Mechanical Q factor measurement

Main flow:

- 1. Excite a resonance at f_0
- 2. Measure its decay time constant τ
- (3. Obtain Q factor using Q = $\pi f_0 \tau$)
- 4. Repeat 1-3 for all the measurable resonances

What we need:

Q factors with & without damping at lower frequency (below 20 Hz). in order to know whether all the resonances, which can disturb the lock-acquisition, are damped enough by active controls.

Requirement for damping is set to following: 1/e decay time constant < 1 min

Ref. <u>https://gwdoc.icrr.u-tokyo.ac.jp/cgi-bin/private/DocDB/ShowDocument?docid=6285</u> <u>https://gwdoc.icrr.u-tokyo.ac.jp/cgi-bin/private/DocDB/ShowDocument?docid=4155</u>

Preparation:

- 1. Measure forced transfer functions in order to know which the appropriate actuator is.
- 2. Calculate eigen-mode-shapes & their resonant frequencies using 3D-rigid-body model.
- 3. Implement damping filters in order to complete this measurement smoothly.

Measurement (for the time being):

1. Open "dv" for watching oscillation of related DoFs.

- 2. Open 2 windows of "diaggui" for excitation & for measurement.
- 3. Set excitation amplitude, frequency, and time duration in diaggui for excitation.
- 4. Input excitation signals and after confirming the resonance is excited enough by looking at dv, turn off the excitation then start measurement of the decay signal.

5. Fit the measured data by following formula:

$$f(t) = A \exp\left(-\frac{t}{\tau_e}\right) \sin\left(2\pi f_0 t\right) + x_0,$$

When it was difficult to excite only one resonant mode and a beating signal is measured, the signals can be fitted by a double decay sine wave function:

$$f(t) = A_1 \exp\left(-\frac{t}{\tau_{e,1}}\right) \sin\left(2\pi f_1 t\right) + A_2 \exp\left(-\frac{t}{\tau_{e,2}}\right) \sin\left(2\pi f_2 t\right) + x_0$$

Photos:

1. Open "dv" for watching oscillation of related DoFs.

X Data Viewer	- - ×	
File Frames	Help	
Input Display Signal Realtime Playback K1:VIS-EX K1:VIS-MCE K1:VIS-MCI K1:VIS-MCI K1:VIS-MCI K1:VIS-PR3 (COLLOUTF_V3_EXC (1 K1:VIS-PR3_IM_COLLOUTF_V3_IN1 (16 K1:VIS-PR3_IM_COLLOUTF_V3_IN2 (16 K1:VIS-PR3_IM_COLLOUTF_V3_IN2 (16 K1:VIS-PR3_IM_COLLOUTF_V3_IN2 (16 K1:VIS-PR3_IM_COLLOUTF_V3_IN2 (16 K1:VIS-PR3_IM_COLLOUTF_V3_IN2 (16 K1:VIS-PR3_IM_DAMP_L_IN1 (16k, test K1:VIS-PR3_IM_DAMP_L_IN1_(16k, test K1:VIS-PR3_IM_DAMP_L_IN2 (16k, test K1:VIS-PR3_IM_COMP_L_IN2 (16k, test K1:VIS-PR3_IM_COMP_L_IN1_COL_(2k, 1 K1:VIS-PR3_IM_COMP_L_IN1_COL_(2k, 1 K1:VIS-PR3_IM_COMP_L_IN1_(16k, test K1:VIS-PR3_IM_COMP_L_IN1_COL_(2k, 1 K1:VIS-PR3_IM_COMP_L_IN1_C	1: K1:VIS-PR3_BF_DAMP_L_IN1 6k, testpo 6k, testpo 6k, testpo 6k, testpo 6k, testpo 7: K1:VIS-PR3_BF_DAMP_V_IN1 4: K1:VIS-PR3_BF_DAMP_V_IN1 5: K1:VIS-PR3_BF_DAMP_Y_IN1 6: K1:VIS-PR3_BF_DAMP_Y_IN1 6: K1:VIS-PR3_IM_DAMP_L_IN1 9: K1:VIS-PR3_IM_DAMP_V_IN1 10: K1:VIS-PR3_IM_DAMP_V_IN1 10: K1:VIS-PR3_IM_DAMP_V_IN1 11: K1:VIS-PR3_IM_DAMP_V_IN1 12: K1:VIS-PR3_IM_DAMP_V_IN1 12: K1:VIS-PR3_IM_DAMP_V_IN1 13: K1:VIS-PR3_IM_DAMP_V_IN1 14: K1:VIS-PR3_IM_DAMP_V_IN1 15: K1:VIS-PR3_IM_DAMP_V_IN1 16: K1:VIS-PR3_IM_DAMP_V_IN1 16: K1:VIS-PR3_IM_DAMP_V_IN1 16: K1:VIS-PR3_IM_DEV_V_IN1_IN1 16: K1:VIS-PR3_IM_DEV_V_IN1_IN1 16: K1:VIS-PR3_IM_DEV_V_IN1_IN1 17: K1:VIS-PR3_IM_DEV_V_IN1_IN1 18: K1:VIS-PR3_IM_DEV_V_IN1_IN1 19: K1:VIS-PR3_IM_DEV_V_IN1_IN1 19: K1:VIS-PR3_IM_DEV_V_IN1_IN1 10: K1:VIS-PR3_IM_DEV_V_IN1_IN1	
◇ Fast ◇ Slow ◇ DHT ◇ Old Selection K1:VISPRS_IM_IESI_L_EXU Connected to kinds0 Running		
X Data Viewer - 🗆 🗙		
<u>F</u> ile F <u>r</u> ames	Help	
Input Display Signal Realtime Playback Type Full = Mode Standard = Ch 1 = 0n Resolution 128 = Refresh 1 = 0n Above = 0.00 Ch 1 = 0n Above = 0.00 Ch 1 = 0n Above = 0.00 Ch 1 = 0n K1:VIS-PR3_BF_DAMP_L_INI Ch 1 = 0 Red = Sec 8 = 0 Hin ±5.00 Unit F Auto Start Stop	1: K1:VIS-PR3_BF_DAMP_L_IM1 Signal 1: K1:VIS-PR3_BF_DAMP_T_IM1 2: K1:VIS-PR3_BF_DAMP_V_IM1 4: K1:VIS-PR3_BF_DAMP_P_IM1 3: K1:VIS-PR3_BF_DAMP_V_IM1 4: K1:VIS-PR3_BF_DAMP_V_IM1 4: K1:VIS-PR3_IM_DAMP_L_IM1 5: K1:VIS-PR3_IM_DAMP_V_IM1 5: K1:VIS-PR3_IM_DAMP_V_IM1 6: K1:VIS-PR3_IM_DAMP_V_IM1 1: K1:VIS-PR3_IM_DAMP_L_IM1 1: K1:VIS	
Connected to k1nds0	Ruppipo	

Step1: \$ dataviewer & (or \$ dv &)

Step2: Add channel names which you want to measure.



k1ctr1, localhost:10.0, Untitled

Photos:

2. Open a window of "diaggui" for excitation.

X Diagnostics test tools - /users/VIS/TypeBp/170615/pr3/q_meaurement/exc.xml -	
Eile Edit Measurement Plot Window	
Input Measurement Excitation Result	
Channel Selection	Input channel names which you
	Input channel names which you
Retive Excitation Channe K1:VIS-PR3 IM TEST Y EXC	want to excite.
Readback Channel: O Default O None O User:	
Waveform Sine Waveform File	Sot a chang of ovcitation signal
Frequency: 0.1 + Hz Amplitude: 5 + Offset: 0 + Phase: 0 + deg Ratio: 50 - %	Set a shape of excitation signal
Freq. Range: 0 Hz Amp Range. 0 Filler.	Set a excitation frequency & amplitude
Channel 1	
Active Excitation Channel:	
Readback Channel: O Default O None O User:	
Waveform: Sine Waveform File: Choose	
Frequency: 100 🖨 Hz Amplitude: 0 🖨 Offset: 0 🖨 Phase: 0 🖨 deg Ratio: 50 🚽 %	
Freq. Range: 0 Hz Ampl. Range: 0 Filter: Foton	Def
Channel 2	Ref:
C Active Excitation Channel:	Chanty & diagoni 8
Readback Channel: O Default O None O User:	Step1: \$ diaggui &
Waveform: Sine Waveform File: Choose	
Frequency: 100 🖨 Hz Amplitude: 0 🖨 Offset: 0 🖨 Phase: 0 🖨 deg Ratio: 50 🚽 %	Step2: open following fie in the application.
Freq. Range: 0 Hz Ampl. Range: 0 Filter: Foton	/users/VIS/TypeBp/1/0615/q_measurement/pr3/exc.xml
Channel 3	
Active Excitation Channel:	
Readback Channel: O Default O None O User:	
Waveform: Sine Waveform File: Choose	
Frequency: 100 🖨 Hz Amplitude: 0 🖨 Offset: 0 🖨 Phase: 0 🖨 deg Ratio: 50 🚽 %	
Freq. Range: 0 Hz Ampl. Range: 0 Filter: Foton	
Start Pause Resume Abort	
Beneat Sine resigninge	

