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Running a VS FMU in Simulink

Functional Mock-up Interface (FMI) is standardized interface to be used in computer simulations to support both model exchange and co-simulation of dynamic models provided using different simulation tools. (See the web site https://www.fmi-standard.org for definitive information about FMI.)

One means for combining simulation tools with FMI is through co-simulation, where each tool is represented in the form of a Functional Mock-up Unit (FMU). Starting with version 2016.0, BikeSim, CarSim, and TruckSim support FMI co-simulation by including the capability to automatically generate a slave VS FMU.

This memo is a tutorial that describes how you can create a VS FMU from BikeSim, CarSim, or TruckSim, and run it within the Simulink environment. The example involves a simple antilock brake system (ABS) example that has long been provided in databases for VehicleSim products.

Notes BikeSim, CarSim, and TruckSim are typically run in Simulink using VS S-Functions, without needing FMI. This memo describes co-simulation with Simulink because this third-party software tool is the most familiar to users of VehicleSim products.

The example ABS controller is not intended for specialists in ABS or brake system modeling. Rather, the point is to show how to set up a VS FMU to work in another environment.

This memo shows datasets and results from CarSim. Nearly identical datasets are provided in BikeSim and TruckSim.

In order to follow this tutorial, you must have your VehicleSim product installed with version 2016.0 or newer and Simulink 2015a or newer (from The MathWorks), with the MATLAB Pilot Support package installed. The document assumes you have a basic understanding of how to use your VehicleSim product; if you have not done so, please go through the Quick Start Guide. You should also be familiar with Simulink, and should first read the Tech Memo available from the VehicleSim product **Help** menu: **Running a VS Math Model in Simulink.**

FMI support in MATLAB was introduced in 2015. The steps in this memo were tested for MATLAB 2015a and MATLAB 2015b with the "Pilot Support Package v0.2.0" installed. With MATLAB 2015a, be sure you have the latest version (near the end of 2015); the initial release did not properly support FMI version 2.0.

Create a Dataset for an FMU

1. Navigate to the existing **Run Control** dataset for the Simulink ABS Example in the category **Simulink and LabVIEW Models** (Figure 1).

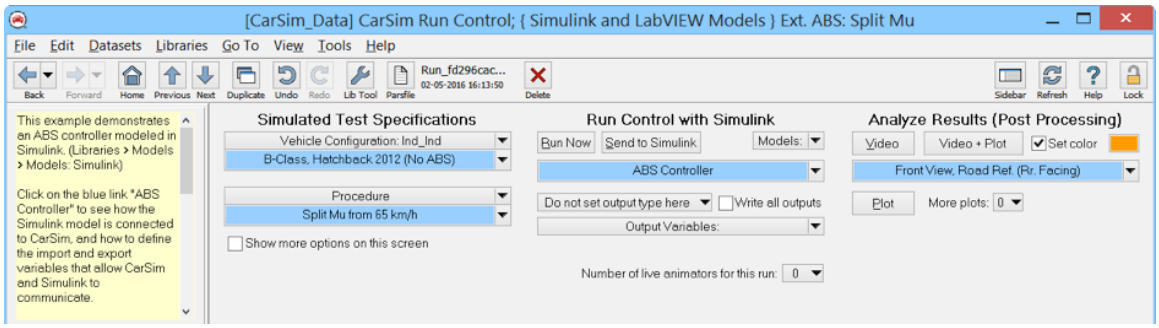

Figure 1. Run Control screen for ABS test on a split-mu surface.

2. Duplicate the dataset using the **Duplicate** button or pressing Ctrl+N. You will be prompted to name the new dataset (Figure 2). For example, change the category to "FMU with Simulink**"** and the dataset title to "Ext. ABS: Split Mu**".**

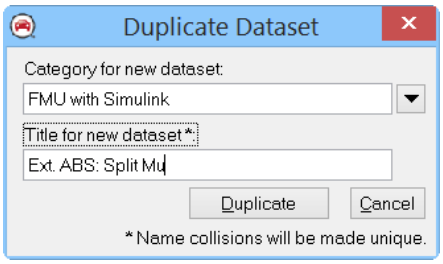

Figure 2. Duplicate the Simulink ABS Example dataset and rename it.

