



# COMMON ISSUES IN SRS TESTING

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# PRACTICAL CONVERSATION ABOUT SRS TESTS

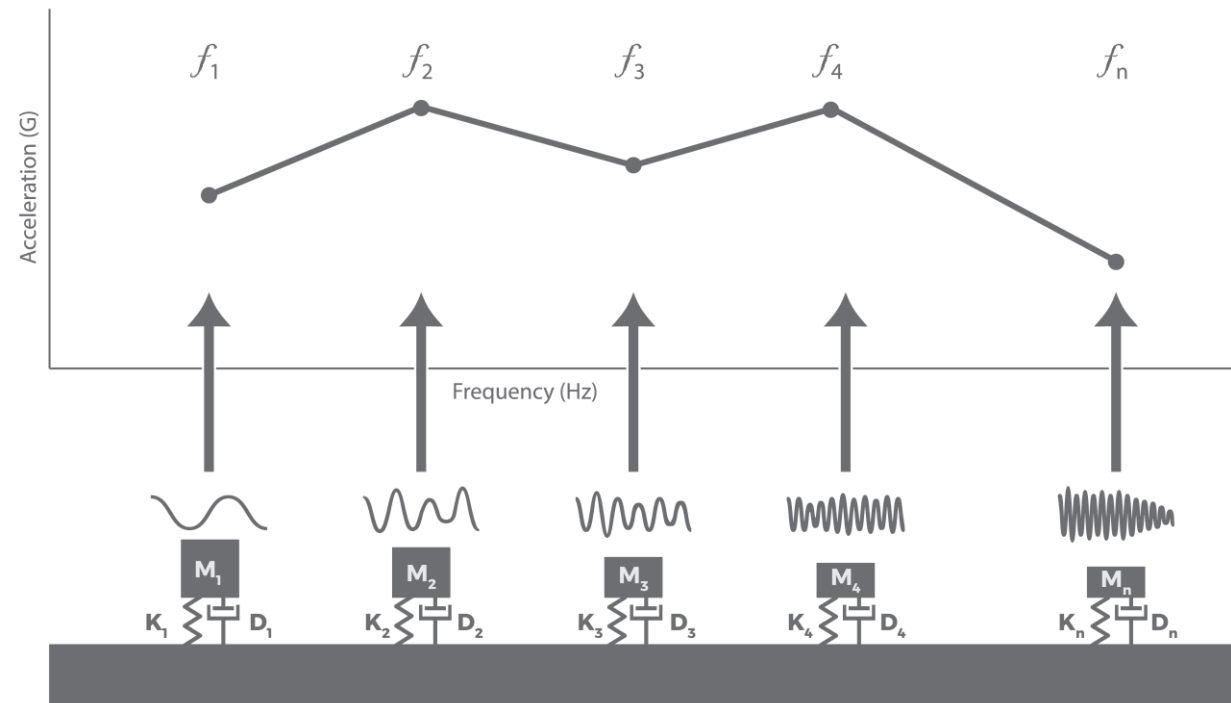


## INTRODUCTION

- Common issues in SRS test specifications
- Reducing # of potential solutions

Who is this information for?

- Test development teams
- Test engineers/technicians
- Test labs, specification evaluation teams



# COMMON PROBLEMS IN SRS TEST SPECS



## IMPROPERLY DEFINED REQUIREMENTS YIELD UNDESIRABLE RESULTS

- Which synthesis type should I use to meet this SRS test specification?
- What is the desired environment for this test specification?
  - Shortest duration
  - Longest duration
  - Least severe (lowest AVD)
  - Most severe (highest Delta V)

Frequency (Hz)	Amplitude (Gpk)
10	14.0365
128	50
1024	50
1290	39.72
2300	39.72

# COMMON PROBLEMS IN SRS TEST SPECS



## SPECIFY TEST PARAMETERS TO REDUCE POTENTIAL # OF SOLUTIONS

- Breakpoint table
- Number of pulses
- Damping/Q-factor
- Te (per MIL-STD-810H)
- TE (per MIL-STD-810H)
- Minimum acceleration, velocity, or displacement
- Tolerances for  $\pm$  SRS

What happens when a specification doesn't provide enough information?