Photos:

2. Open another window of "diaggui" for measurement

X Diagnostics test tools - /users/VIS/TypeBp/170615/pr3/q_meaurement/template.xm	ml – 🗆 🗙	
Eile Edit Measurement Plot Window	<u>H</u> elp	
Input Measurement Excitation Result		
Measurement		
C Fourier Tools C Swept Sine Response C Sine Response . Triggered Time Response		• • • • • • • • • •
⊢ Measurement Channels		Input channel names which you
Channels 0 to 15 C Channels 16 to 31 C Channels 32 to 47 C Channels 48 to 63 C Channels 64 to 79 C Channels 80 to 95		want to managura
0 🔽 K1:VIS-PR3_BF_DAMP_L_IN1 🔹 8 🖾 K1:VIS-PR3_IM_DAMP_V_IN1		Walle to measure.
1 🔽 K1:VIS-PR3_BF_DAMP_T_IN1 9 🗹 K1:VIS-PR3_IM_DAMP_R_IN1		
2 🗹 K1:VIS-PR3_BF_DAMP_V_IN1 💽 10 🗹 K1:VIS-PR3_IM_DAMP_P_IN1		
3 🗹 K1:VIS-PR3_BF_DAMP_R_IN1 💽 11 🗹 K1:VIS-PR3_IM_DAMP_Y_IN1	•	
4 🗹 K1:VIS-PR3_BF_DAMP_P_IN1	<u> </u>	
5 🗹 K1:VIS-PR3_BF_DAMP_Y_IN1 💽 13 🗹 K1:VIS-PR3_TM_OPLEV_TILT_PIT_IN1	•	
6 🗹 K1:VIS-PR3_IM_DAMP_L_IN1	_	
7 🗹 K1:VIS-PR3_IM_DAMP_T_IN1 💽 15 🗹 K1:VIS-PR3_BF_DAMP_GAS_IN1	· ·	
Measurement Time: 60 = sec BW: 10 = Hz Settling Time: 10.0 = %		
Pre-trigger Time:		
		Ker:
Filter:	Foton	Step1: \$ diaggui &
C Start Time		
Now O In the future: 0:00:00 ♦ hh:mm:ss		Step2: open following fie in the application.
C GPS: 1143962319 🖨 sec 0 🖨 nsec C In the past. 0:00:00 🖨 hh:mm:ss		/users/VIS/TypeBp/170615/g_measurement/pr3/template.xm
C Date/time: 6/4/2016 d dd/mm/yy 7:18:22 🖨 hh:mm:ss UTC Time now Lookup	Slow down: 0 🚔 sec/avrg.	
Measurement Time: 25/05/2016 10:15:38 056467 LITC Comment / Description		
Start Pause Pause	Abort	
	AUUIT	
hepear	miggereu time resputise	

Ex. PR3 SAS (Type-Bp):







→ NOT Measured







Since these higher-resonant-frequency-modes are so difficult to be excited and also the decay time constants of these modes are expected originally smaller. Thus we do not take care of them for the time being. Result:



You can automate the above method more: