PODIUM

ADVANCED TECHNOLOGIES

SCG007C – WEC Hypercar

DAMPING INITIAL STUDY

Worst case dimensioning

Introduction

Worst case definition:

- Highest damping force required

Worst case for central dampers:

- Low roll damping
- High heave damping

Worst case for lateral dampers:

- High heave damping
- No central damper mounted

Worst case dimensioning

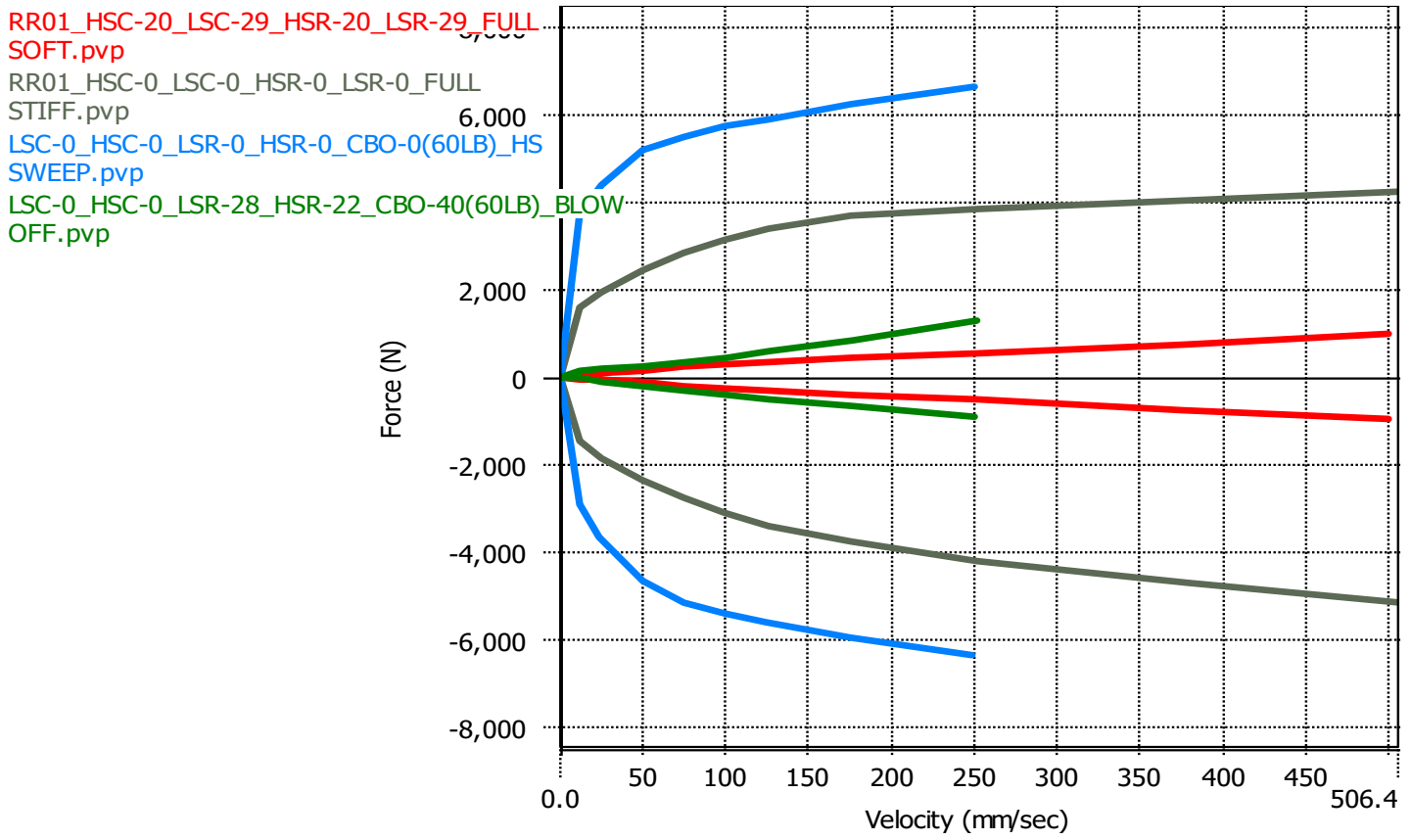
Preliminary observations on the damper plots

- The “knee” speed of the Penske dampers is quite low ~25-50 mm/s
- The maximum adjustment range up to 250mm/s is quite symmetrical in bump and rebound
- The big damper has been tested only up to 250mm/s
- The blowoff intervention is not visible in the damper curves

  -> is it possible that the small damper doesn’t have a blow off?

  -> what speed is usually used for the blowoff?

  -> should the blowoff being mounted on the side damper only?



