A simple approach to solving transient problems with ETAS ASCMO

Use Case

Do you know this challenge?

In engine calibration, DoE (Design of Experiments) is a widely used method for solving multi-parameter problems with conflicting goals. The models typically used with this method are limited to stationary problems and are unable to represent transient characteristics of dynamic systems. Although highly accurate models exist and are available with tools like ETAS ASCMO-DYNAMIC, the high complexity of the transient DoE process comes with a much higher effort. There is however a simpler solution that one should consider.

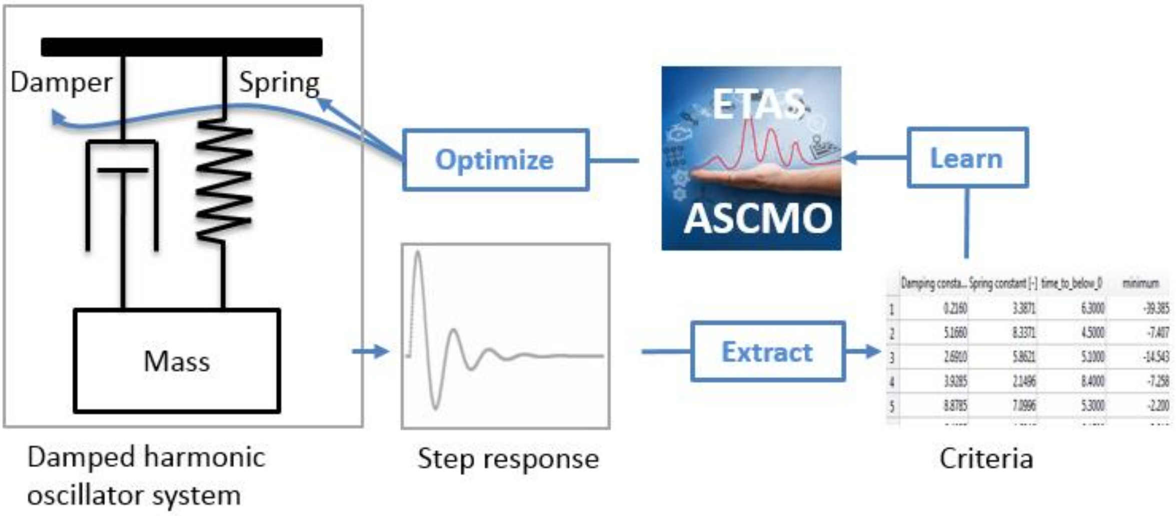
Our Solution - The criteria based DoE approach

For some dynamic calibration tasks it is possible to significantly simplify the problem by taking only specific key features of the problem into account. In the case of a step response for example, this can be achieved by focusing on maximum overshoot or settling time after step excitation instead of focusing on all transient characteristics. In this case, the much simpler “steady state” DoE methodology of ASCMO-BASE can be applied.

Technical Details

The following example represents a simple physical dynamic system. Its behavior can be altered by tunable parameters. The task here is to find a set of parameters that allow the system to settle in the fastest way possible without overshoot, a case known as aperiodic borderline.

It is not a steady state system, but the extracted features of the step response are not time dependent. Therefore, the standard steady state DoE methodology can be applied here.



	Damping consta...	Spring constant [-]	time_to_below_0	minimum
1	0.2160	3.3871	6.3000	-39.385
2	5.1660	8.3371	4.5000	-7.407
3	2.6910	5.8621	5.1000	-14.543
4	3.9285	2.1496	8.4000	-7.258
5	8.8785	7.0996	5.3000	-2.200

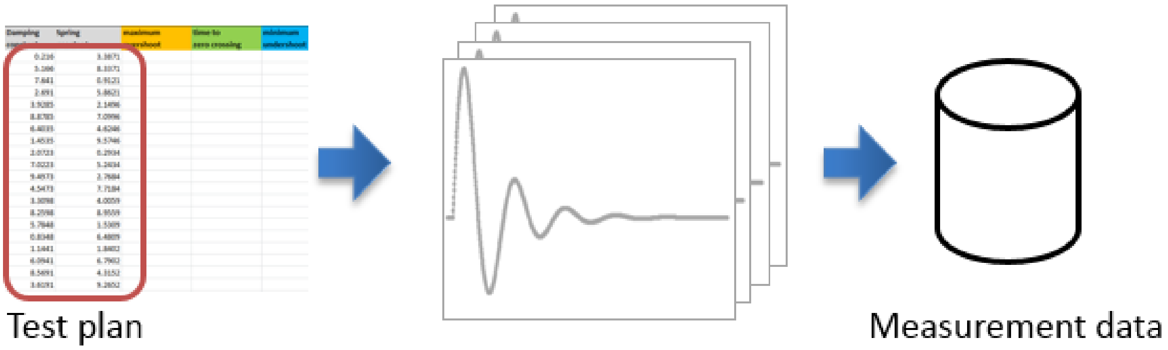
Example: Workflow for criteria based DoE

Step 1: Test plan design

- Set range of parameters for variation.
- Generate test plan with ASCMO ExpeDes.

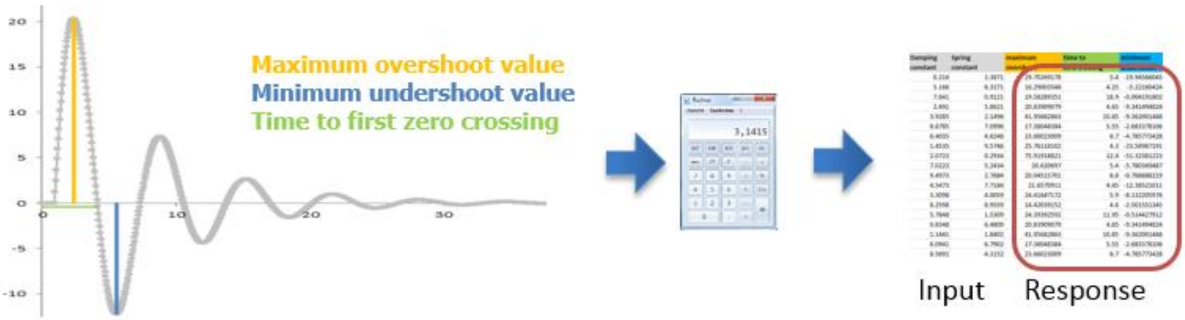
Step 2: Conduct measurements

- Change systems calibration parameters according to test plan.
- Apply step excitation.
- Collect measurement data.



Step 3: Feature extraction

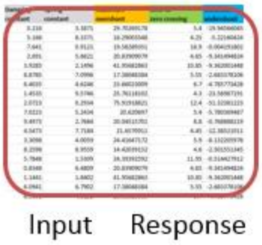
- Calculate features from measured dynamic response signals.

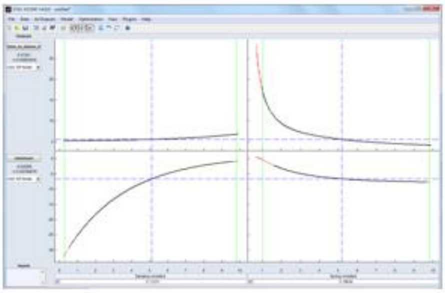


In this example, the criteria of interest would be maximum over- and undershoot and the time to first zero crossing. These criteria are calculated from the measured signals for different calibration value settings.

Step 4: Build data driven model

- Read DoE measurement data.
- Perform ASCMO model training.





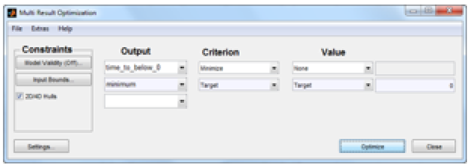
Feature model of step response

Instead of dealing with the whole transient characteristics of the system, the model represents only certain features of the signals. For a number of use cases, this is everything one needs in order to solve the calibration problem.

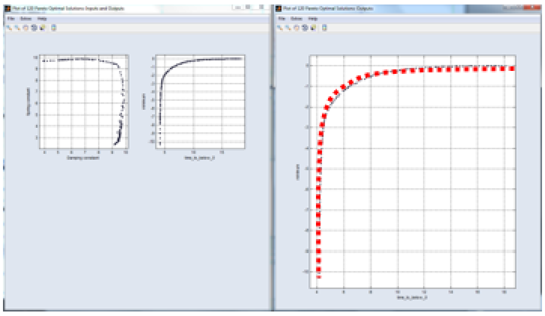
Typical applications in engine calibration are drivability or low idle regulator optimization.

Step 5: Define optimization criteria

- Calculate pareto optimal solutions with ASCMO.



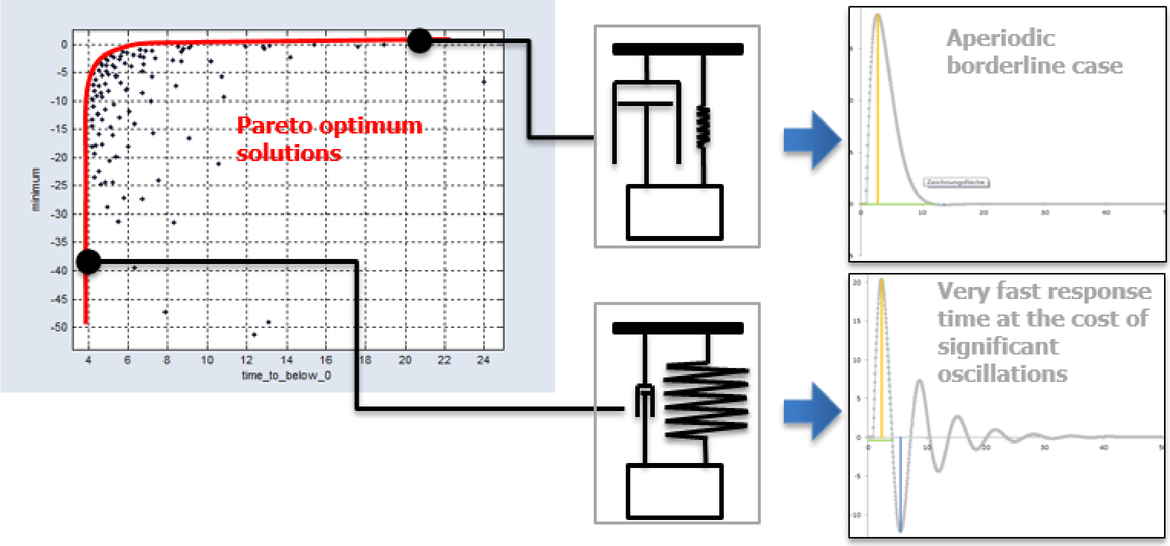
- Maximize the minimum value
- Minimize the time to first zero crossing



Pareto optimal calibration values with corresponding results

Step 6: Evaluate optimization results

- Analyze the simulated results on the pareto optimal solutions front, which represents the tradeoff between the fastest response and the smallest over- and undershoot.
- Verify the optimization results for the real system.



The pareto optimum indicated by the red line represents the solutions that have the smallest oscillations for a given settling time (time to first zero crossing). Any faster settling times will be at the cost of stronger oscillations. A very specific and often searched-for solution is the aperiodic borderline case. This is simply the fastest possible settling time without any oscillations. It can easily be found with ASCMO.

Tools used

- ETAS ASCMO 4.7

Your ETAS Contact

Dariusz Humienik; +49 711 3423 - 2416
dariusz.humienik@etas.com