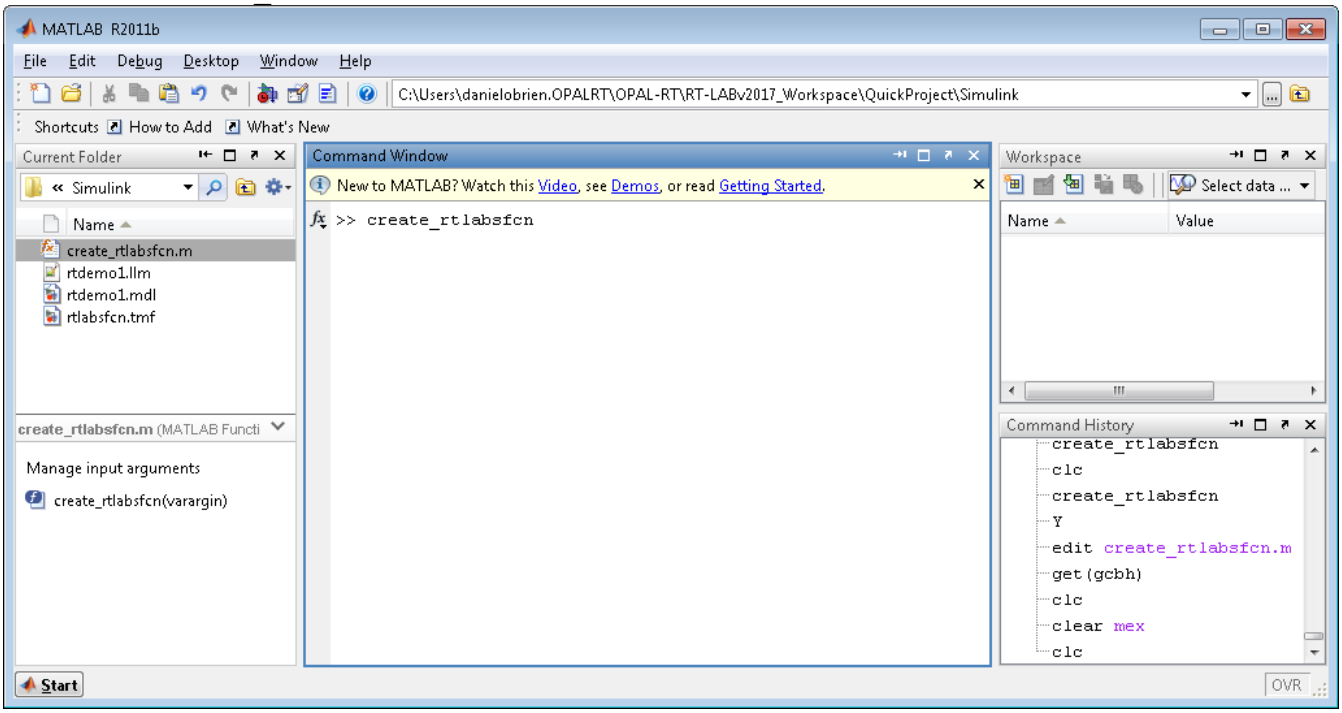


5. Give a significant name to the resulting subsystem as in will be used in the name of the S-Function.

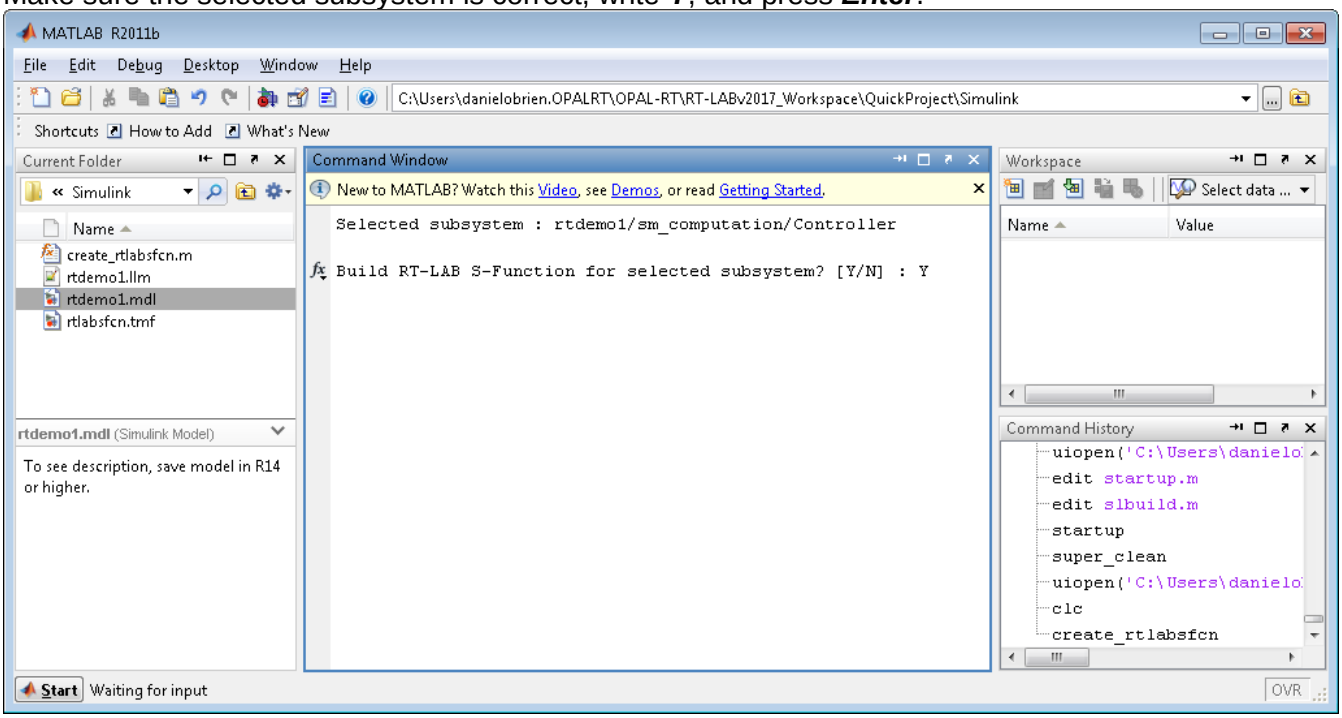


6. Make sure that the model runs in Simulink without any problem at this point. In other words, you must be able to press *Start simulation* in Simulink.

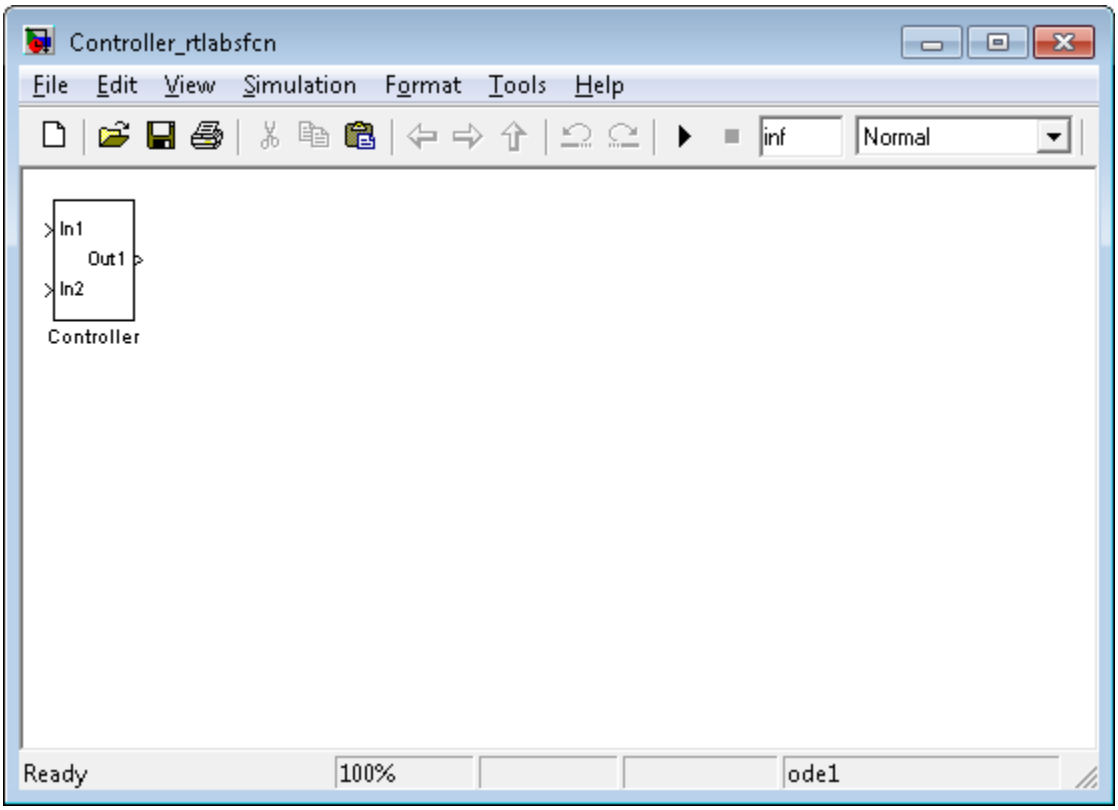
7. Click on the subsystem in order to have it selected. Then, in the MATLAB command window, enter the command: `create_rtlabsfcn`



8. Make sure the selected subsystem is correct, write ***Y***, and press ***Enter***.



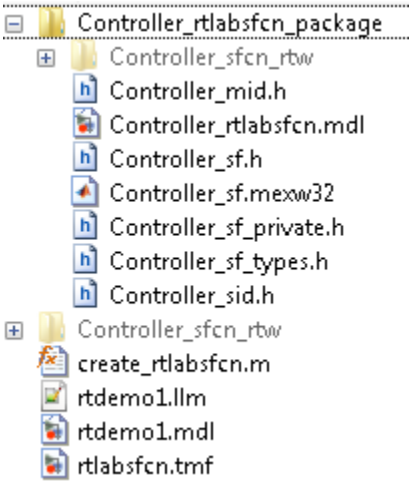
9. A new Simulink window will appear with your generated S-Function block in it.