Worst case dimensioning

Choosing the “extreme” damping values in heave

References

- SCG003C: Low speed damping 1.2 in bump, 0.35 high speed
- OptimumG Tech Tips: 0.6-0.7 starting value, half in high speed
- Milliken: IndyCar example 0.9 front 0.75 rear, up to 1.9 front 1.4 rear
- Balkwill: Optimum of 0.33 for harmonic road, 0.17 for pothole (non aero car)
- Learn&Compete Kasprzak About 1 for ground effect cars

Table 22.3 Indy Oval Track Car Damping Ratios

Condition	Damping Ratio, Fraction Critical			
	Ride F.	Ride R.	Roll	Pitch
1. Baseline Config.	0.938	0.747	5.944	2.188
2. Max. Damping on Front	1.938	0.747	9.129	3.750
3. Min. Damping on Front	0.219	0.747	3.655	1.066
4. Max. Damping on Rear	0.938	1.387	8.477	2.809
5. Min. Damping on Rear	0.938	0.157	3.606	1.616
6. Front Springs Up 50%	0.766	0.747	5.356	1.907
7. Front Springs Dn 50%	1.326	0.747	6.781	2.647
8. Rear Springs Up 50%	0.938	0.610	5.278	2.012
9. Rear Springs Dn 50%	0.938	1.057	6.949	2.421

Worst case dimensioning

Central dampers

Damping ratios

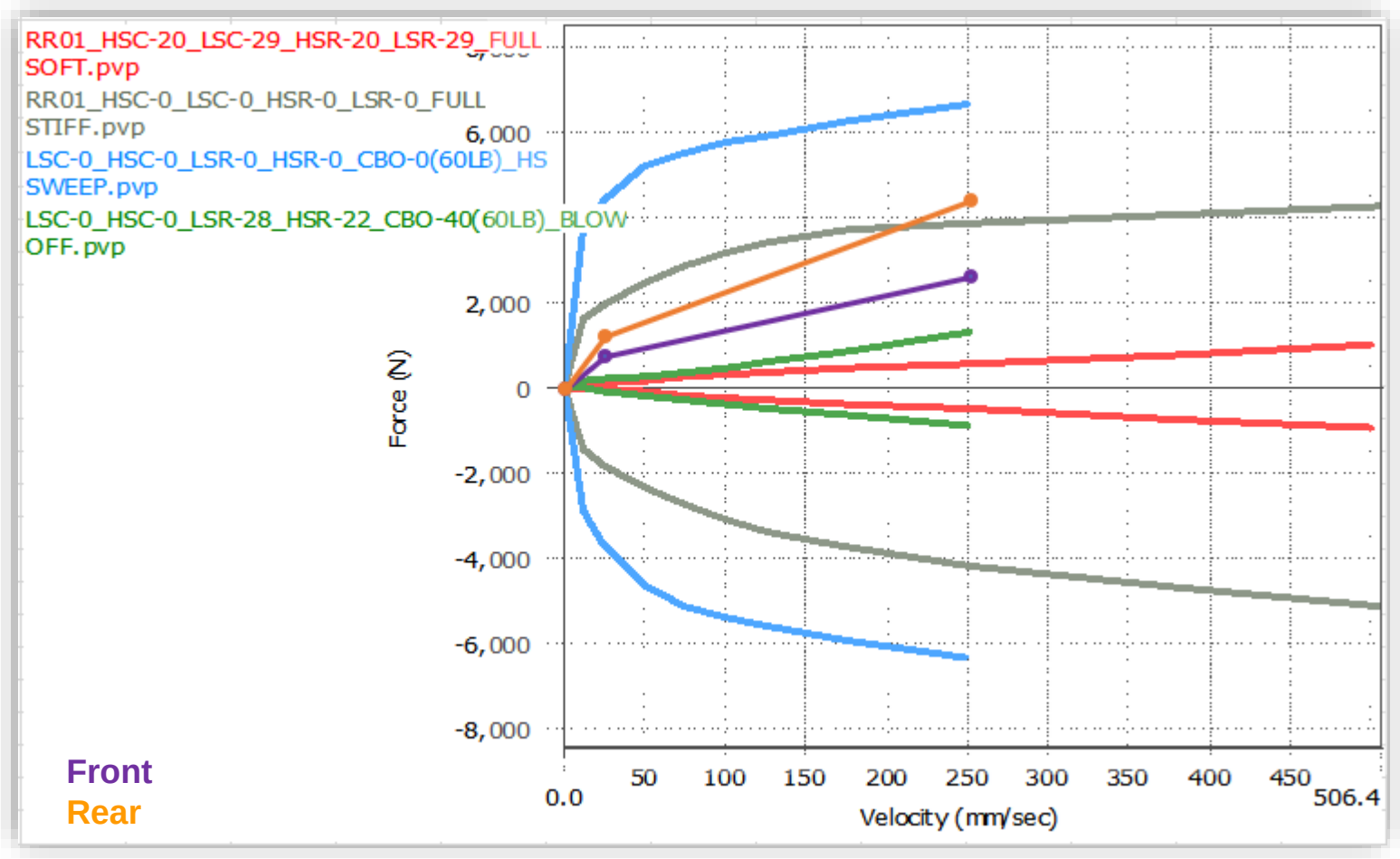
	Heave*	Roll
Low speed	1.5	0.5
High speed	0.5	0.3

* Stiffness @ 160 km/h, latest non-linear setup

- Symmetrical bump/rebound assumed
- Damping ratio calculated with 1-dof

Notes:

With the small body a lot of low speed damping margin Is available, high speed damping not exceptional above 200mm/s.