3. From the drop-down **Models** control, select the option **Models: Export FMU/FMI** (Figure 3).

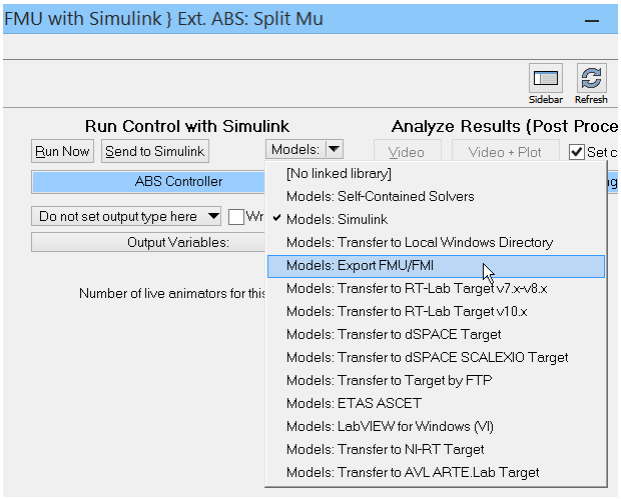

Figure 3. Select "Export FMU/FMI" from the Models drop-down control.

4. Use the drop-down control for the link that appears, and select **Link to New Dataset** (Figure 4). When prompted, name the new dataset "FMU Simulink" (Figure 5) and click the **Create** button.

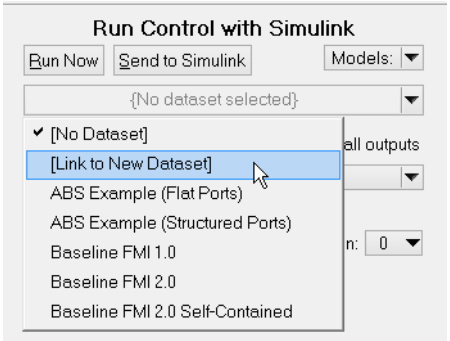

Figure 4. Link to a new Dataset

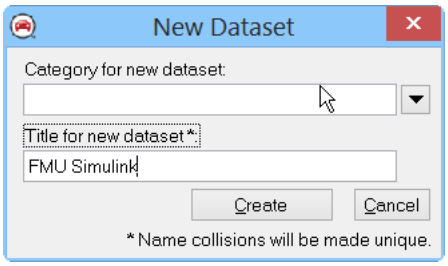

Figure 5. Name the Model name to "FMU Simulink".

5. Click on the blue link for **FMU Simulink** to view the new dataset in the library **Models: Export FMU/FMI** (Figure 6).

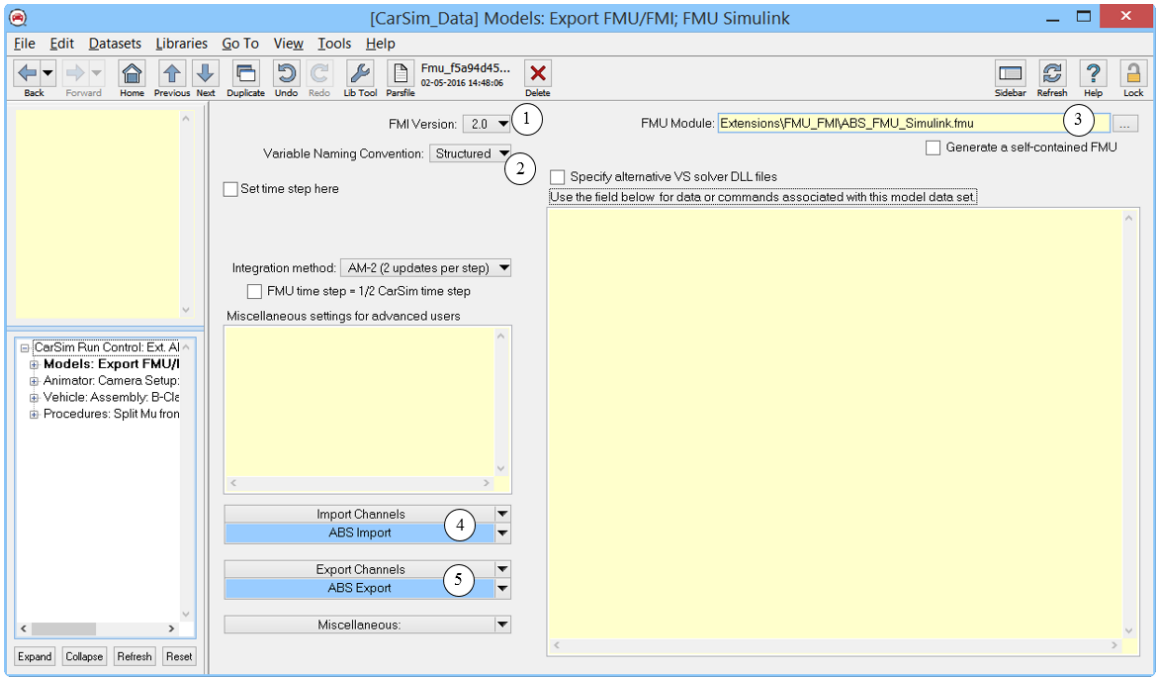

Figure 6. FMU Model screen.

6. Make the following changes for the new dataset:

(1) Choose **FMI Version 2.0**.

(2) Choose the Variable Naming Convention: **Structured.** This option will show channels as a one dimension array to the VS FMU in Simulink.

(3) Specify a relative pathname for the FMU Module that you will soon create: `Extensions\FMU_FMI\ABS_FMU_Simulink.fmu`

(4) Use the **Import Channels** link to select **ABS Import** in the category **Braking Imports**.

(5) Use the **Export Channels** link to select **ABS Export** in the category **Braking Exports**.

7. Go back to the **Run Control** screen and click the button **Generate FMU for this Run**. A new FMU with the specified pathname will be created (Figure 7).

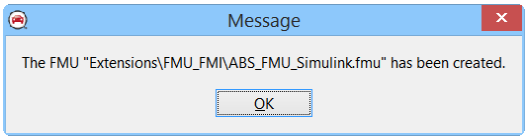

Figure 7. Generate an FMU file.

You have now created an FMU that can be run in co-simulation. Next, you will create a Simulink model to make use of this FMU.

Create a Simulink Model that Uses an FMU

1. In the Windows File Explorer, copy the existing Simulink file (e.g., `abs_CS9.mdl`) from the folder `Extensions\simulink` to the folder `Extensions\FMU_FMI` and rename it to the specified name: `abs_fmu.mdl`.

2. Open this Simulink model (Figure 8). (Recall that MATLAB 2015a or newer is required with the "Pilot Support Package v0.2.0" installed.)