# CASE #1 – TYPICAL SRS TEST SPEC



## BREAKPOINT TABLE, # OF PULSES AND Q/DAMPING

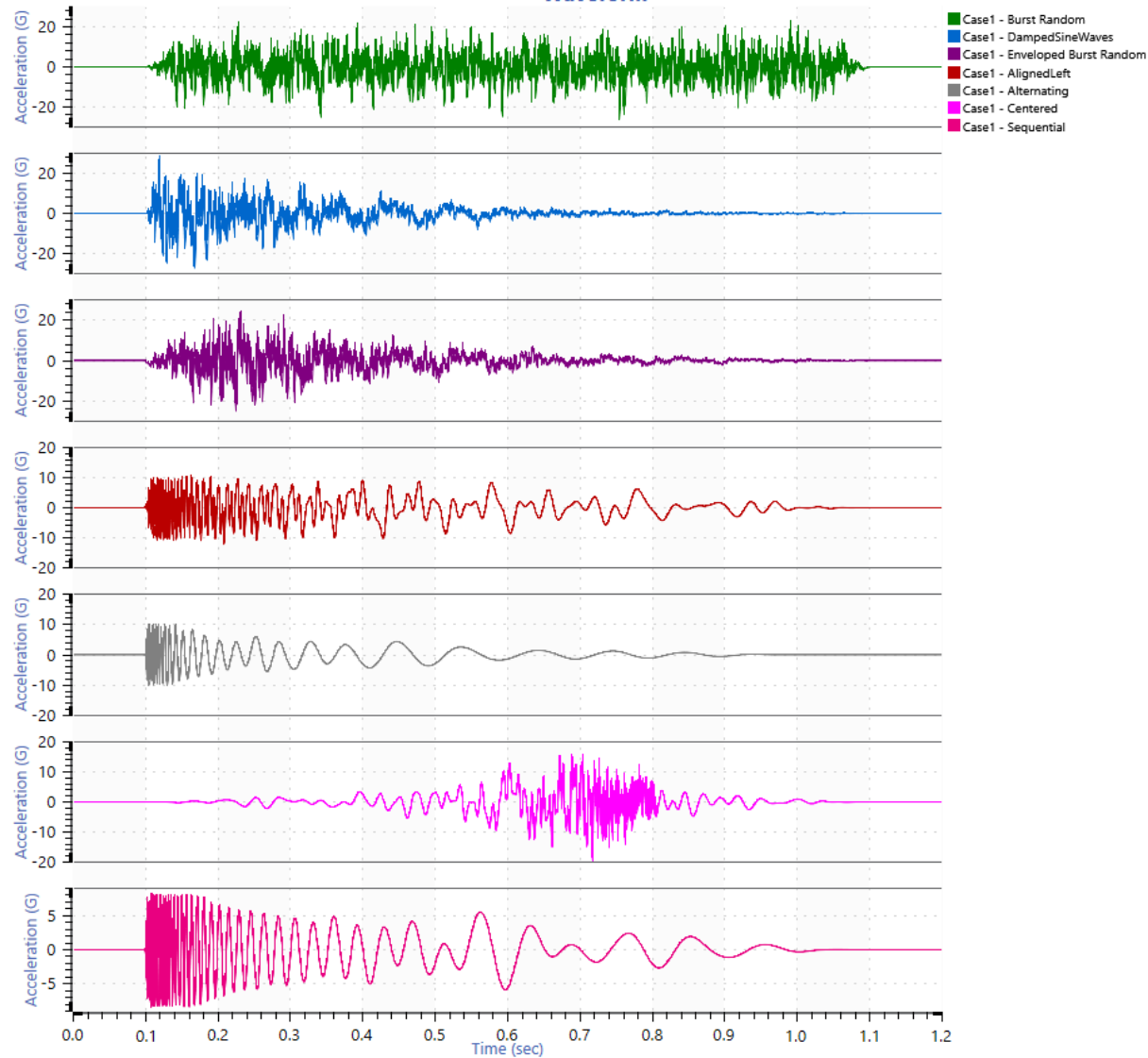
- Requirements:
  - Breakpoint Table
  - # of Pulses
  - Damping = 5% (Q=10)
- Questions:
  - What is the pulse duration?
  - What is the pulse shape?
  - What is the expected AVD?

Frequency (Hz)	Amplitude (Gpk)
10	14.0365
128	50
1024	50
1290	39.72
2300	39.72

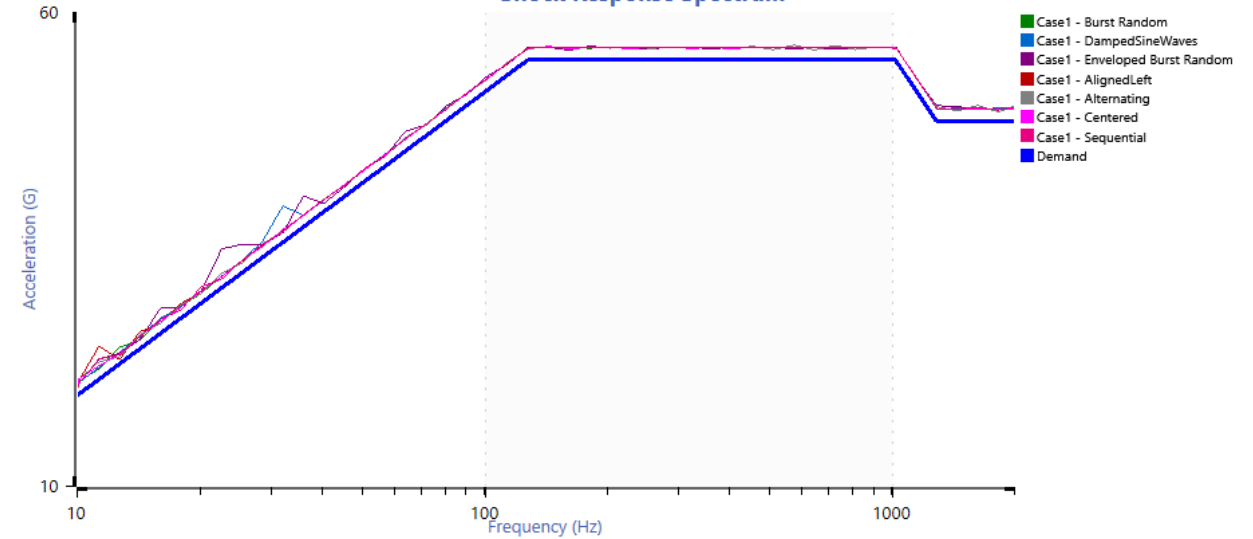
# CASE 1



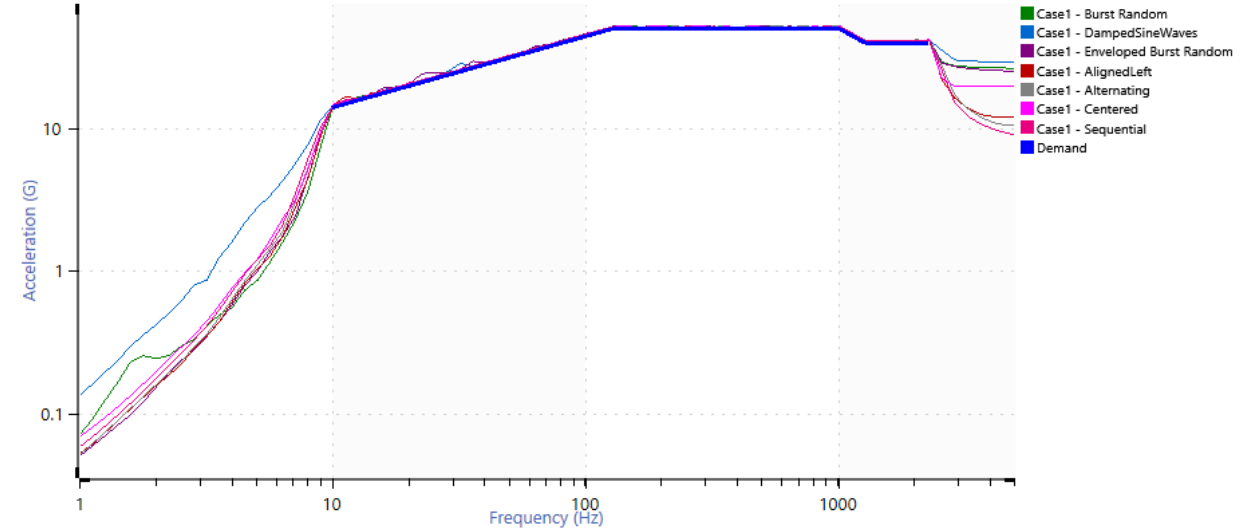
Waveform



Shock Response Spectrum



Shock Response Spectrum



# CASE 1



## OVERVIEW

- Wide range of AVD and durations
- Infinite # of solutions
- What is the desired outcome of the test?

