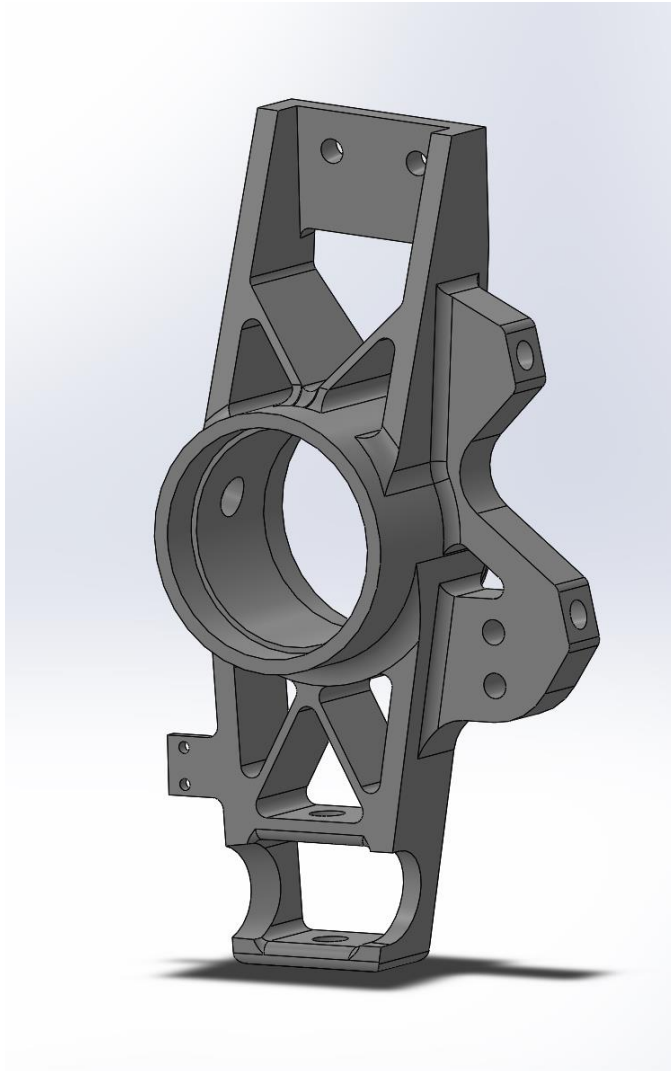


Finite Element Method

Applications on FSAE Uprights

Sam Glover



Background

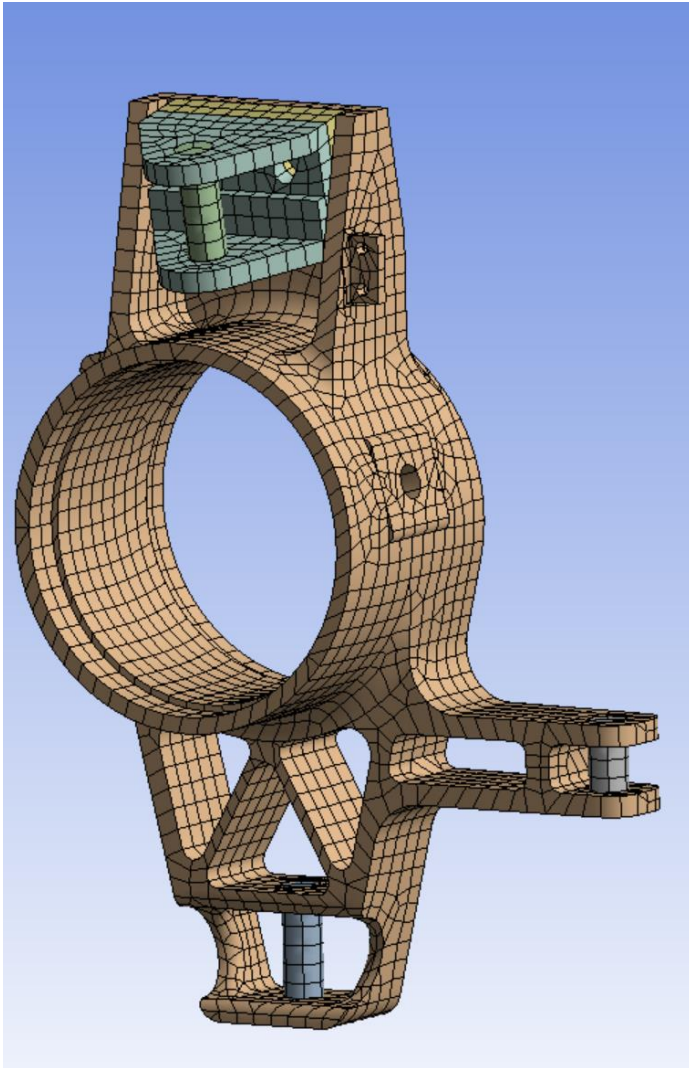
- ▶ Function
 - ▶ Connect wheels to frame (i.e. distribute load to frame)
 - ▶ Structural support for brakes
- ▶ Interfacing hardware
 - ▶ Wheel hubs
 - ▶ A-Arms
 - ▶ Brake calipers
- ▶ No failure permitted
 - ▶ Surrounding components required to fail before uprights

Detailed Load Analysis

- ▶ Methodology
 - ▶ Based on A-Arm and shock geometry
 - ▶ Assumes all tube members are two-force members and not subject to bending loads.