3. Delete the block named **Unresolved Link** (1) that represented the VS S-Function in the original Simulink model.

4. Go to the Simulink **Library Browser** window (Figure 9). Drag the **FMU Co-Simulation** block to the Simulink model.

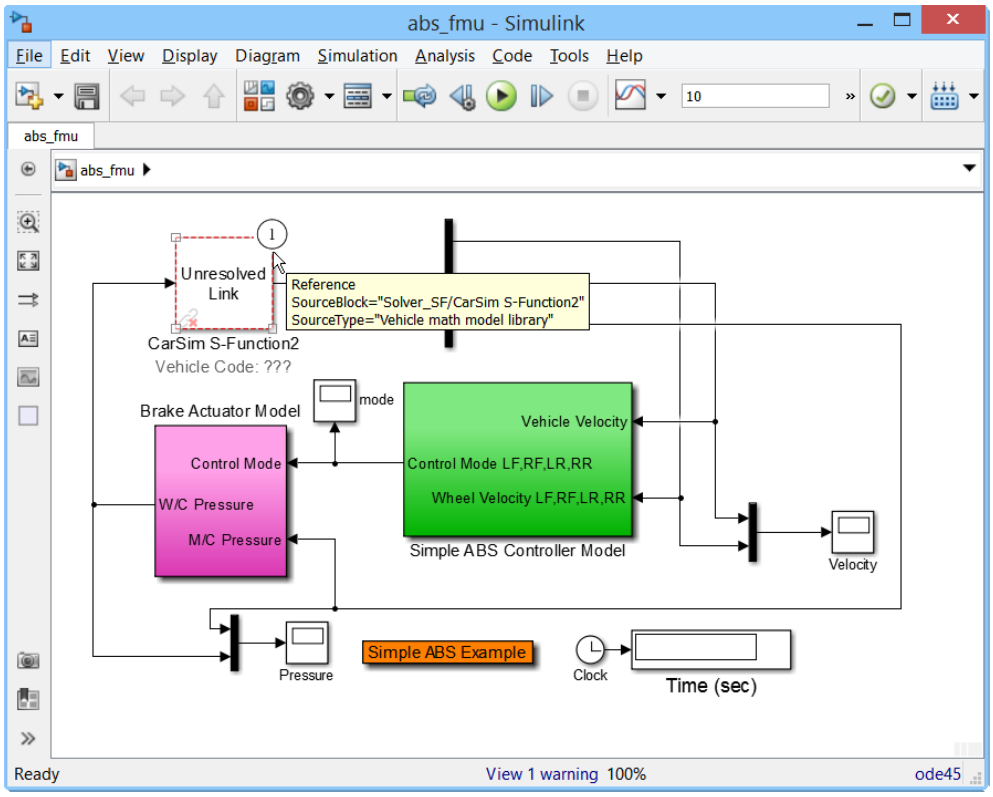

Figure 8. Open copied Simulink model.

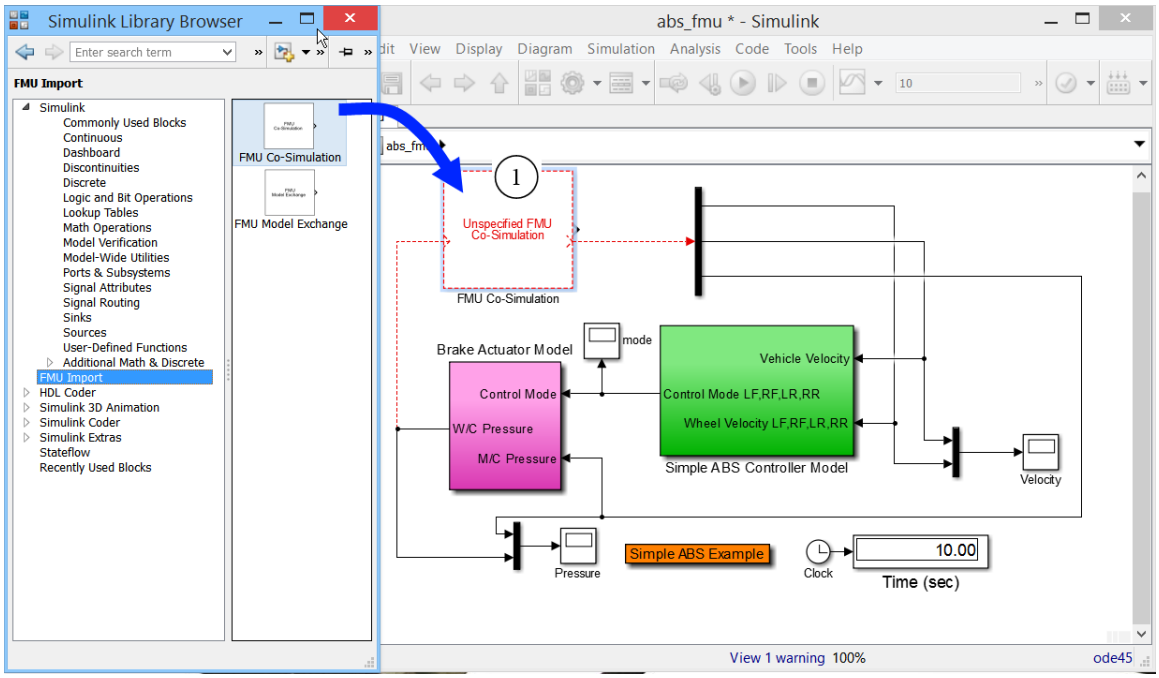

Figure 9. Insert a FMU Co-Simulation Simulink block

5. Double-click the block named **Unspecified FMU Co-Simulation** (① in Figure 9) to bring up a window to set parameters (Figure 10). Set the FMU name to match the name

of the FMU you created in step 5, and then click the **OK** button. The Simulink model should now match the appearance shown in Figure 11.

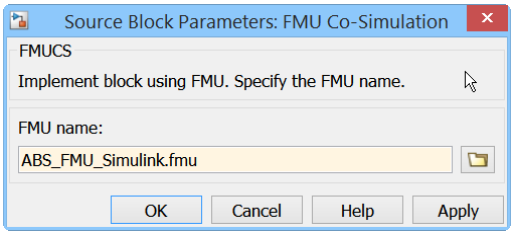

Figure 10. Input FMU name

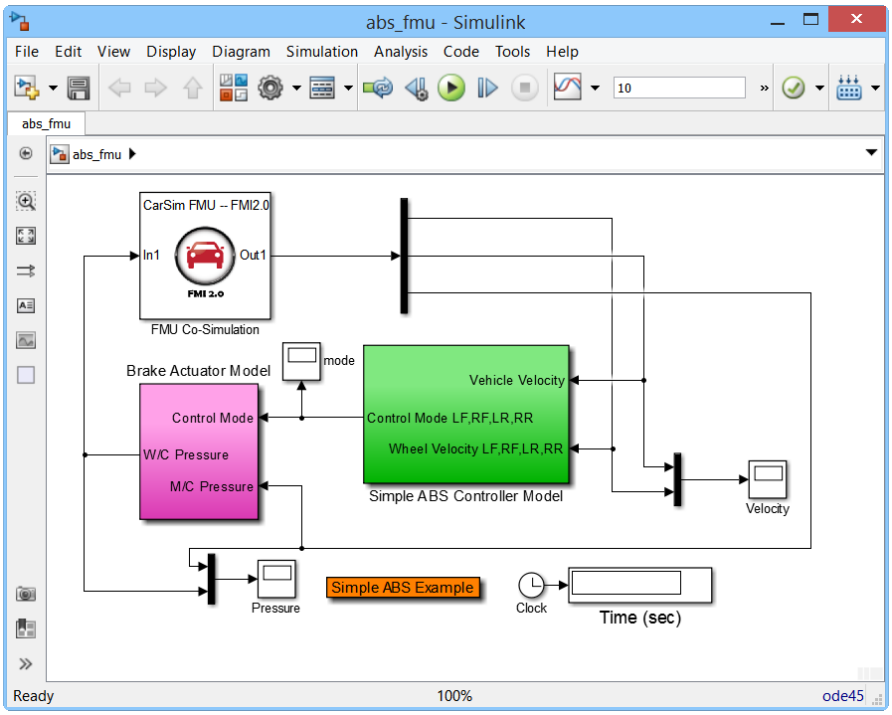

Figure 11. The Simulink model after changing the FMU name to "ABS_FMU_Simulink.fmu"

6. Double-click the FMU block again to see more options (Figure 12). Set the time step to 0.001, and then click the **OK** button to return to the Simulink model.

7. Save the Simulnk model.

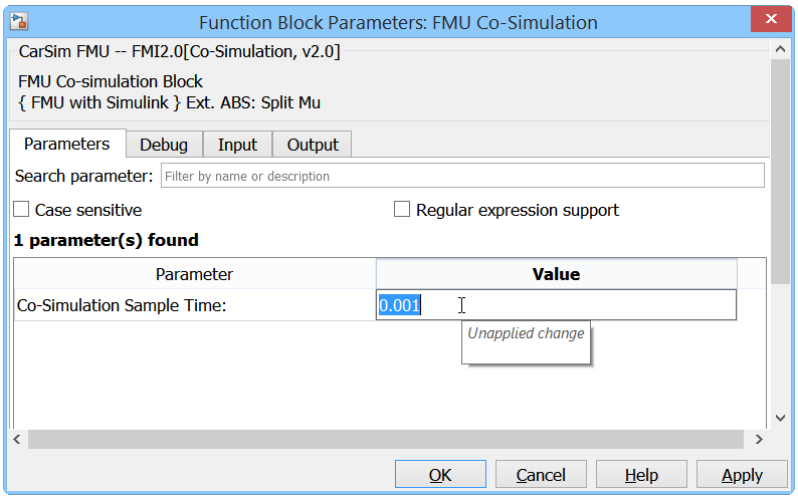

Figure 12. Set simulation time step

8. Run the model; click the button or type **Ctrl+T**. Simulink will show plots as the model runs (Figure 13).

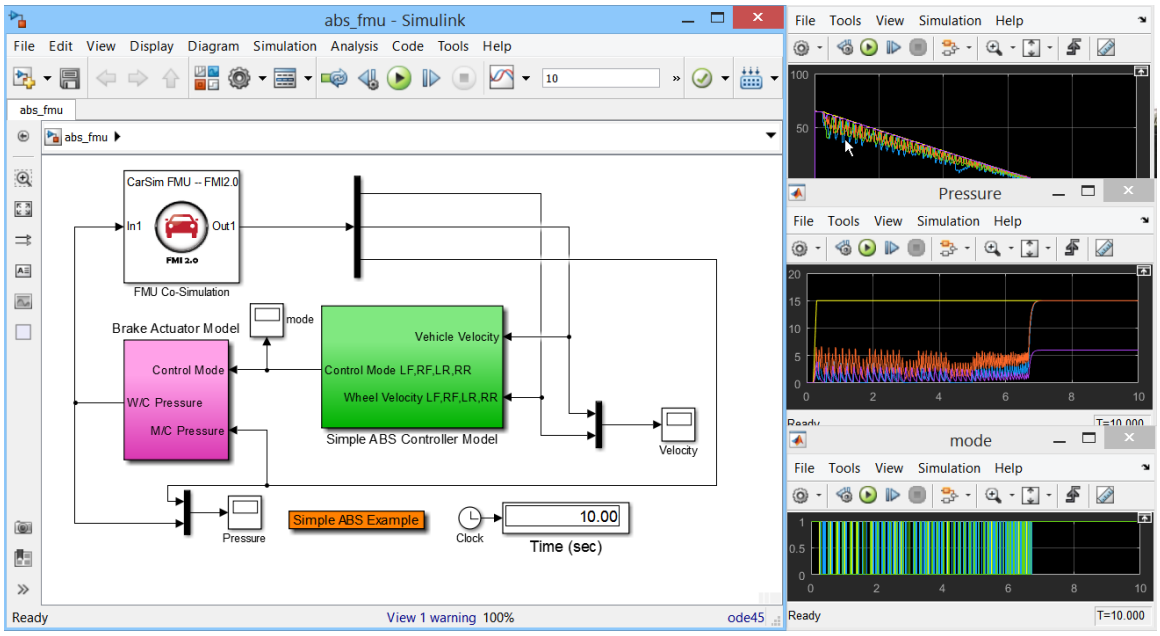

Figure 13. Running the Simulation in Simulink.

9. Return to the **Run Control** screen and click the button "**Video + Plot**" to view results with VS Visualizer (Figure 14).

