Beta 2 Resources ▾ QR Documentation By:

The following tutorial is based on the assumption that the GME tool suite and the META add-on are installed on the user's computer.
The GME tool can be downloaded **here**.
The META add-on can be downloaded **here**.

Qualitative Verification Test Bench and Tool

Table of Contents

1.0 Purpose

The purpose of the Qualitative Verification Test Bench and Tool is to provide qualitative and symbolic properties of a design with respect to requirements. These properties can be used by a designer to make changes in the design to meet requirements.

2.0 Procedures

The instructions in this manual assume that the user has installed the latest version of GME and the META add-on.

2.1 Installation

This test bench will be provided as a test bench in the CyPhy model: **MSD_Big_PARC.xme**

2.2 Tool

The Qualitative Verification Test Bench is the test bench in GME that the designer uses to interface with the Qualitative Reasoning Module (QRM) included in the META add-on for the GME. The Module accepts a design, a set of requirements, analyzes them and returns a result.

Qualitative verification is an automated process which has as inputs an original design solution and a set of requirements. It explores a larger design space than the initial point design against the design requirements. The results of the analysis are suggestions of parametric changes that ensure the design meets the requirements as well as other symbolic properties.

Test Bench: Qualitative Verification Analysis

The test includes the qualitative verification of a Mass-Spring-Damper (MSD) configuration (Figure 1), where a costant force is applied to the mass. We use the MSD example to show how to set up and analyze the qualitative analysis results. These concepts can be used on other models in the same way

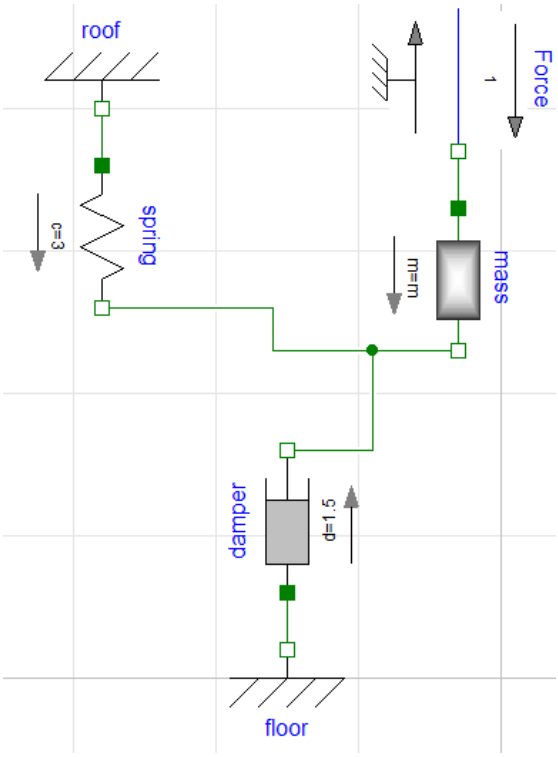


Figure 1: Mass-Spring-Damper configuration

Requirements Tested

Bounded system variables (true/false): the variables of the system will remain within some bounds during the operation of the system. Specifically, we test for the existence of an instant in which the absolute value of the spring force exceeds 17 Newtons. If this is the case then the requirement is not met.

Theory of Operation

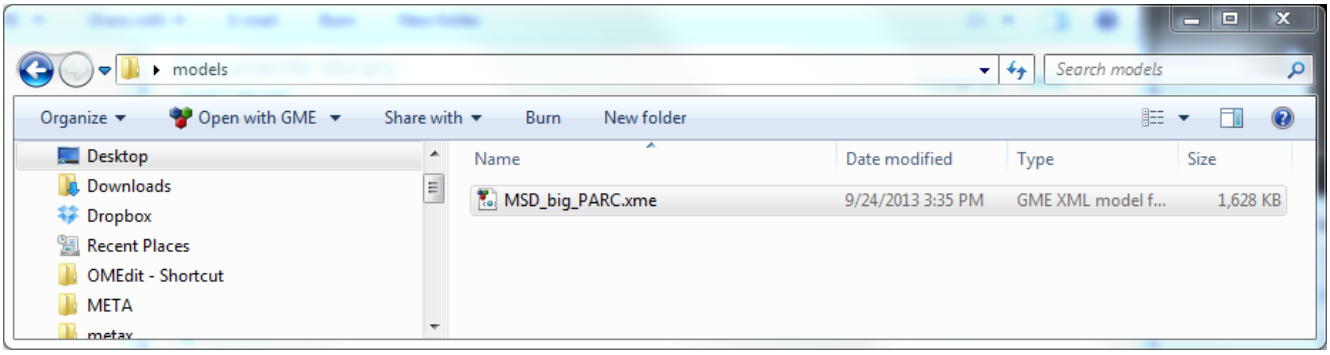
The MSD system design is represented as a CyPhy system configuration based on parameterized components from the AVM component library. The system configuration is used in a CyPhy test bench, which is the input for the qualitative reasoning tool.

Test Bench Structure

This test bench contains an MSD assembly connected to two fixed structures (floor and roof) and to which a constant force is applied. To use the test bench, perform the following steps:

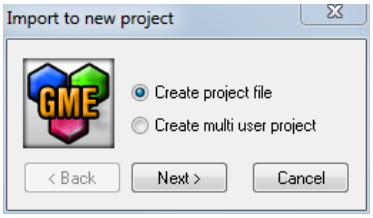
Step 1

Open MSD_Big_PARC.xme in CyPhy.



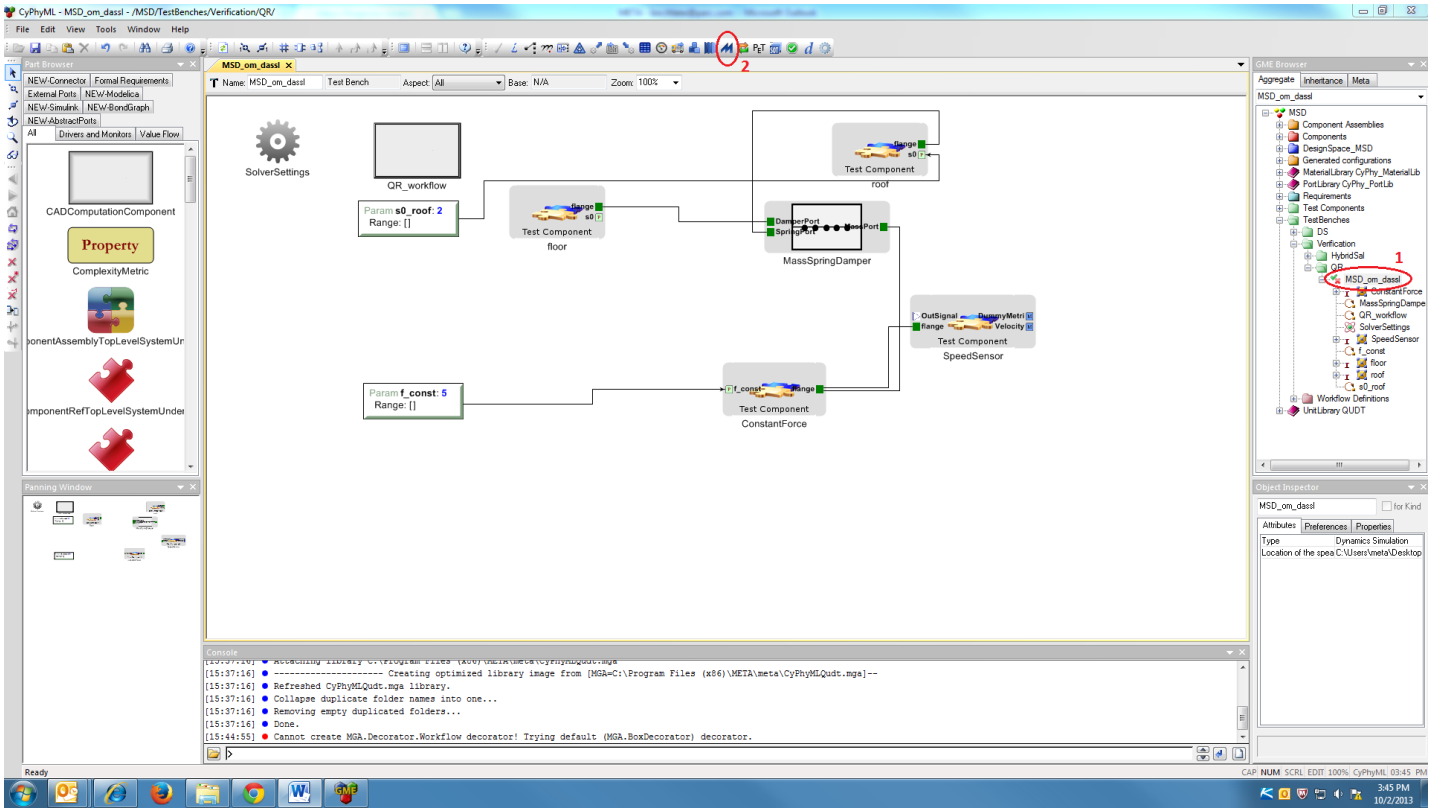
Step 2

Select “Create project file” and click next. Select the default name and continue.



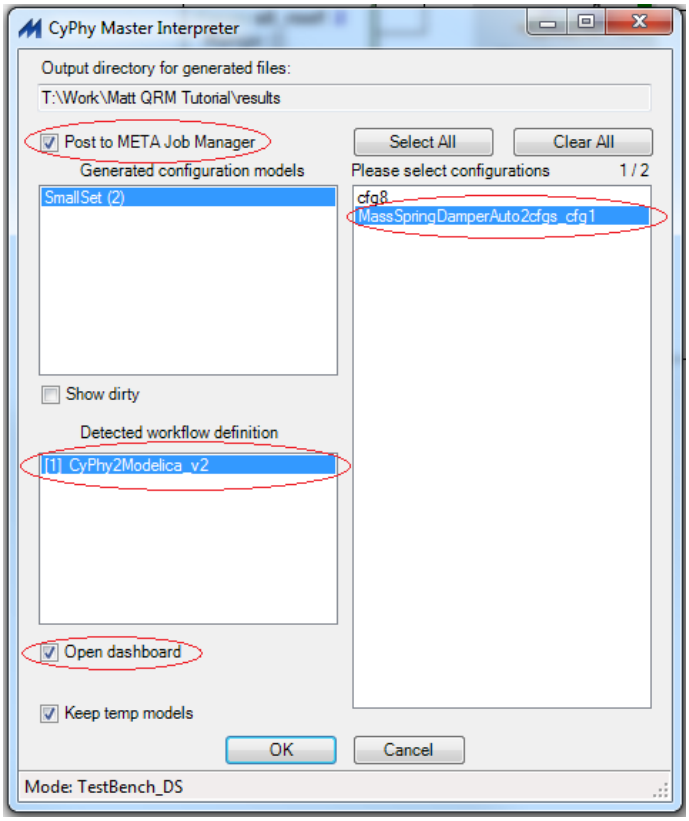
Step 3

In the GME browse window, navigate the tree as follows: MSD->TestBenches->Verification->QR->MSD_om_dassl and double click on (1) MSD_om_dassl. Then, click on the MasterInterpreter icon (2), the blue M.



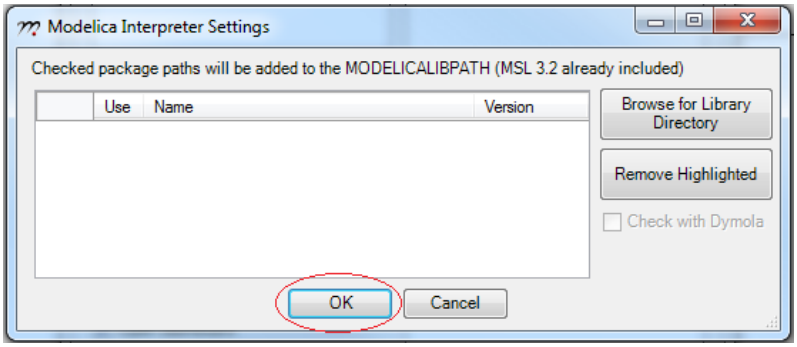
Step 4

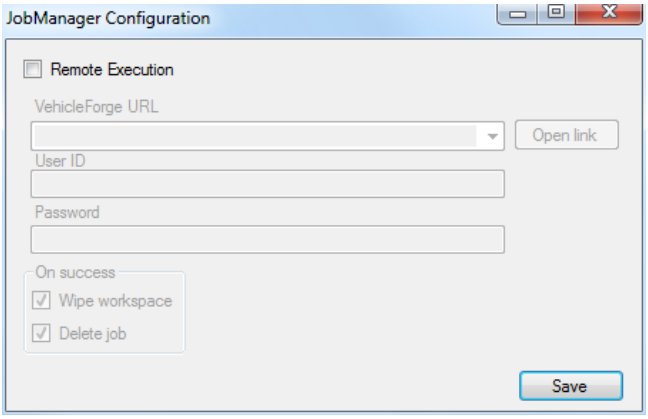
Select the second configuration (MassSpringDamperAuto2cfgs_cfg1), check the “Post to META Job Manager” checkbox, check the “Open dashboard” checkbox to open the dashboard, and select the CyPhy2Modelica_v2 workflow.



Step 5

Click “ok” on the screen for additional libraries and a number of windows will open. Navigate to the job Manager window and click save.