Wishbone Geometry					
Front/Rear	Identifier	Location	X (in)	Y (in)	Z (in)
Front	Upper	Fwd-Frame	10.22	11.79	64.52
		Aft-Frame	10.21	10.00	55.73
		Upright	18.77	12.49	60.76
	Lower	Fwd-Frame	6.89	5.16	66.99
		Aft-Frame	6.95	5.16	51.74
		Upright	19.60	5.16	61.27
	Tierod	Upright	18.63	7.70	59.12
		Rack	7.05	7.04	59.45
	Shock	Wishbone	17.85	5.91	61.27
		Frame	11.67	12.09	61.27
Rear	Upper	Fwd-Frame	9.72	10.48	9.04
		Aft-Frame	9.58	10.45	-3.65
		Upright	17.55	12.00	0.00
	Lower	Fwd-Frame	8.44	4.88	7.35
		Aft-Frame	8.43	4.88	-3.05
		Upright	19.03	4.88	0.00
	Tierod	Upright	19.03	6.93	-3.50
		Frame	7.71	6.11	-3.33
	Shock	Wishbone	17.25	6.00	0.50
		Frame	6.92	18.45	6.65

Upright Calculations					
Location		Fx (lbf)	Fy (lbf)	Fz (lbf)	Magnitude (lbf)
Front	Top Control Arm	236.2	41.5	4.9	239.9
	Lower Control Arm	-541.7	156.9	-7.9	564.0
	Toe Arm	-104.2	-7.5	1.6	104.5
Rear	Top Control Arm	149.0	87.5	304.5	350.1
	Lower Control Arm	-758.7	339.6	-792.2	1148.3
	Toe Arm	245.7	13.9	-7.0	246.2

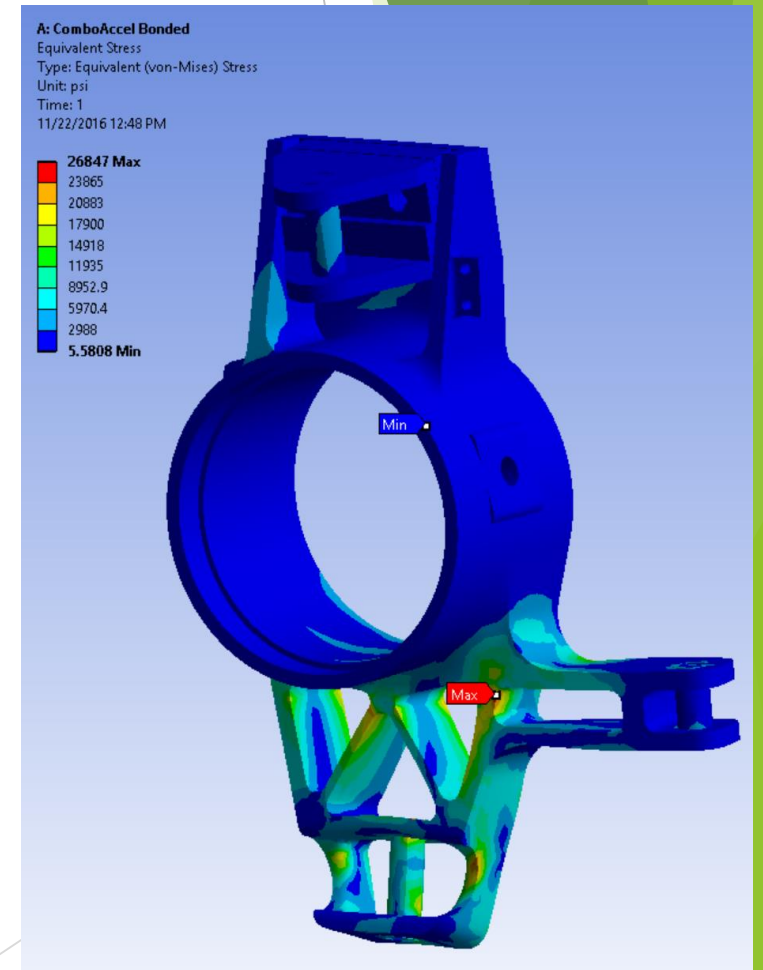
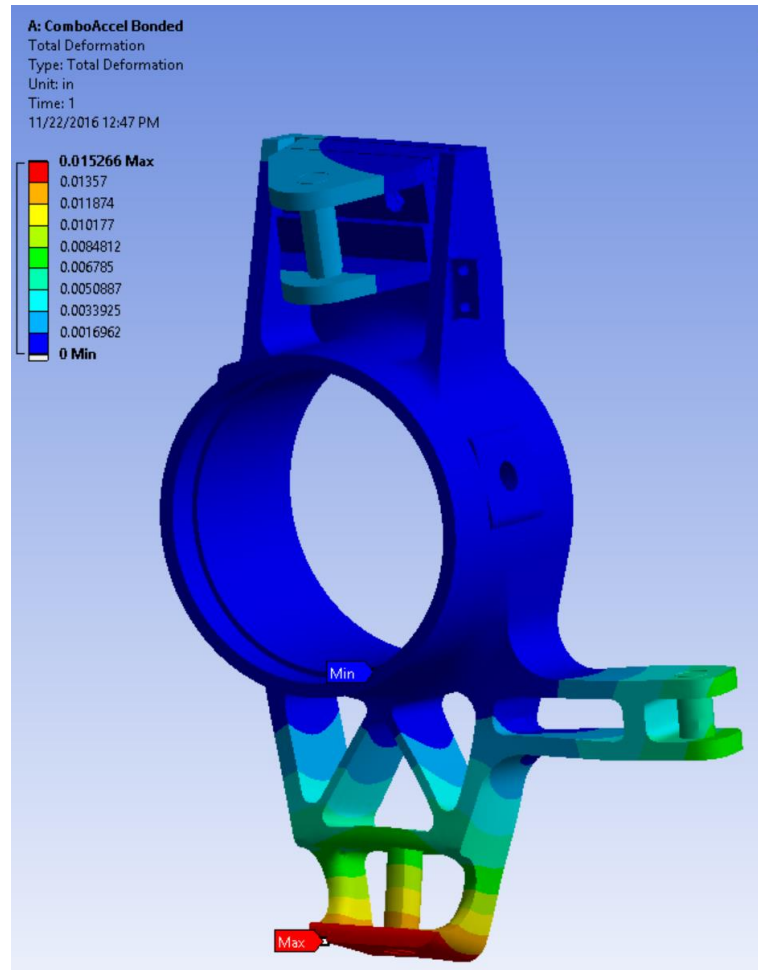
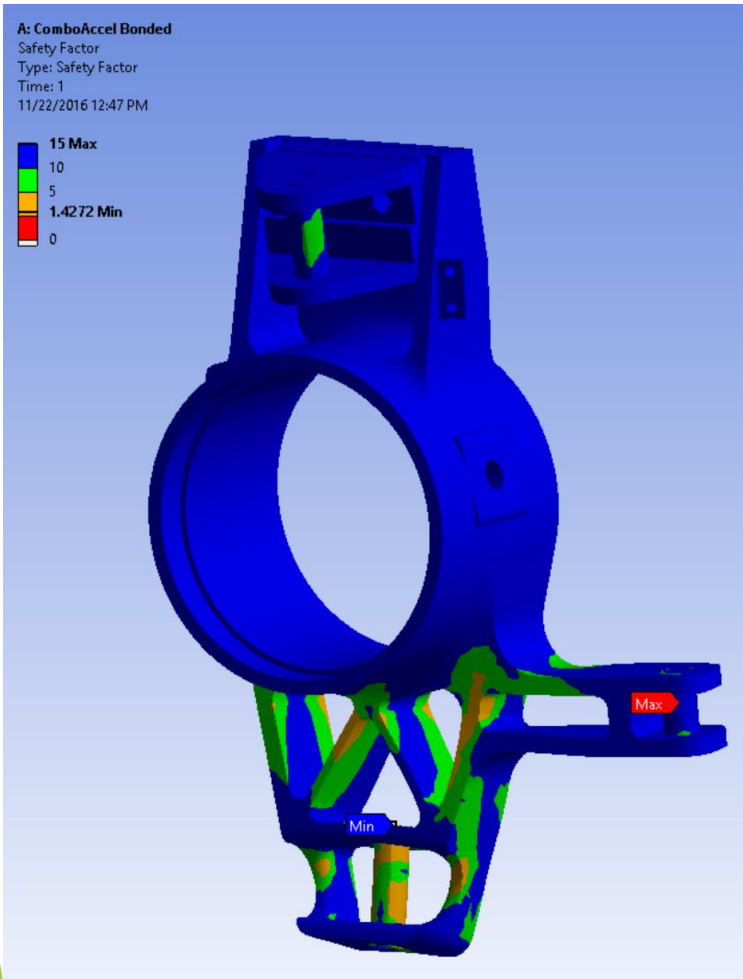