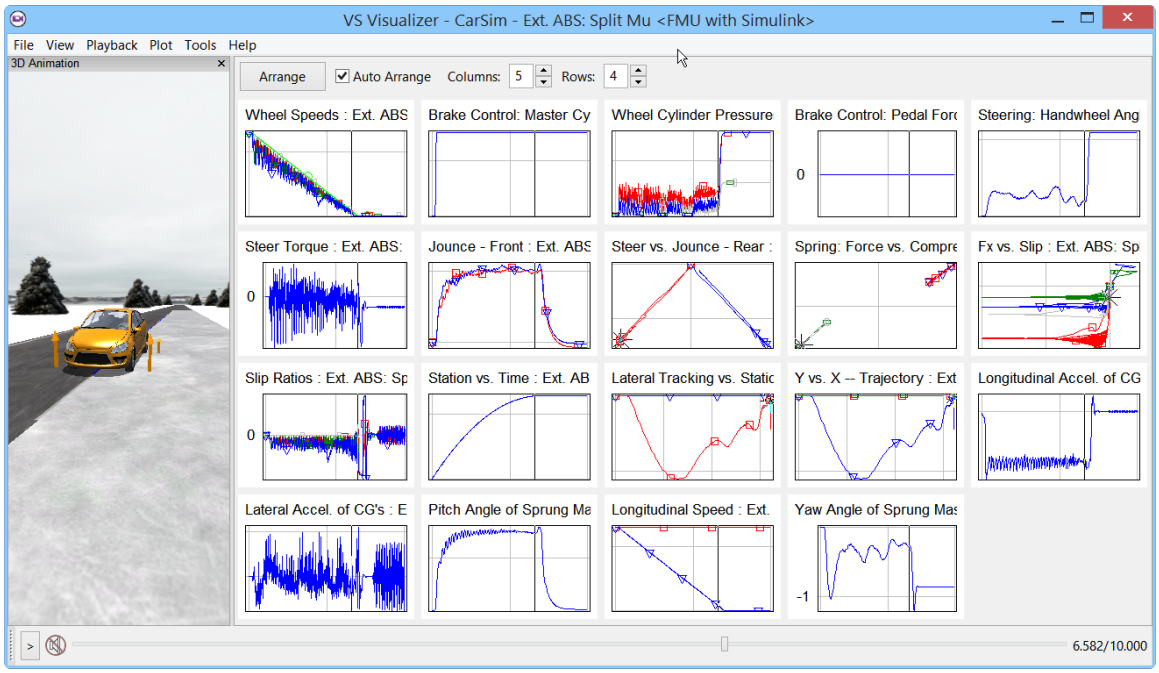

Figure 14. View the simulation results with VS Visualizer (Video + Plot).

FMU Multiple Ports in Simulink

You can configure VS FMU I/O ports as a single port or with multi-ports. To see this, return to the **Models: Export FMU/FMI** dataset (Figure 6). The drop-down control **Variable Naming Convention** (2) (Figure 6) has two options: **Structured** and **Flat**.

1. The **Structured** option provides Ports (Import and Export with Simulink) to match datasets linked to the **Models: Export FMU/FMI** dataset. In the example shown, there is a single Import Port and a single Export Port, with channels for each port set using the linked I/O Import and Export datasets (**ABS Import** and **ABS Export**, Figure 15).

   The **Structured** option also supports linking to an **I/O Channels: Ports** dataset that can in turn link to a single Import and a single Export dataset (see the bottom part of Figure 15), or multiple Import and/or Export datasets (Figure 16).

2. The **Flat** option always provides multiple ports, each with a single value for Import or Export data (Figure 17).

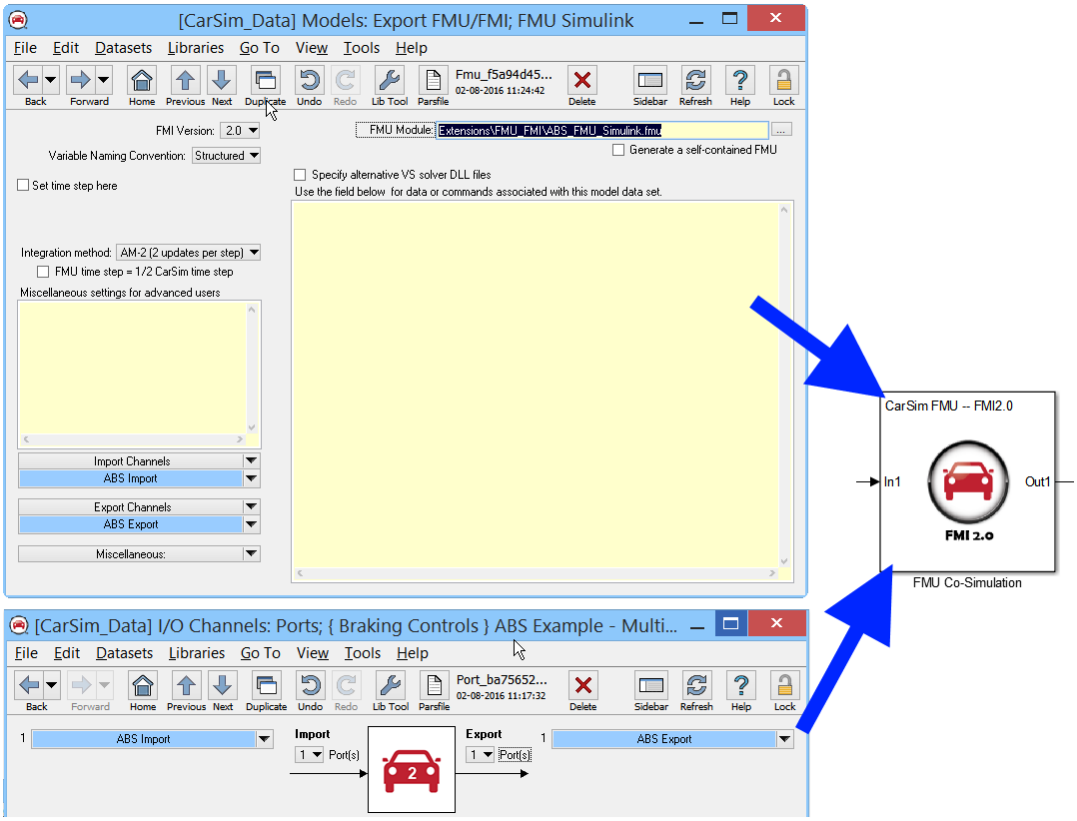

Figure 15. One Input port array and one Output port array.

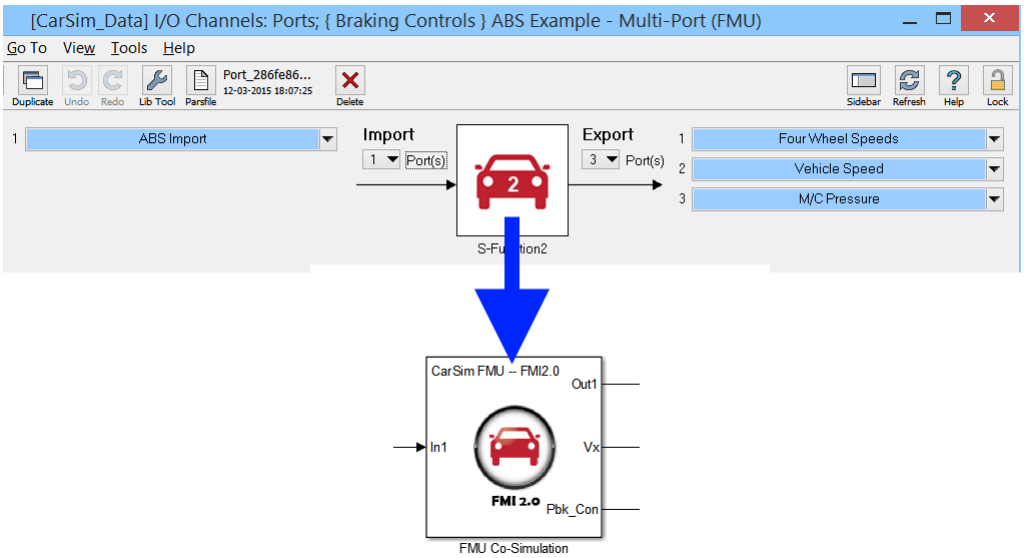

Figure 16. Multiple Ports with separate arrays of Imports and Exports.

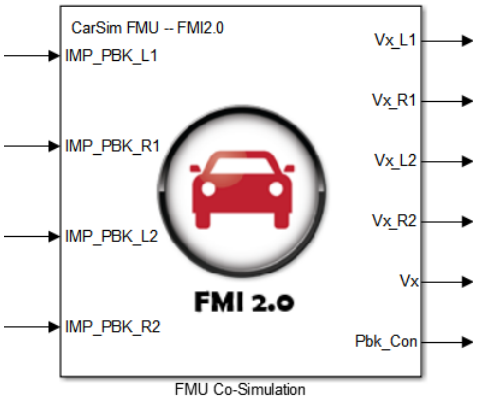

Figure 17. Multiple ports, each for a single I/O channel.