Step 6

Once the job has been posted to the Job Manager, the design and requirements information will be transformed into a Modelica model which will be analyzed by the QR module. In the results folder, there will be two output files that contain information about the qualitative verification analysis: stat.json and summary.testresults.json. The information in these files can be used to modify the design to meet the requirements.

Description

Qualitative Verification Analysis is an automated process implemented through the QR module, which given an initial design and a set of requirements, it explores a larger design space against the requirements. If the requirements are not met, it provides suggestions to the designer on how to change the parameters of the design to meet the requirements. The CyPhy MSD test bench is transformed into a Modelica model, then translated into qualitative constraints for use in the QR module. The results of the qualitative analysis are returned in two files: stat.json and summary.testresults.json.

Metrics

We check if the absolute value of the spring force is less than 17 Newtons.

Outputs

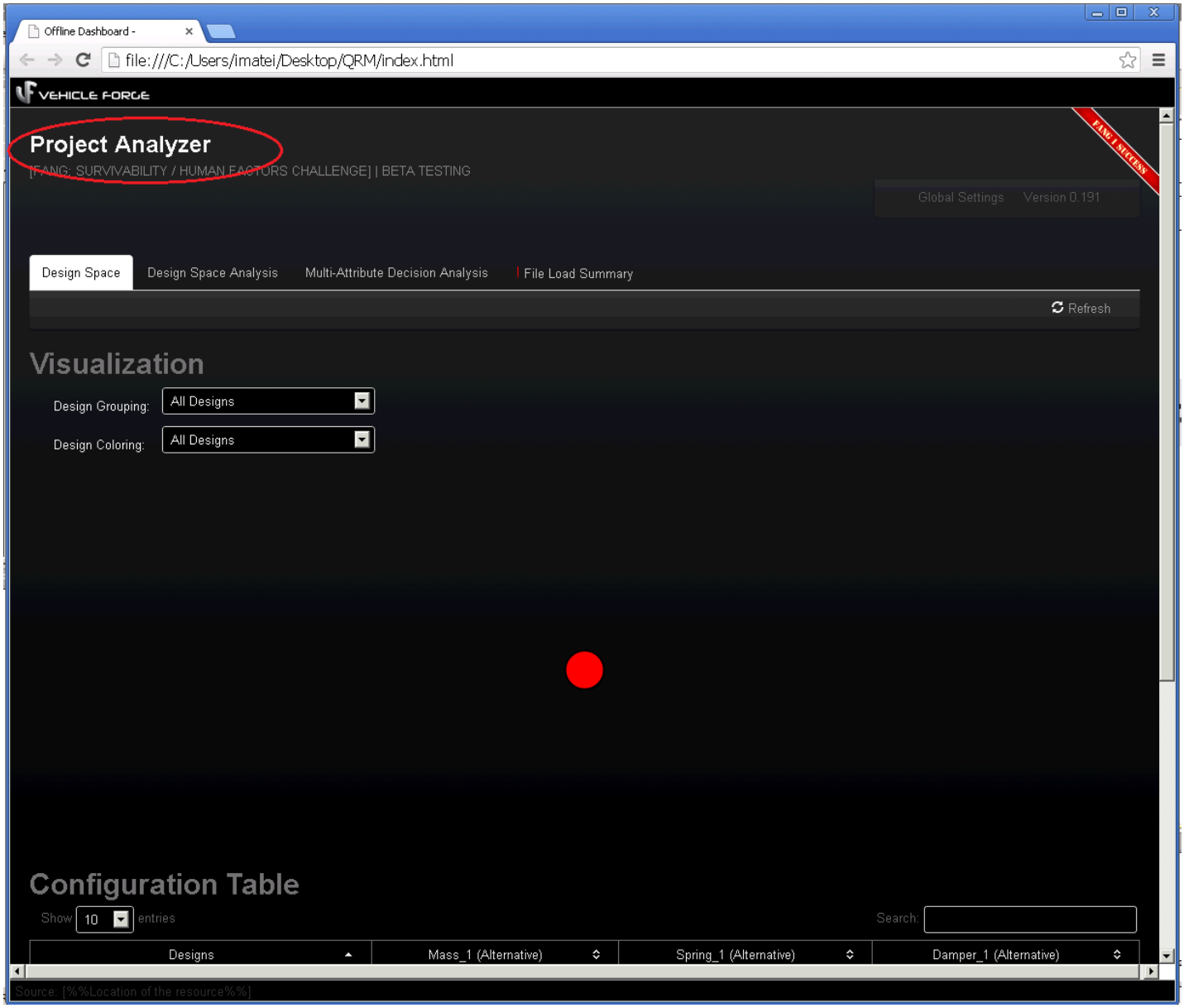
The output of this test bench is two results files: stat.json and summary.testresults.json. The summary results show if the requirements were met, and in case the configuration failed to meet the requirements, the results include suggestions on how to change the parameters of the design to meet the requirements.


```
"FormalVerification": [
        {
            "Source": "PARC",
            "Result": "FAIL",
        "ReqName": "Limit1",
        "Details": [
            {
                "GroupBody": [
                    "Decrease MassSpringDamper.Spring_1__Spring_9.c",
                    "Decrease roof.s0",
                    "Increase floor.s0",
                    "Decrease MassSpringDamper.Spring_1__Spring_9.s_rel0",
                    "Increase MassSpringDamper.Damper_1__Damper_9.s_rel"
                ],
                "GroupTitle": "Changes suggested by QRM's symbolic differential qualitative analysis"
            }
        ]
    }
```