Mesh

- ▶ Hex dominant
- ▶ .2 in mesh size

- ▶ Stats
 - ▶ Orthogonal Quality=.51349
 - ▶ Skewness=.60
- ▶ Mesh Considered Good

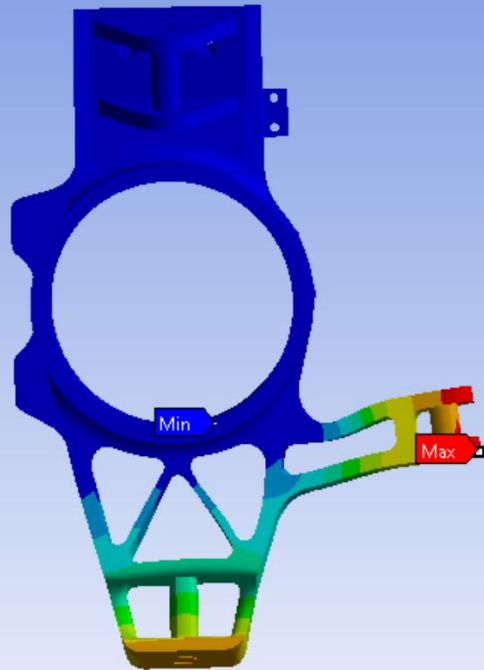
Preliminary Structural Analysis



Modal Analysis: Modes 1-3

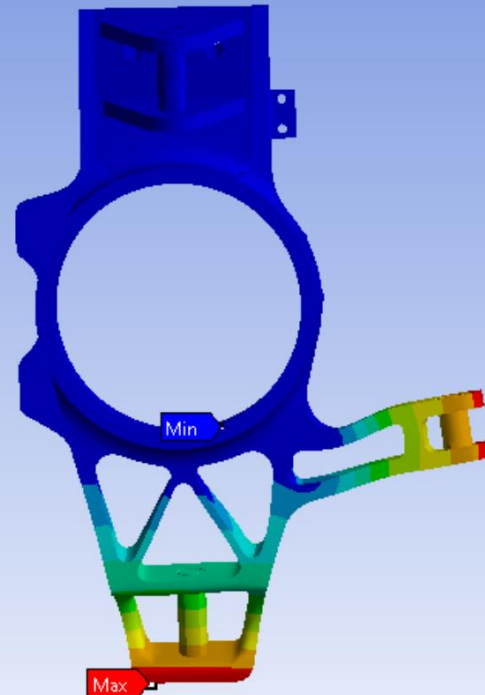
B: Modal
Total Deformation
Type: Total Deformation
Frequency: 2528.9 Hz
Unit: in
11/25/2016 7:06 PM

43.038 Max
38.256
33.474
28.692
23.91
19.128
14.346
9.564
4.782
0 Min



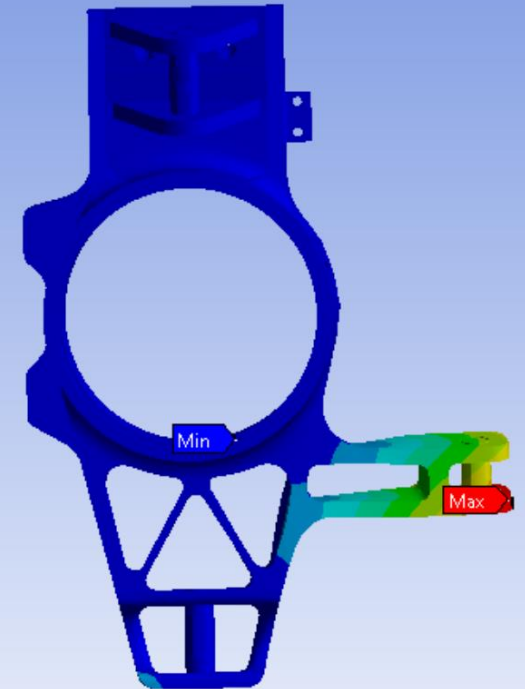
B: Modal
Total Deformation 2
Type: Total Deformation
Frequency: 2591.6 Hz
Unit: in
11/25/2016 7:08 PM

39.91 Max
35.476
31.041
26.607
22.172
17.738
13.303
8.8689
4.4345
0 Min

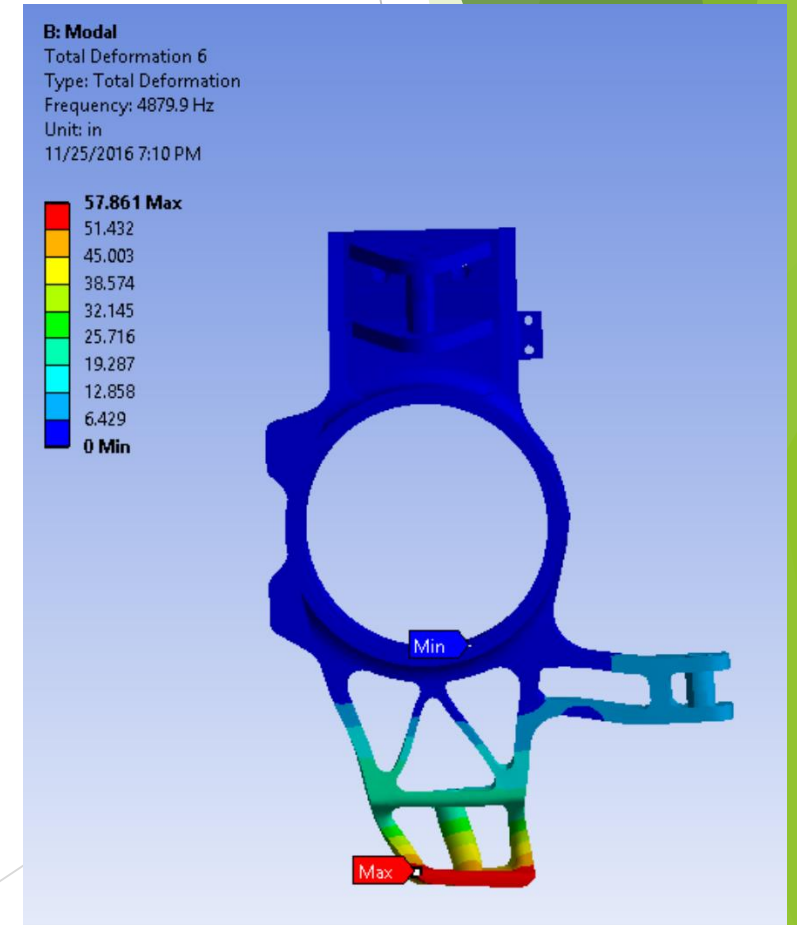
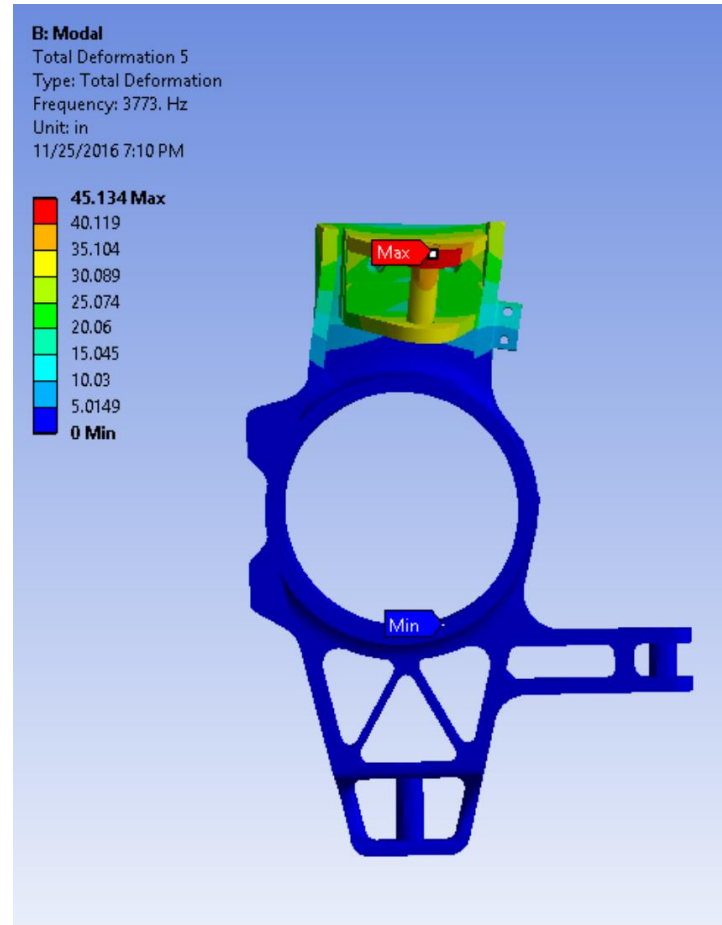
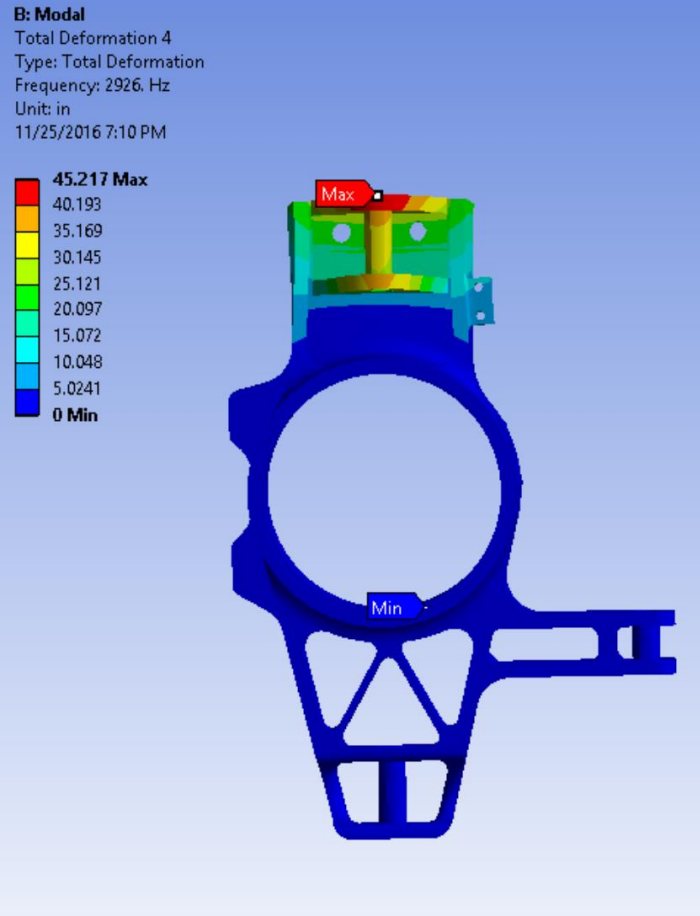


B: Modal
Total Deformation 3
Type: Total Deformation
Frequency: 2868.8 Hz
Unit: in
11/25/2016 7:08 PM

70.399 Max
62.577
54.755
46.933
39.111
31.288
23.466
15.644
7.8221
0 Min



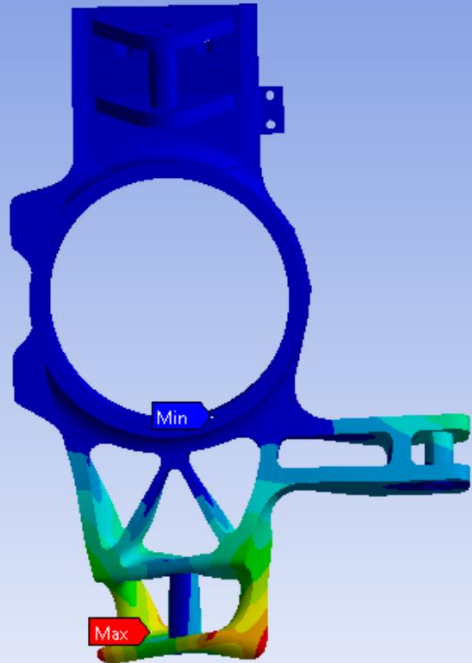
Modal Analysis: Modes 4-6



Modal Analysis: Modes 7-9

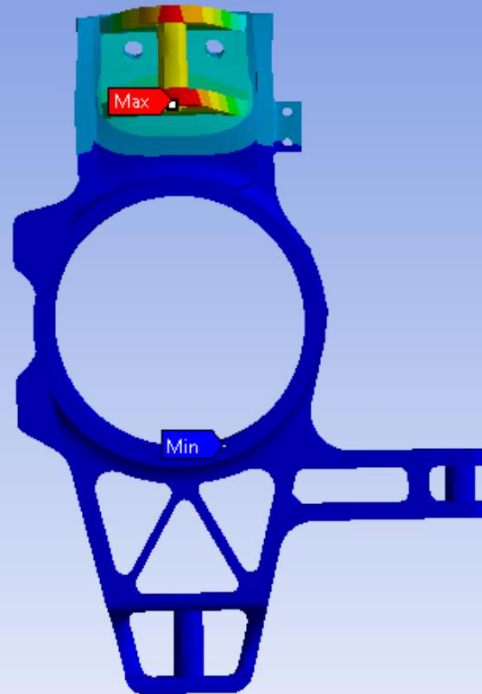
B: Modal
Total Deformation 7
Type: Total Deformation
Frequency: 5372.3 Hz
Unit: in
11/25/2016 7:11 PM

63.934 Max
56.83
49.726
42.623
35.519
28.415
21.311
14.208
7.1038
0 Min



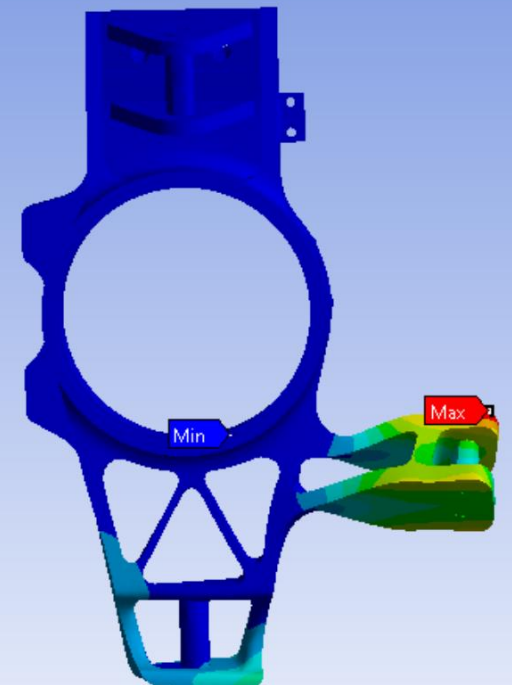
B: Modal
Total Deformation 8
Type: Total Deformation
Frequency: 5782.4 Hz
Unit: in
11/25/2016 7:11 PM

59.139 Max
52.568
45.997
39.426
32.855
26.284
19.713
13.142
6.571
0 Min

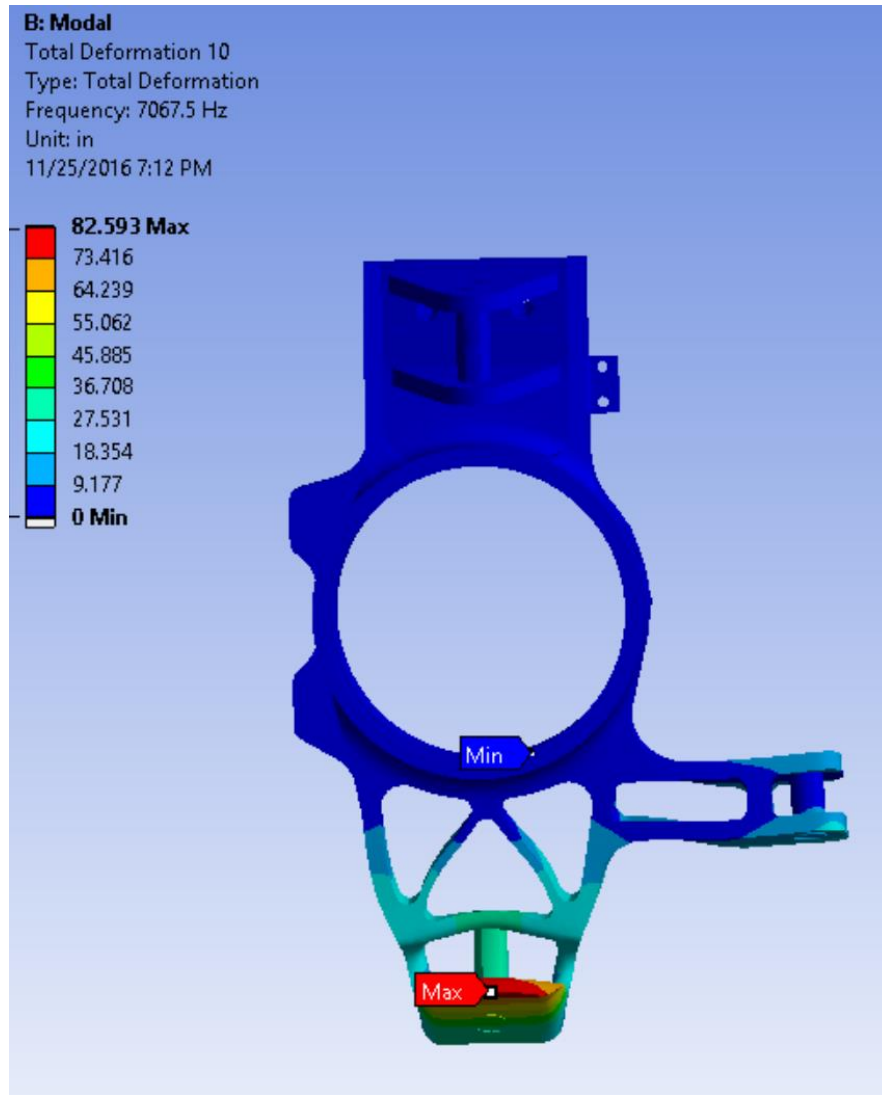


B: Modal
Total Deformation 9
Type: Total Deformation
Frequency: 6268.2 Hz
Unit: in
11/25/2016 7:12 PM

82.996 Max
73.774
64.553
55.331
46.109
36.887
27.665
18.444
9.2218
0 Min



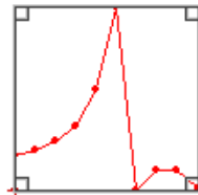
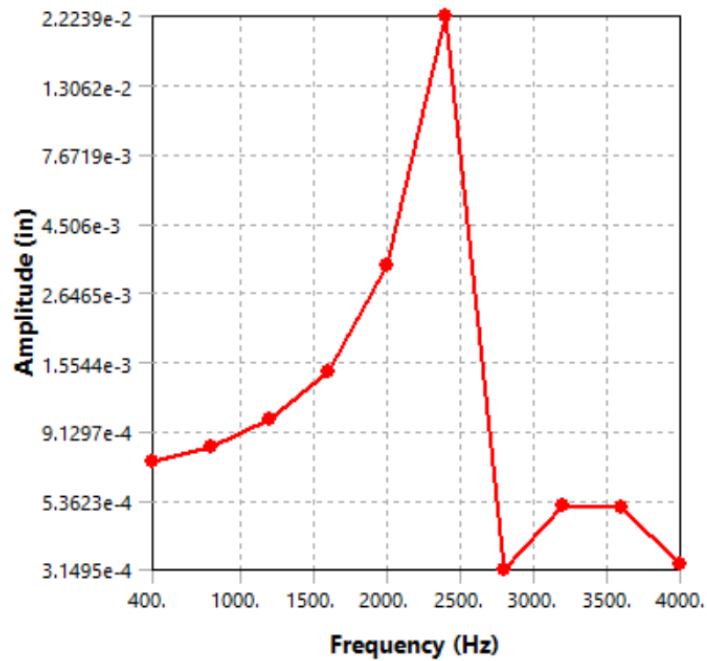
Modal Analysis: Mode 10 and Conclusions



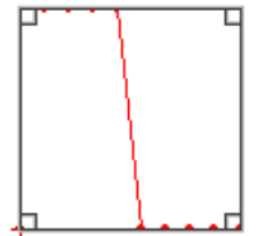
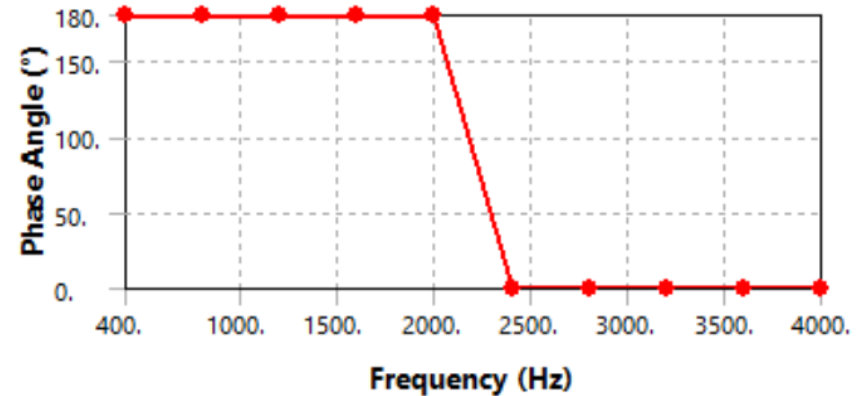
- ▶ Natural frequencies outside typical operating stimulus from bearing carrier of around 10-25 Hz
- ▶ Natural frequencies outside any machining stimulus (typically around 20-100Hz) w/ first natural frequency being around 2500Hz
- ▶ No modal concerns expected in operation or machining

Frequency Response

Frequency Response



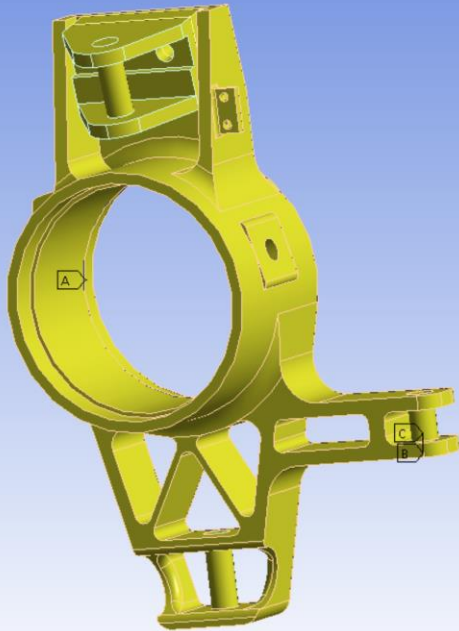
- ▶ Upright shows sensitivity to stimuli in 2000-2500Hz range
- ▶ Far outside operation range (as mentioned previously) therefore no concern



Thermal Analysis

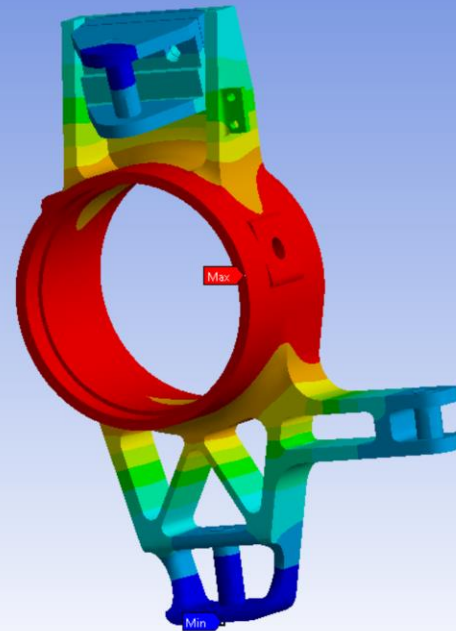
D: Steady-State Thermal
Steady-State Thermal
Time: 1, s
11/26/2016 1:58 PM