Worst case dimensioning

Lateral dampers

Damping ratios

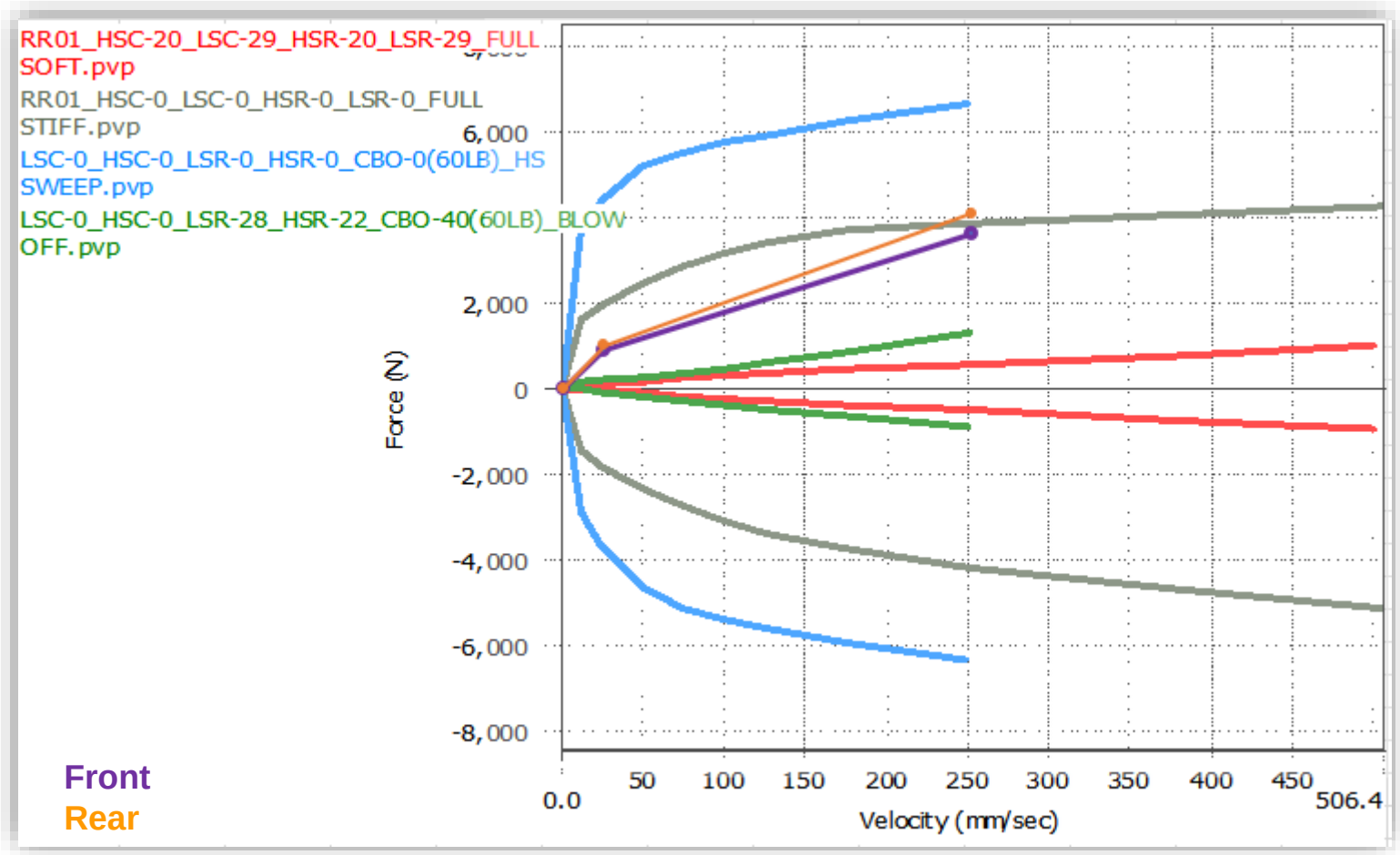
	Heave*	Roll
Low speed	1.5	-
High speed	0.5	-