The summary results can be seen and compared with other system metrics in the Dashboard (the Vehicle Forge manufacturability visualization tool).

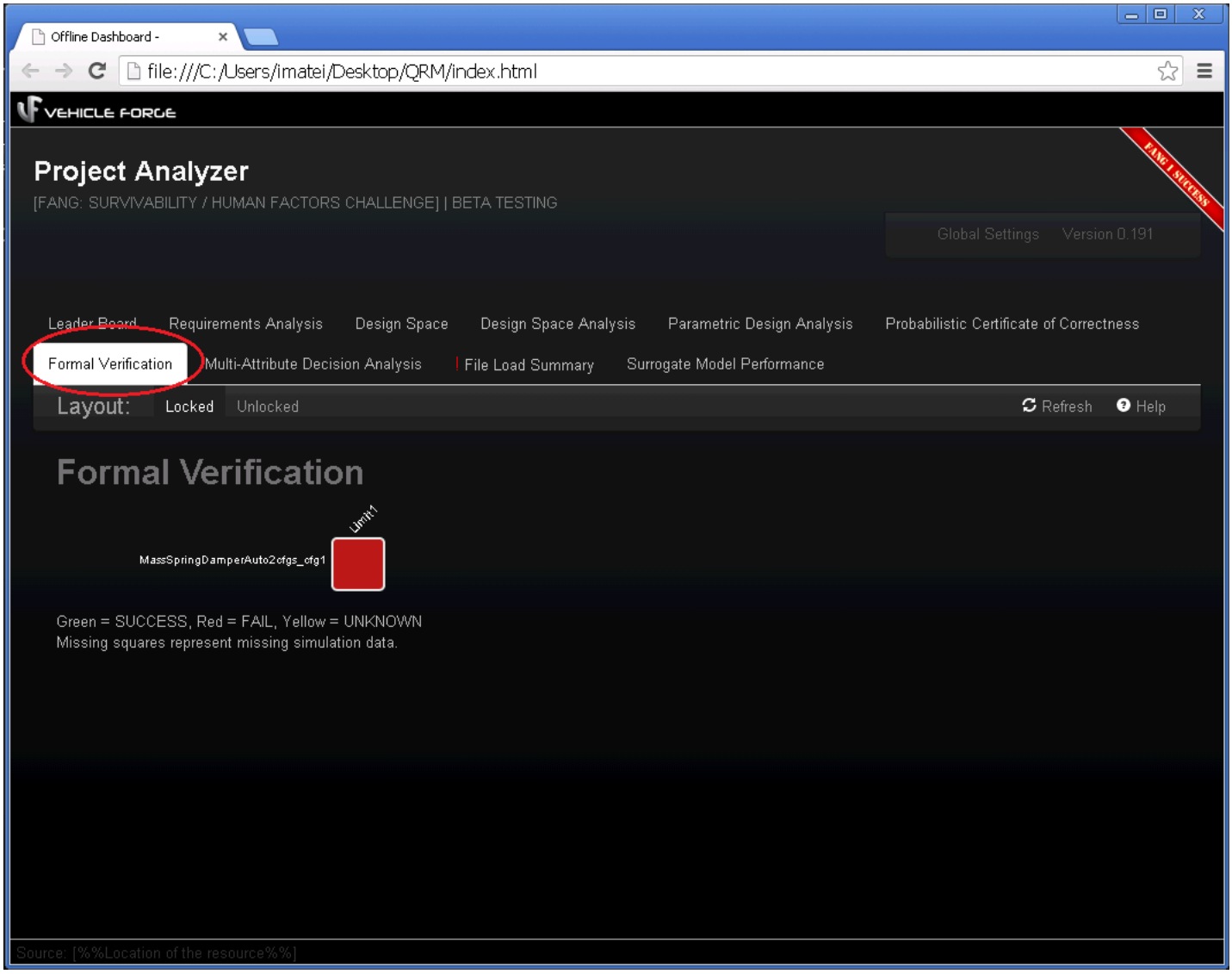
Step 1

Select the browser window that opened, named the Offline Dashboard (requires chrome as default browser and started with --allow-file-access-from-files flag). Next ctrl+click on Project Analyzer.

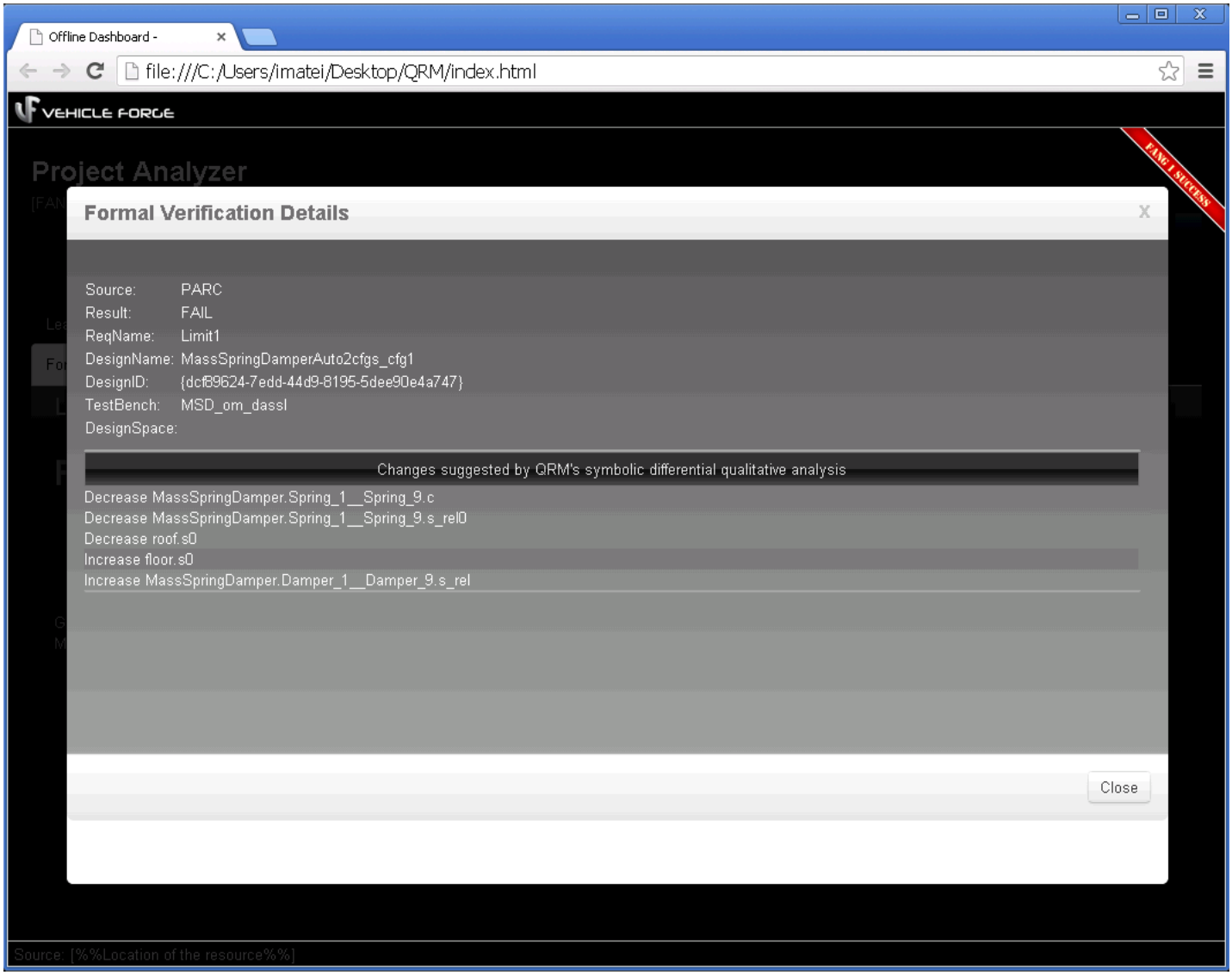


Step 2

Select the “Formal Verification” tab, and you will see that the configuration failed the requirement, as indicated by the red color.