- A Temperature: 125, °F
- B Convection: 71.6 °F, 3.3972e-005 BTU/s-in²*F
- C Radiation: 71.6 °F, 0.1



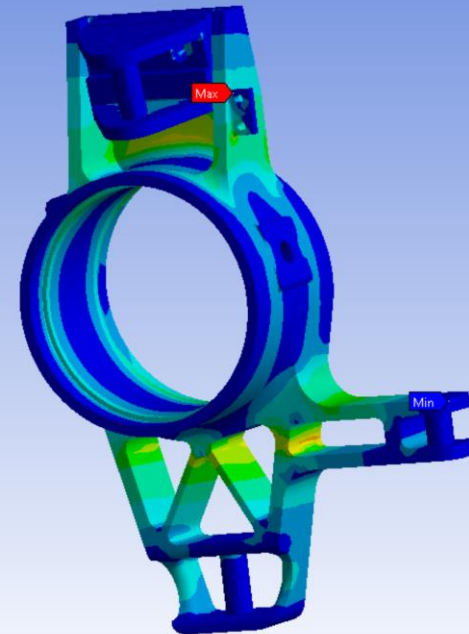
D: Steady-State Thermal
Temperature
Type: Temperature
Unit: °F
Time: 1
11/26/2016 2:00 PM

125 Max
120.77
116.54
112.31
108.08
103.85
99.624
95.395
91.166
86.936 Min

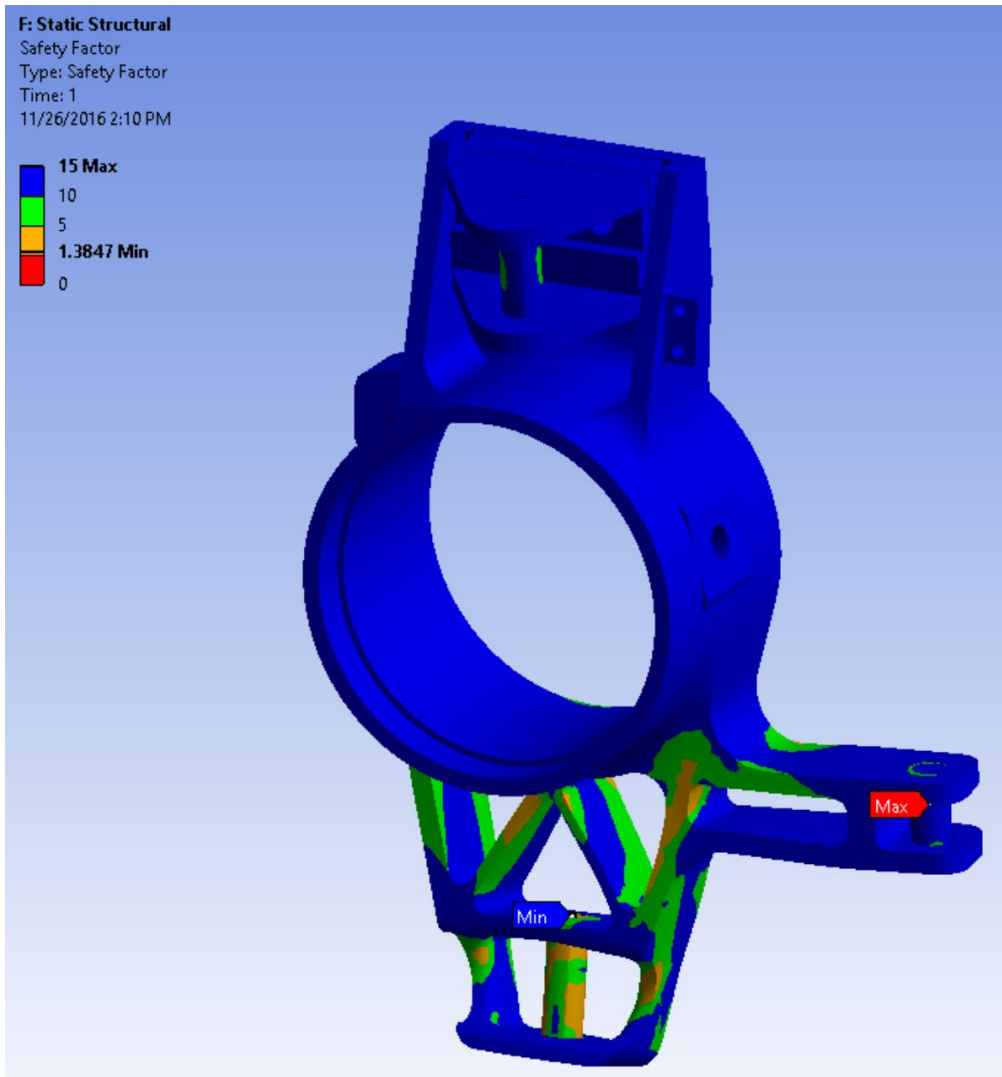


D: Steady-State Thermal
Total Heat Flux
Type: Total Heat Flux
Unit: BTU/s-in²
Time: 1
11/26/2016 2:00 PM

0.065587 Max
0.058923
0.051058
0.043794
0.036529
0.029265
0.022
0.014736
0.0074712
0.00020667 Min



Final Structural Analysis



- ▶ After including thermal loads from previous analysis, factor of safety decreases from 1.42 to 1.38
- ▶ Design validated in worst case conditions