* Stiffness @ 160 km/h, latest non-linear setup

- Symmetrical bump/rebound assumed
- Damping ratio calculated with 1-dof

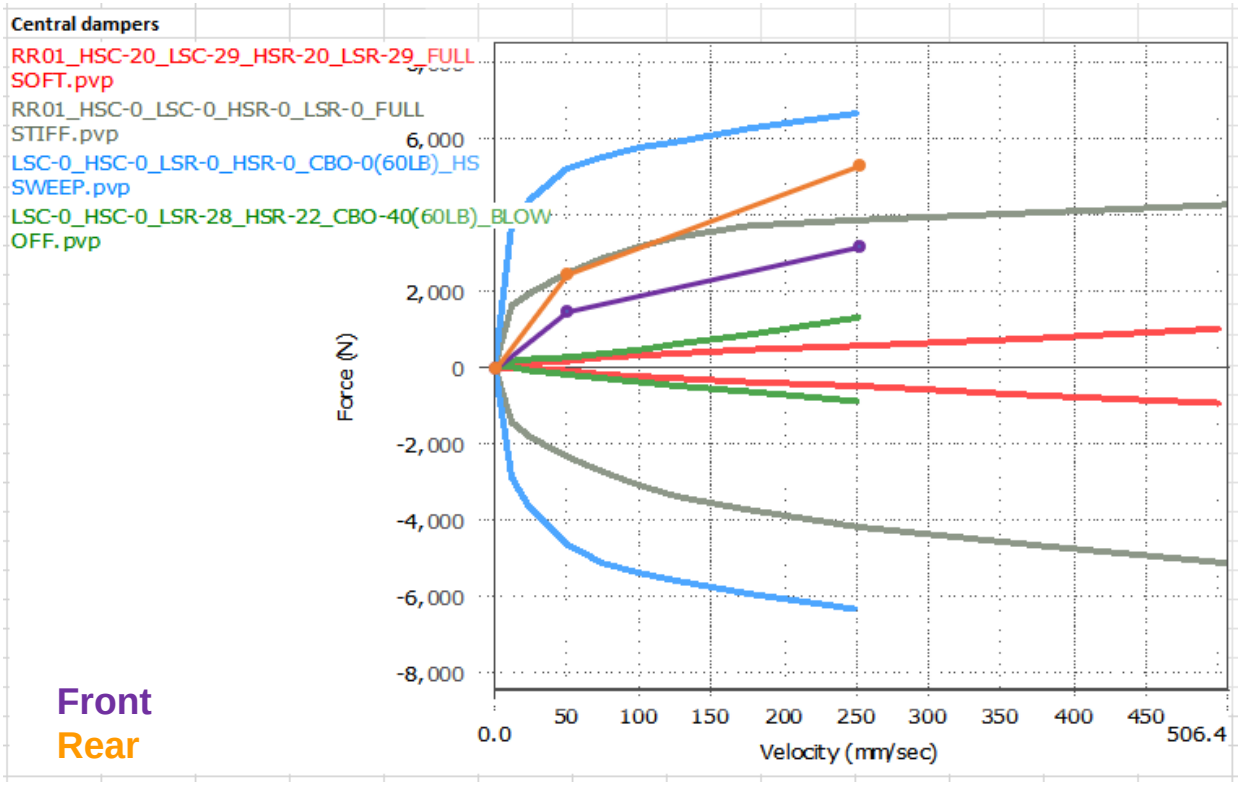
Notes:

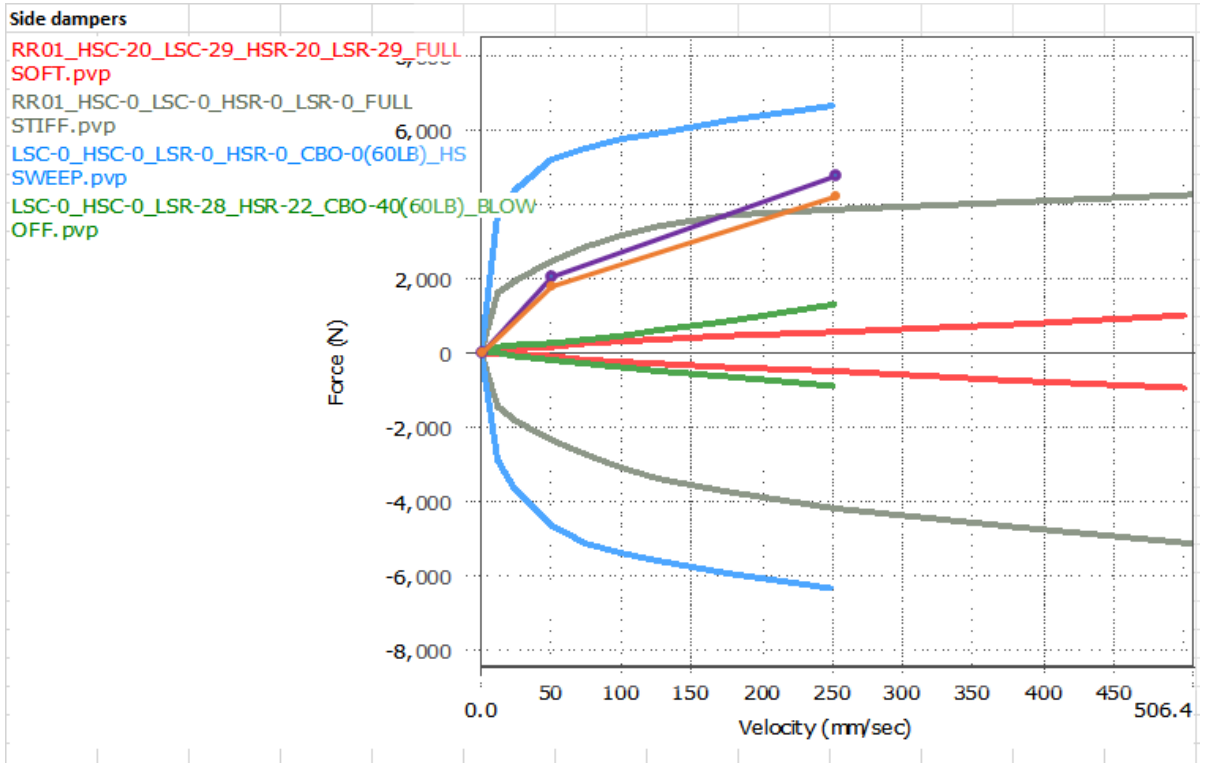
Supporting all the car damping with seem possible also with small side dampers only.