10. Make sure you see the following message at the end of the execution of the script.

```
SUCCESSFUL GENERATION OF RT-LAB S-FUNCTION
```

11. Next to the model, you should see a *rtlabsfcn_package* folder.



SECTION 2: CODE COMPILATION (FOR HIDDING THE SOURCE CODE)

Now that the S-Function is generated, its source code must be compiled in order to hide any intellectual property. The procedure is different depending on the platform of the target you will use with RT-LAB.

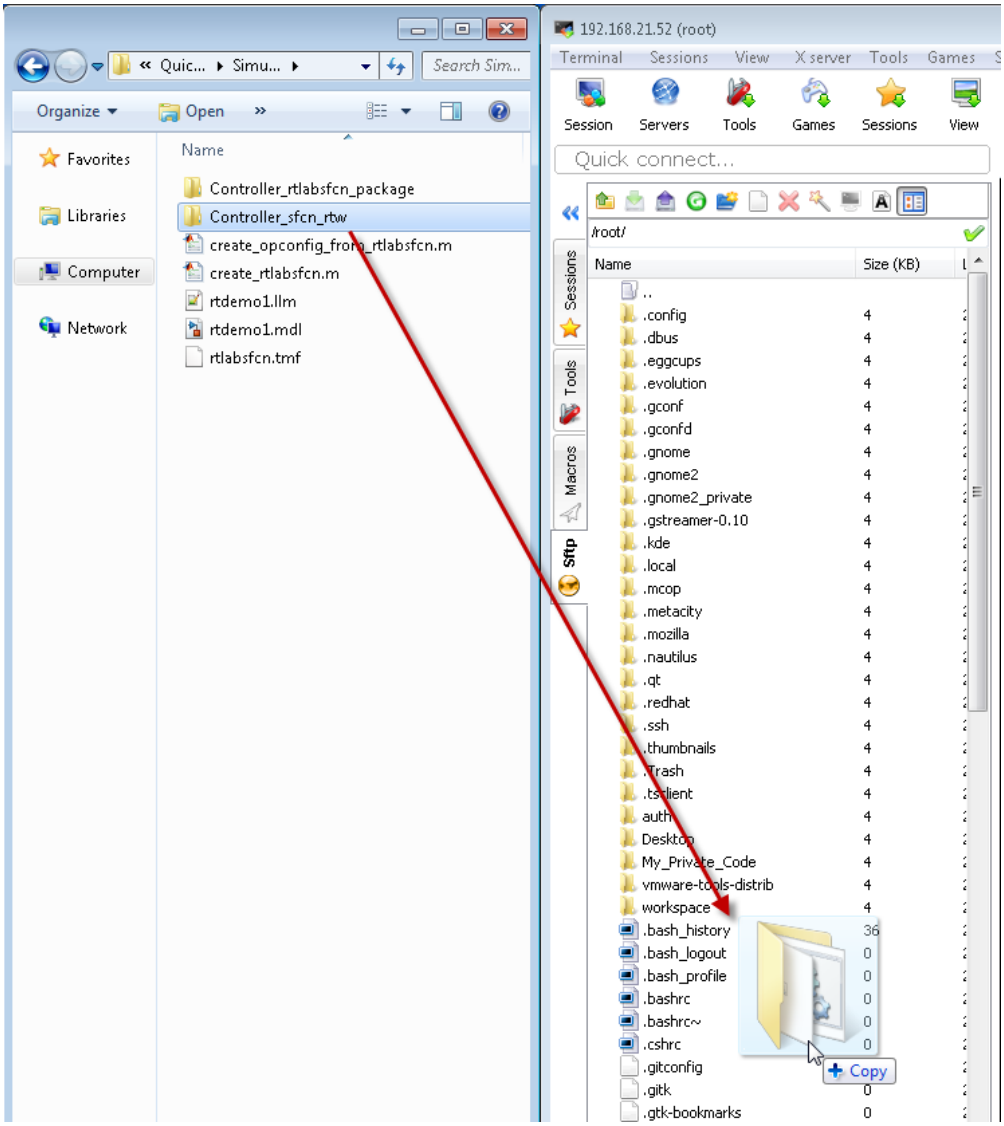
Note: Throughout this section, *Controller* is used as the name of the S-Function. You may replace it by the name of your S-Function.