Clicking on the red square will display the results of differential qualitative analyses, shown below. This pane includes the list of parameter changes to meet the requirements.

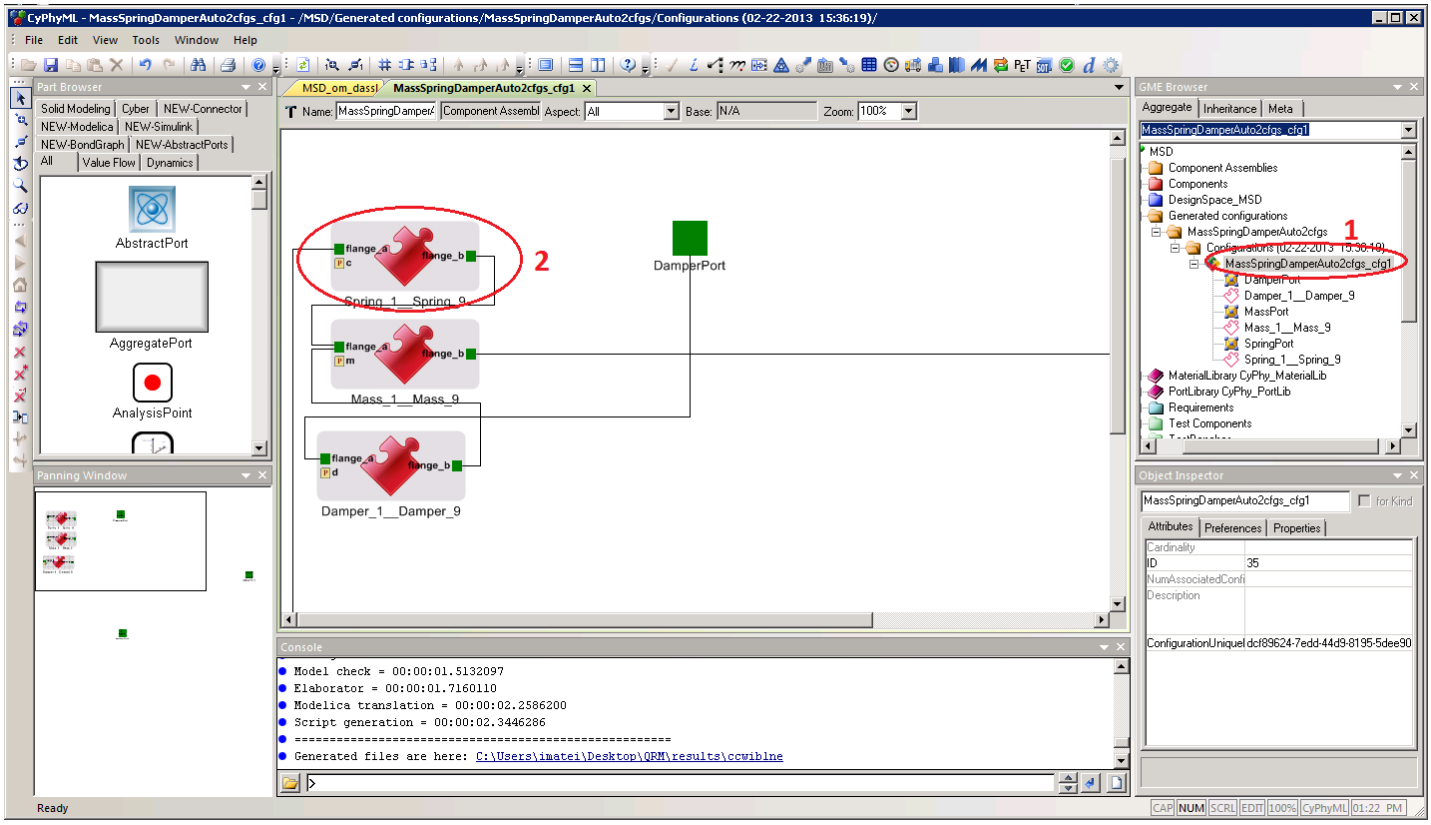


Using the qualitative analysis results to meet requirements

The initial configuration fails to meet the requirement, and QRM uses differential qualitative analysis to suggest parameter changes to the designer. After making changes to the design, a second analysis by QRM results in an abstract design space with successful and violating designs. At this point, the designer should invoke additional analyses, such as simulation and PCC. Future releases of QRM will identify inequalities between parameters that ensure the design meets the requirements as well as other symbolic properties.