Worst case dimensioning

With 50mm/s “knee” speed





Base setup update

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Introduction

To assess a baseline for damping setup the following simulations have been performed:

- Post-rig heave (low speed central dampers)
- Post-rig roll (low speed of lateral dampers)

- Post-rig pitch (to adjust the front and rear central dampers relative ratio)

- Post-rig single wheel bump (to adjust central dampers bump-to-rebound ratio)

- Le Mans lap, flat road (to evaluate reduction in CPL and RH amplitude)

- Le Mans, rough road (next steps)

Base setup update

Heave

Heave damping	C	Split	ζ	|z0/h0| max	F max [Hz]
Front side damper	24.5	0.53	0.70	2.3	4
Rear side damper	21.7	0.47			

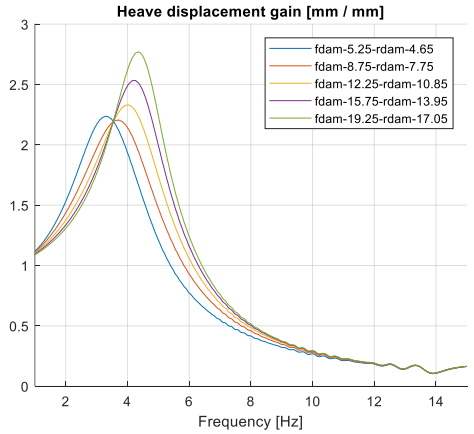
- 0.5 to 15.5 Hz frequency sweep
- 0.5 Hz/s frequency rise rate
- 25mm/s actuator constant velocity peak
- Aero speed 160km/h

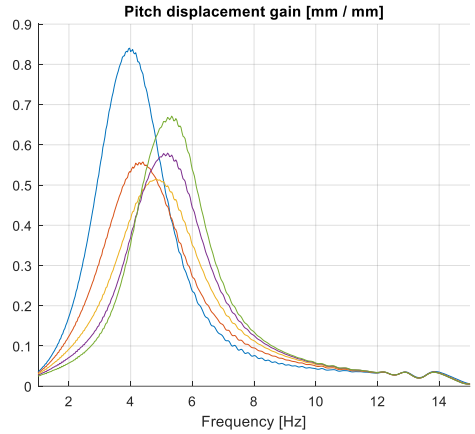
- Same front and rear damping ratio

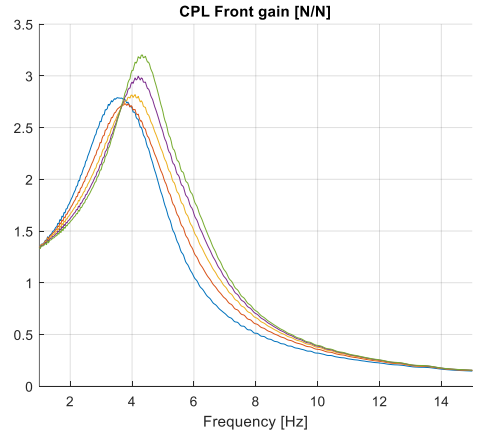
Chosen option:

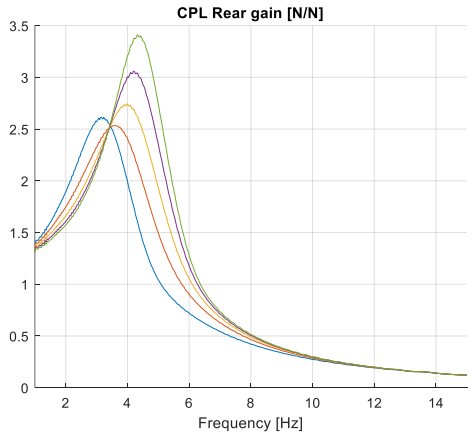
Yellow

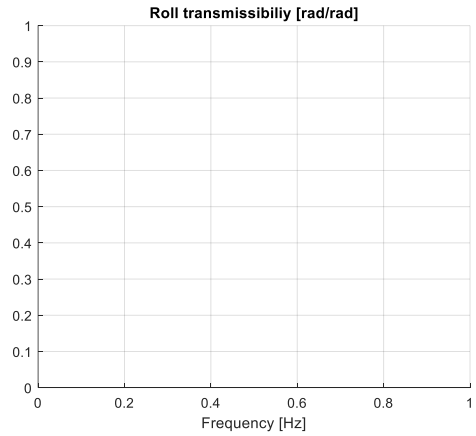
- Just over-dampened (looking at plots)
- Better (lower) pitch-heave coupling