OPAL-RT LINUX (X86-BASED) TARGET

For *OPAL-RT Linux* target platforms, you must either have access to an OPAL-RT simulator, or configure a virtual machine by following the procedure described here:
https://www.opal-rt.com/KMP/index.php?/article/AA-01281/8/HowTo/How-to-create-a-Virtual-machine-with-OPAL-RT-Linux.html

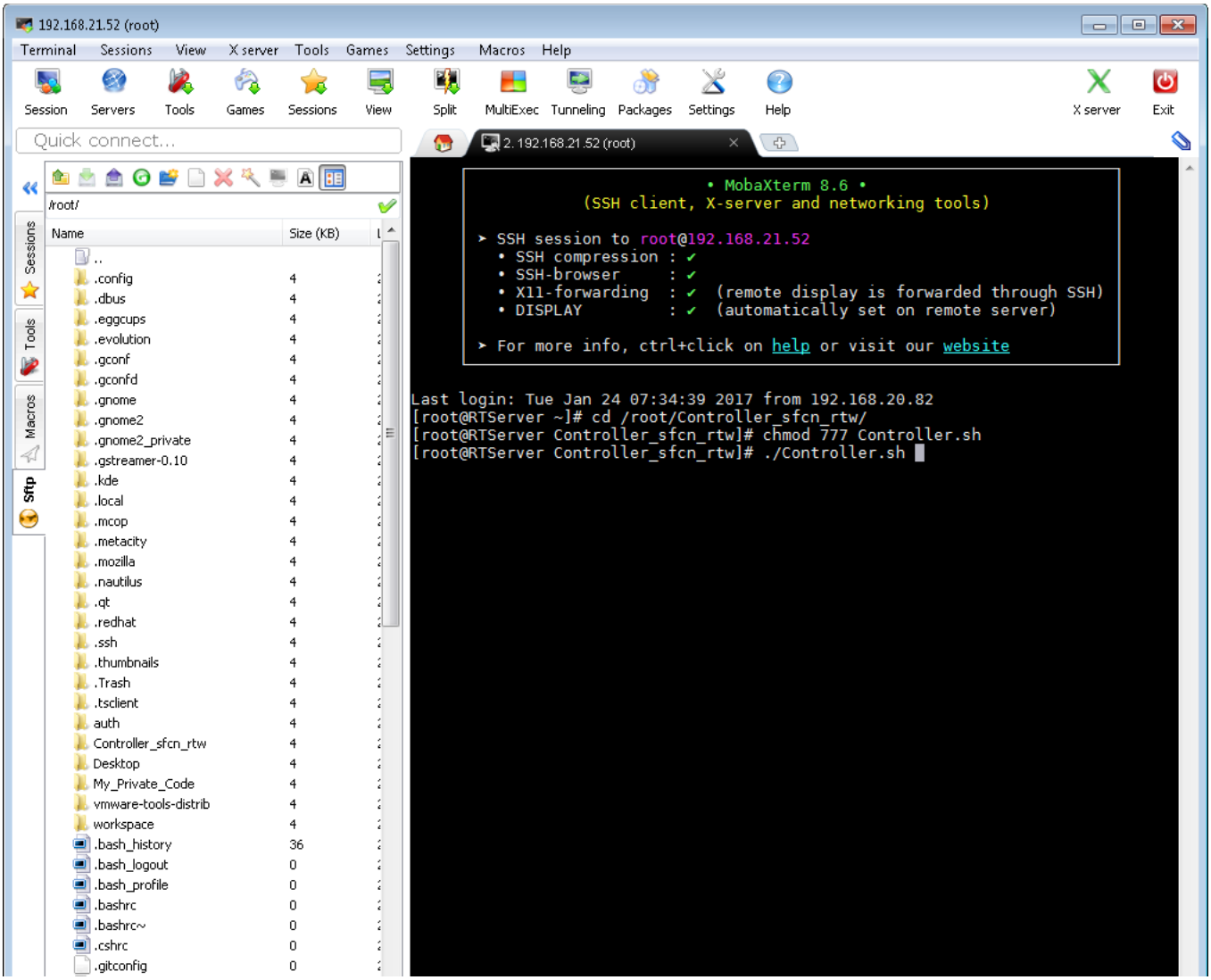
1. Follow Annex 1 in order to install and configure MobaXterm. You may use an alternative ssh/sftp client if you are more familiar with it.

2. Drag and drop the folder *Controller_sfcn_rtw* to MobaXterm's *sftp* tab.



3. In the terminal, write the following commands:

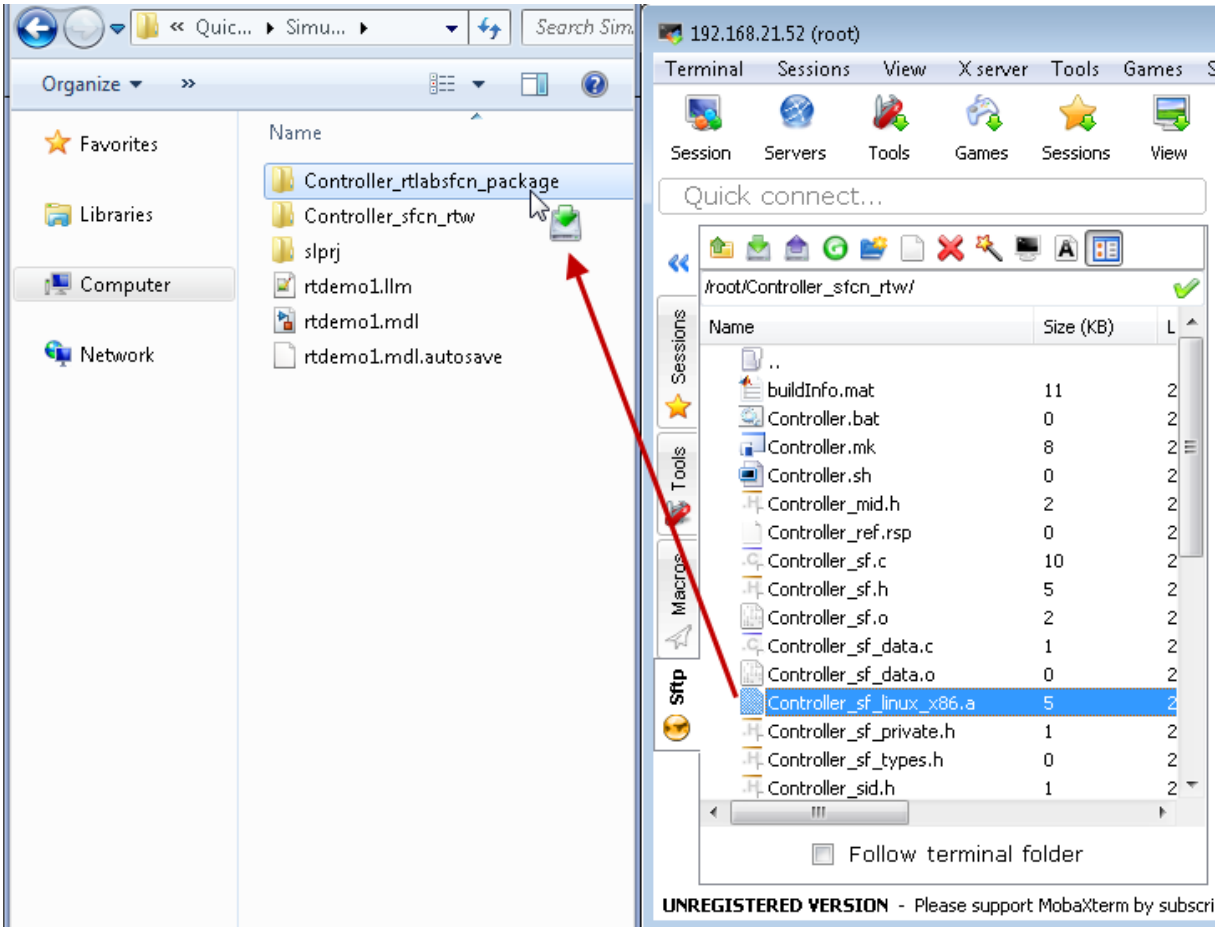
```
cd /root/Controller_sfcn_rtw
chmod 777 Controller.sh
./Controller.sh
```



4. Make sure you see the following message at the end of the execution of the script.

```
SUCCESSFUL GENERATION OF LINUX X86 .A LIBRARY
```

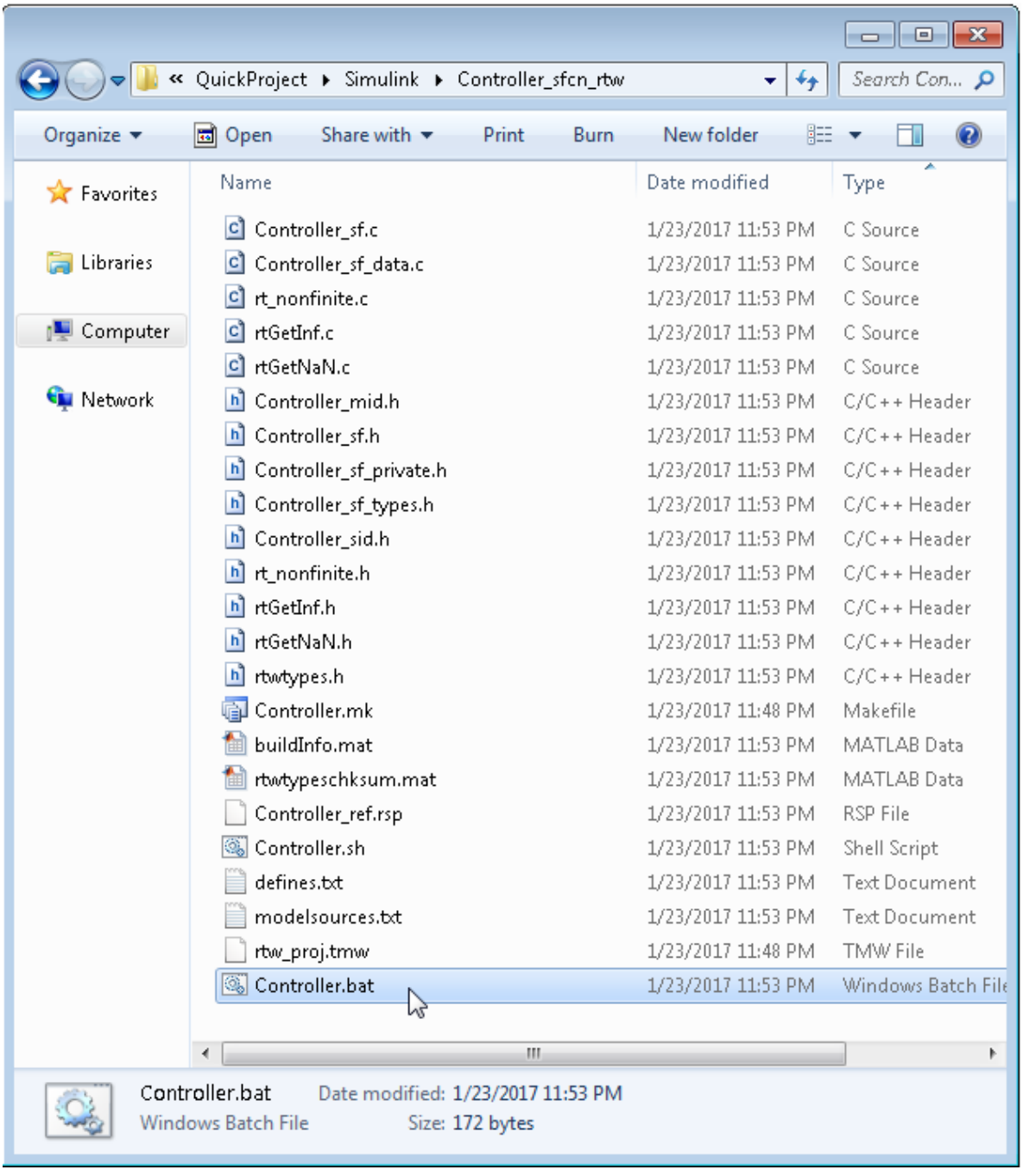
5. In MobaXterm's *sftp* tab, go inside the */root/Controller_sfcn_rtw* folder. You should see a file named *Controller_sf_linux_x86.a* that is the result of the compilation process. Drag and drop it inside the *Controller_rtlabsfcn_package* folder on the Windows PC.



WINDOWS TARGET

1. In order to compile the source code for a Windows target, the Visual C++ 2010 compiler must be installed.

2. Inside the *Controller_sfcn_rtw* folder, double click on *Controller.bat*.



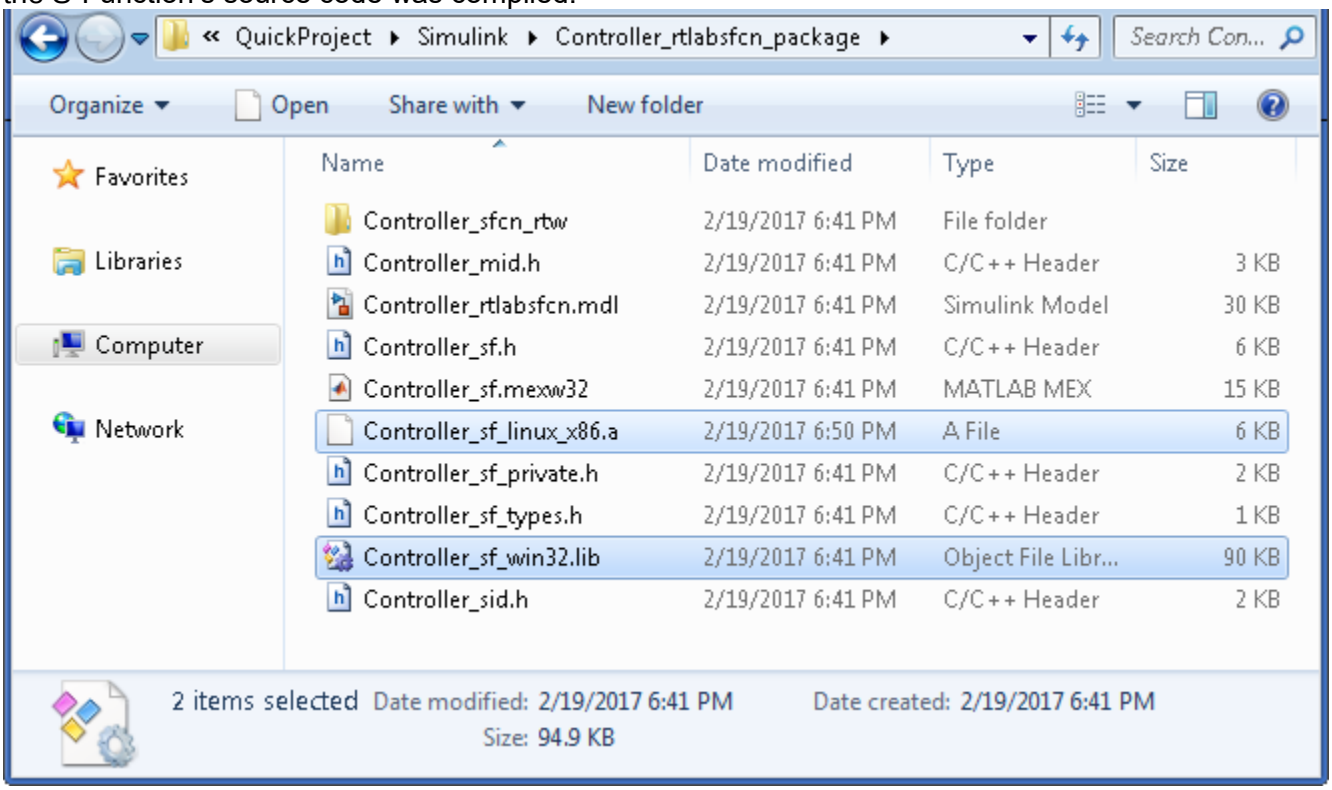
3. Make sure you see the following message at the end of the execution of the script.

```
SUCCESSFUL GENERATION OF WIN32 LIB
```

4. You should see a file named *Controller_sf_win32.lib* that is the result of the compilation process. Copy it inside the *Controller_rtlabsfcn_package* folder.

RT-LAB S-FUNCTION PACKAGE

The resulting *Controller_rtlabsfcn_package* should look like the following depending on which target platforms the S-Function's source code was compiled.



- *Controller_sf_linux_x86.a* is for OPAL-RT Linux (x86-based) targets.
- *Controller_sf_win32.lib* is for Windows targets.

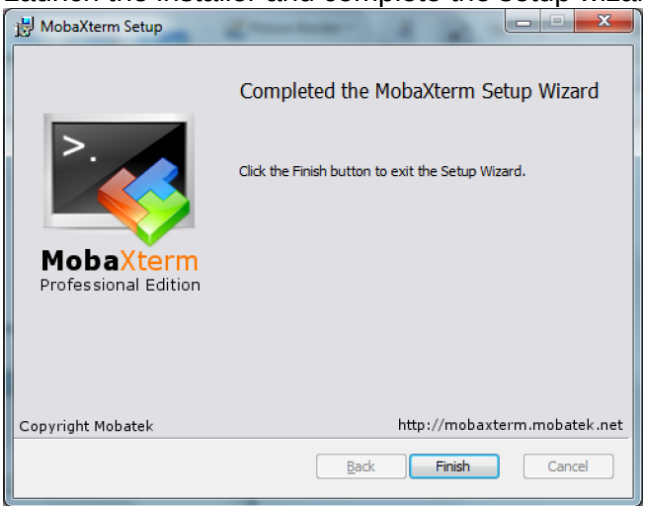
Verify the content of the *Controller_rtlabsfcn_package* folder to make sure there is no intellectual property. You can now send it to the party who will integrate the S-Function into a RT-LAB model.

ANNEX 1: MOBAXTERM INSTALLATION AND CONFIGURATION

MobaXterm will be used in order to transfer the source files of the S-Function to the target and execute commands. It is a free program. We will be using the SSH and SFTP client functionalities.

INSTALLATION OF MOBAXTERM

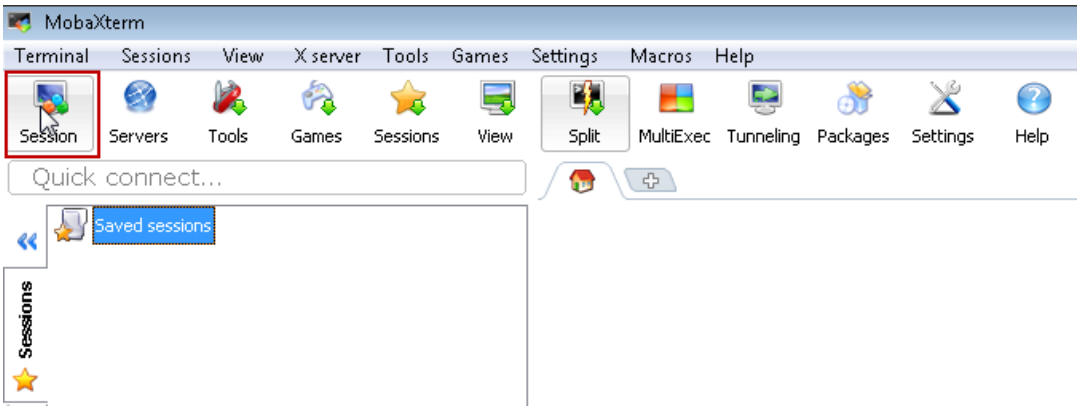
1. Download MobaXterm: http://mobaxterm.mobatek.net/download.html.
2. Launch the installer and complete the setup wizard.