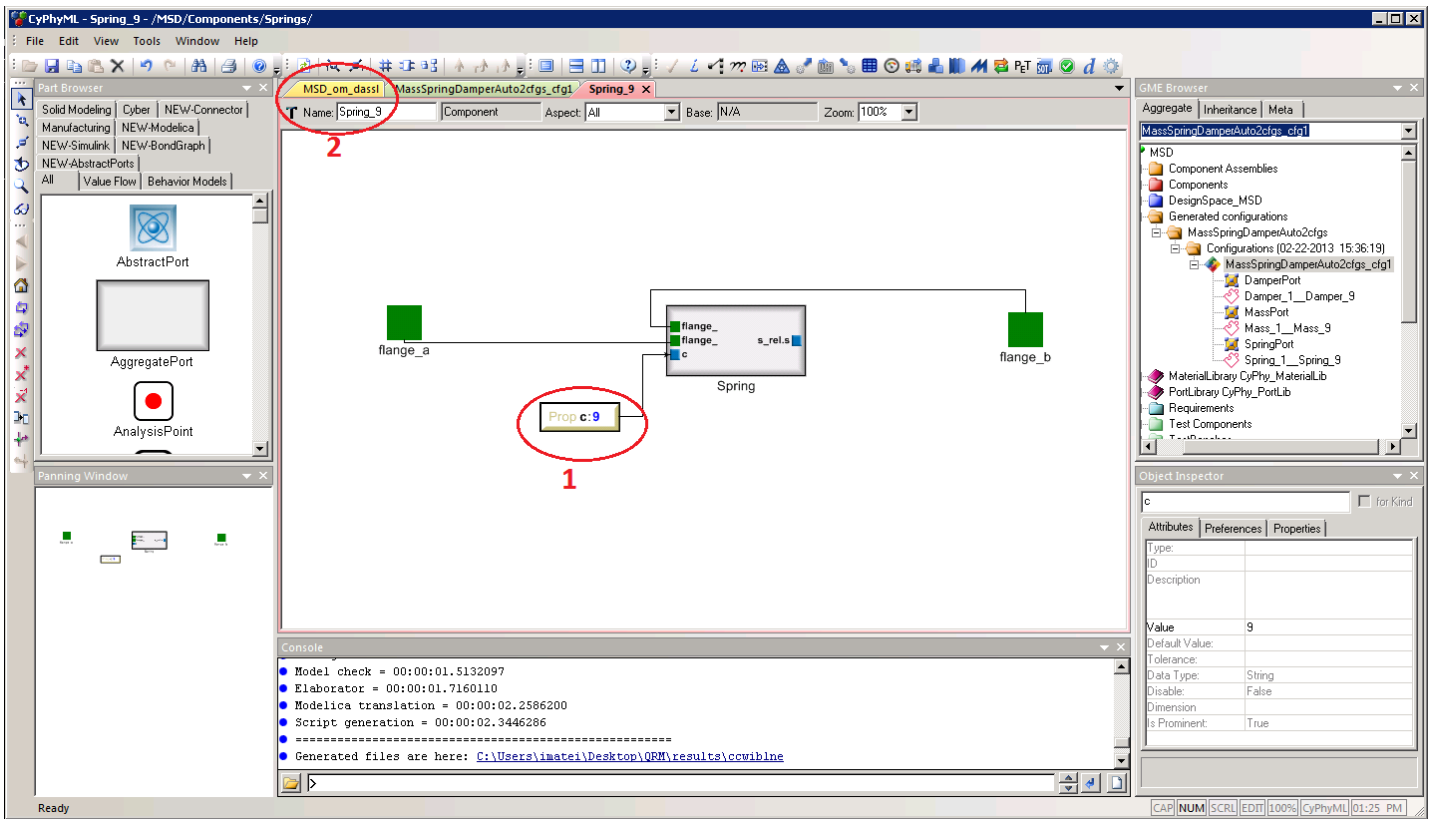
Step 1

Return to GME. In the GME Browser navigate to the configuration as follows, MSD->Generated configurations->MassSpringDamperAuto2cfgs->Configurations (2-22-2013 15:36:19)->MassSpringDamperAuto2cfgs_cfg1, and double click (1). Then double click on the spring component (2).



Step 2

Change the spring constant from 9 to 3 by double clicking on the Prop item, and then return to the testbench named MSD_om_dassl.



Step 3

Repeat steps 4 and 5 to execute the analysis again.

Step 4

Return to the dashboard, and check the analysis. You should find qualitatively the requirement is unknown ('yellow'), meaning that these parameters may meet the requirements and further analyses should be considered for this point design.