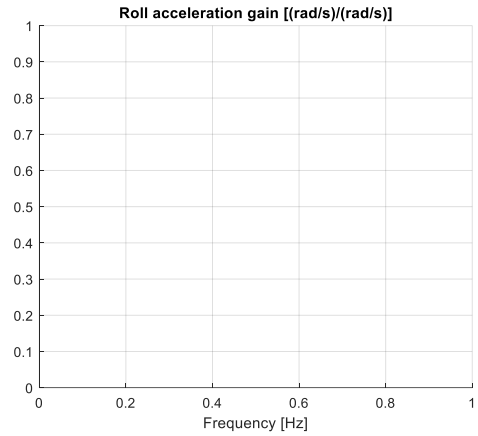












Base setup update

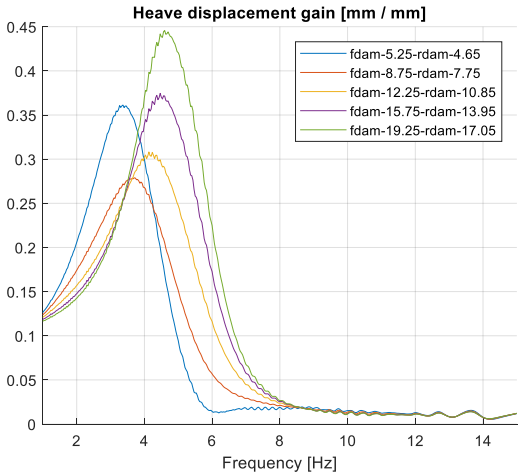
Pitch

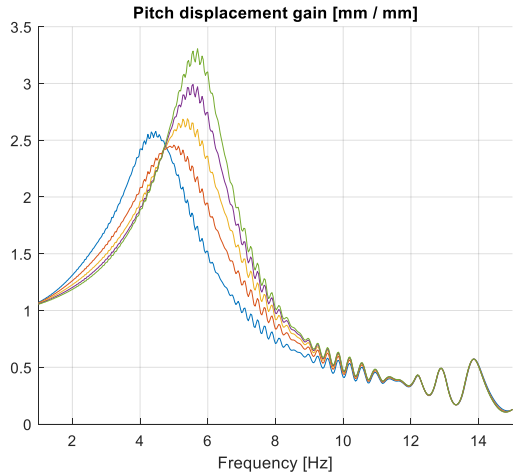
- 0.5 to 15.5 Hz frequency sweep
- 0.5 Hz/s frequency rise rate
- 25mm/s actuator constant velocity peak
- Aero speed 160km/h

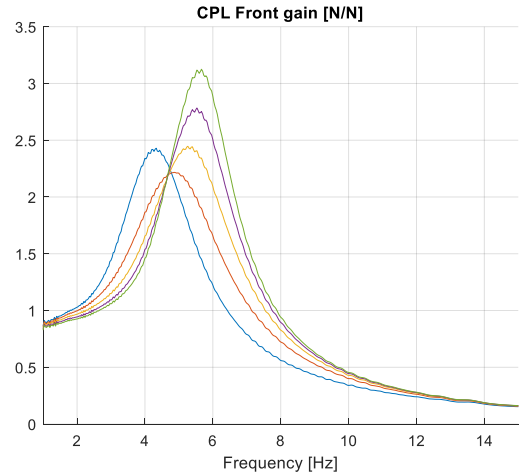
- Same front and rear damping ratio

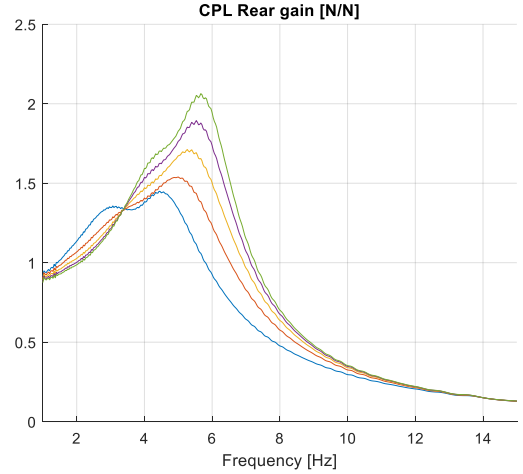
Comments:

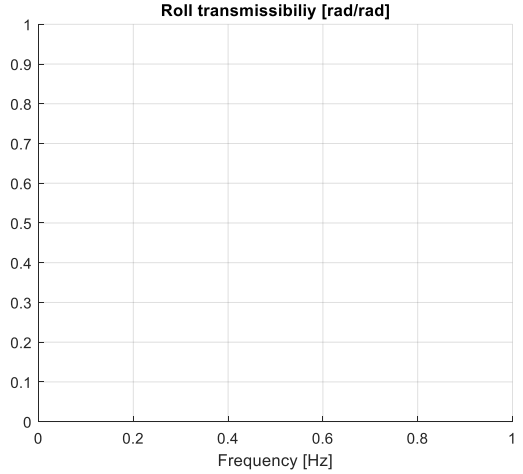
The yellow option chosen from heave simulations is really close to the “optimal” one for pitch too.