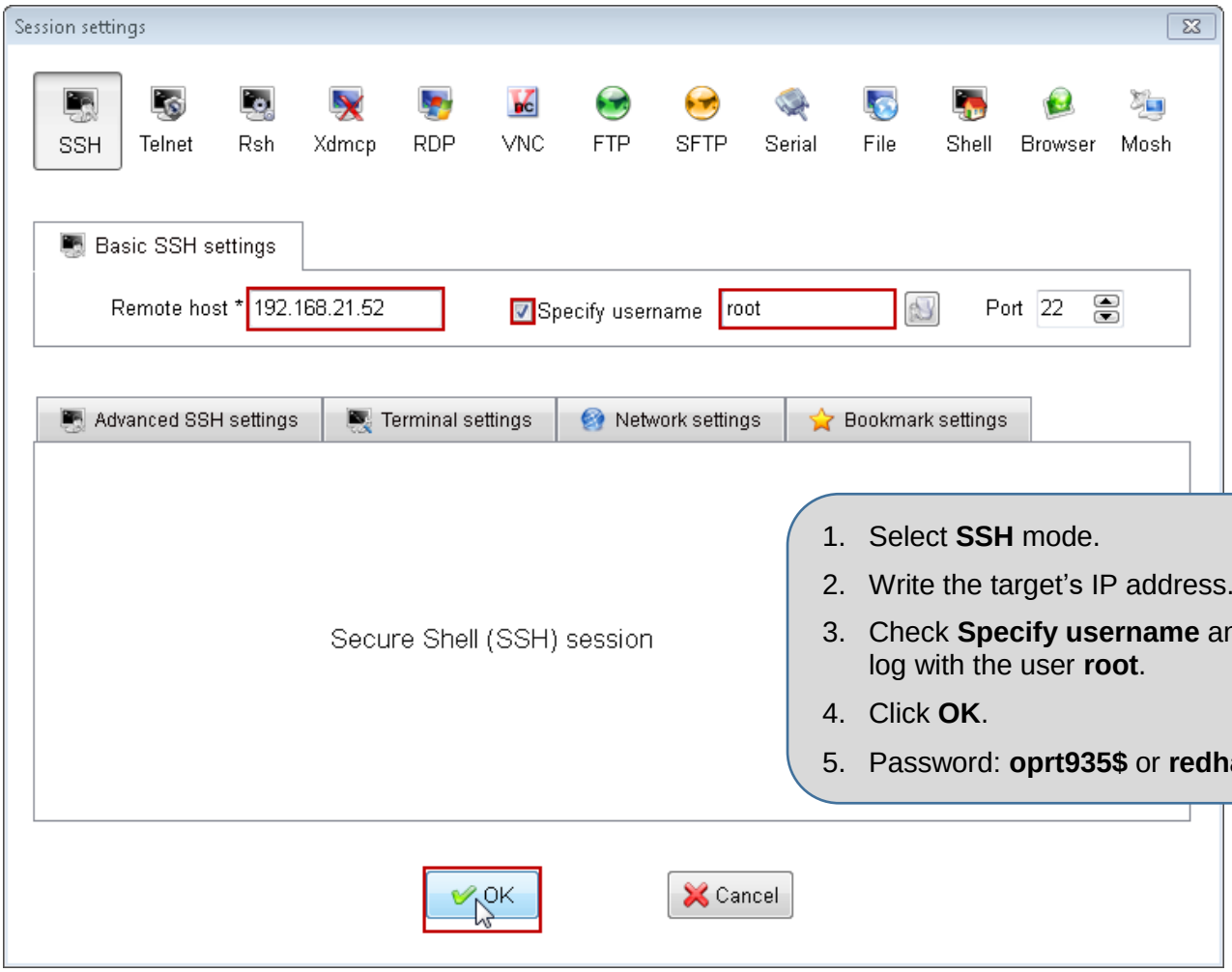
CONFIGURATION OF MOBAXTERM

3. Open MobaXterm

4. Click **Session** to create a new session.



5. Configure the new session:



6. When the session configuration is completed, a session starts automatically. For future use, open a session by double clicking on the session list on the left side of MobaXterm.

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