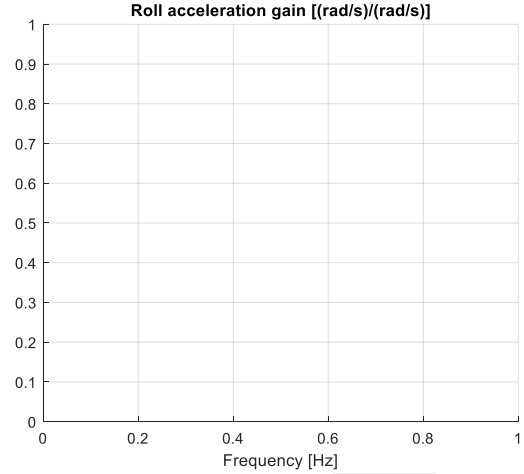










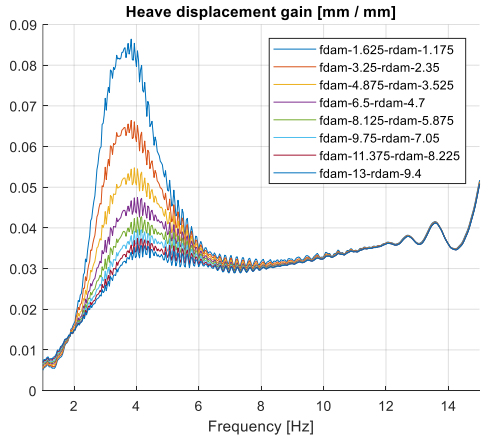


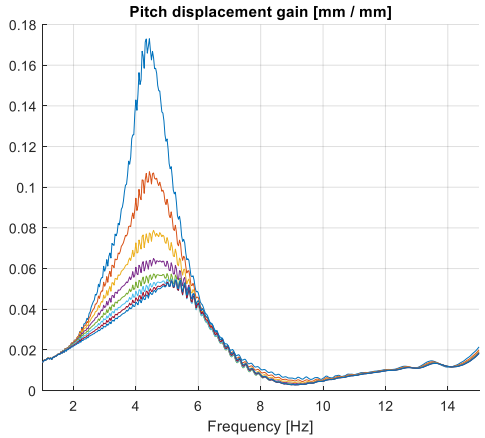
Base setup update

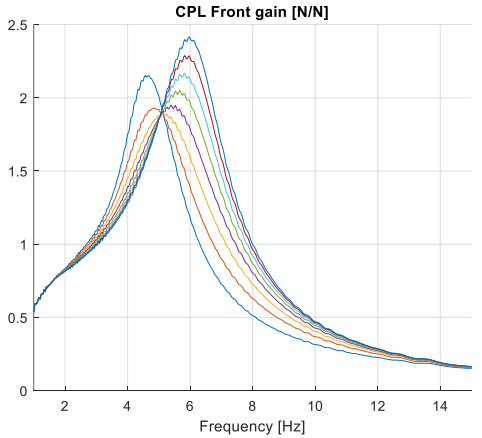
Roll

Roll damping	C	Split	ζ	|z0/h0| max	F max [Hz]
Front side damper	6.5	0.58	0.74	2.66	5.49
Rear side damper	4.7	0.42			

- 0.5 to 15.5 Hz frequency sweep
- 0.5 Hz/s frequency rise rate
- 25mm/s actuator constant velocity peak
- Aero speed 160km/h
- Front/Rear damping distributed as stiffnesses, under/over steer in dynamic condition could suggest a different ratio

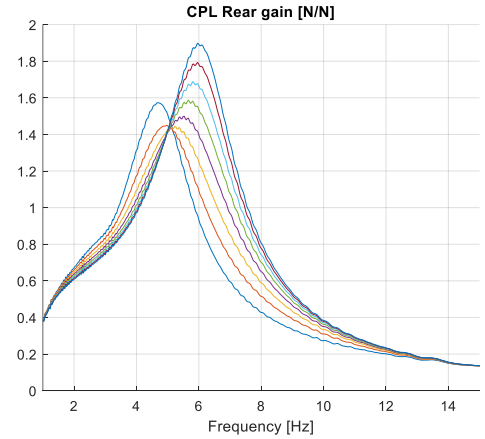


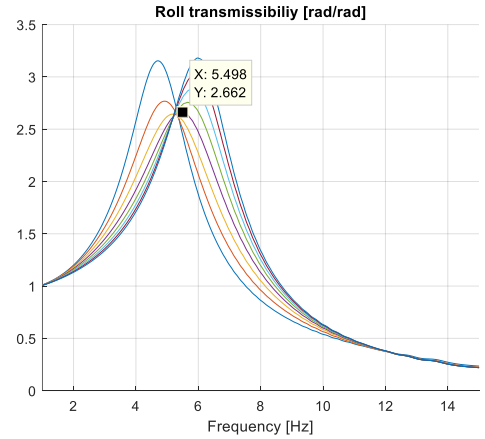


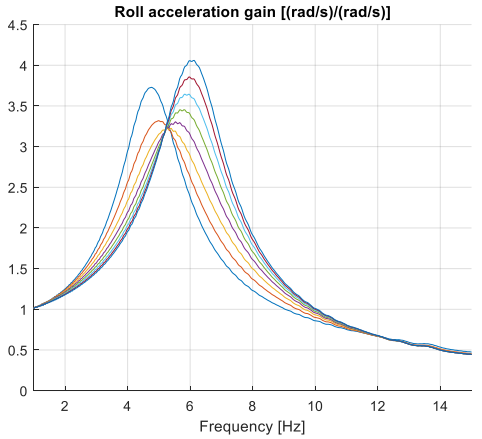


Chosen option: **Violet**

- Minimum amplification factor
- Damping ratio 0.7, literature suggests much higher values (up to 5 or 6) to improve responsiveness, benefits to be evaluated







Base setup update

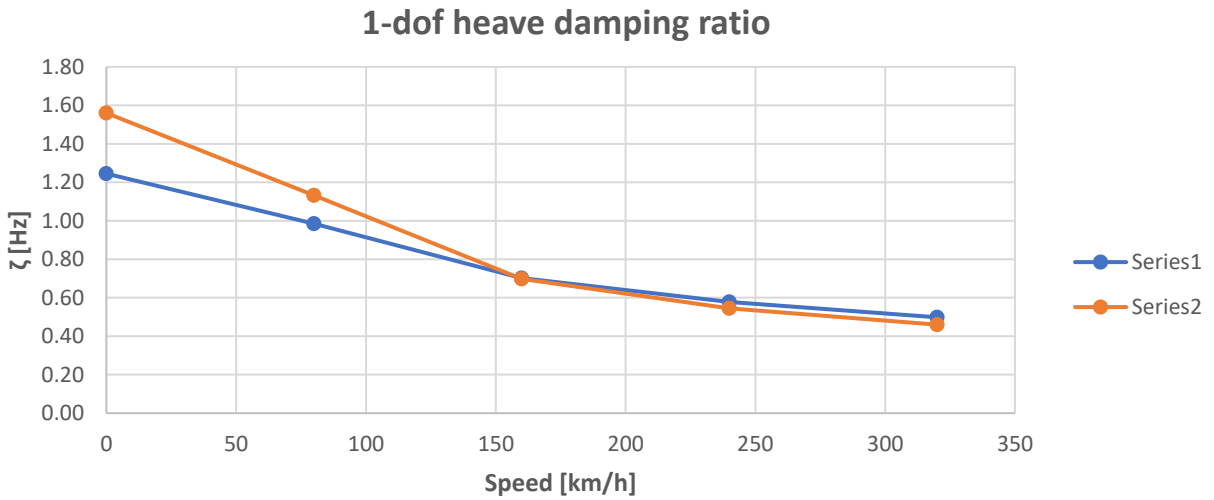
“New” setup

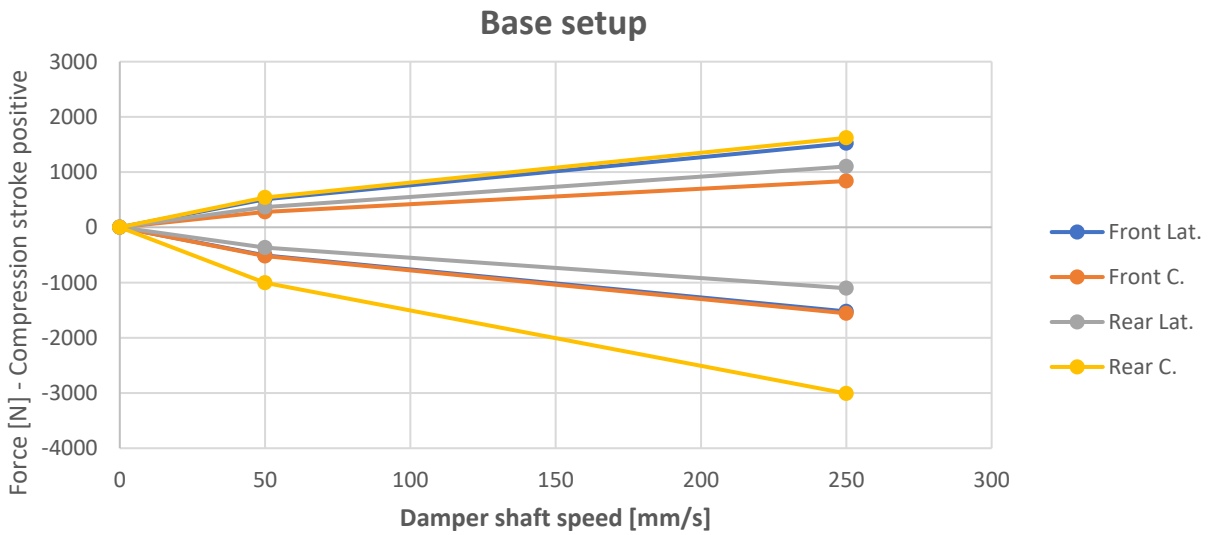
Biggest open point: bump-to-rebound ratio

Next simulations:

- Step steer / Step braking
- Chicane
- Rough road

Damping Ratio ζ @160km/h				
	LSC	HSC	LSR	HSR
Front Heave	0.60	0.30	0.80	0.40
Rear Heave	0.53	0.26	0.75	0.37
Roll	0.74	0.37		
Single wheel F	0.58	0.29	0.77	0.39
Single wheel R	0.59	0.30	0.78	0.39





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