Case #	Synthesis Type	Accel (G)	Vel (in/s pk)	Delta Vel (in/s pk)	Disp (in pk-pk)	Te (mS)	TE (mS)
1	Damped Sine Waves	28.66	28.49	40.18	1.61	585.49	449.20
1	Alternating	10.31	22.68	43.84	0.65	736.30	393.62
1	Env Burst Random	24.89	27.60	45.64	0.52	759.33	503.97
1	Burst Random	26.41	26.08	46.64	0.69	970.63	944.73
1	Aligned Left	12.24	25.75	49.63	0.62	869.91	711.74
1	Sequential	8.52	28.27	51.03	0.71	818.17	537.14
1	Centered	19.82	33.44	61.49	0.75	712.01	341.70

Variable	Min	Max	Range
Acceleration (Gpk)	8.52	28.66	20.14
Velocity (in/s pk)	22.68	33.44	10.76
Displacement (in pk-pk)	0.52	1.61	1.09
Te	585.49	970.63	385.14
TE	341.70	944.73	603.03



# CASE 2 – TYPICAL SRS TEST SPEC



## BREAKPOINT TABLE, # OF PULSES, Q/DAMPING, $T_e$

Requirements:

- Breakpoint table
- # of pulses
- Damping = 5% ( $Q=10$ )
- $T_e < 300$  mS

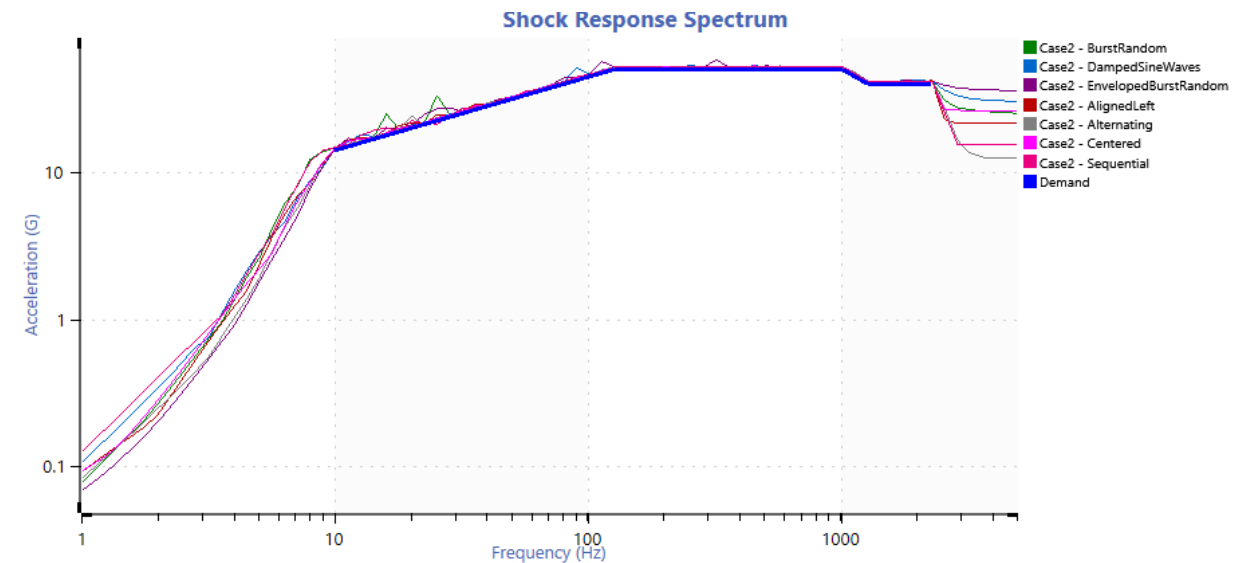
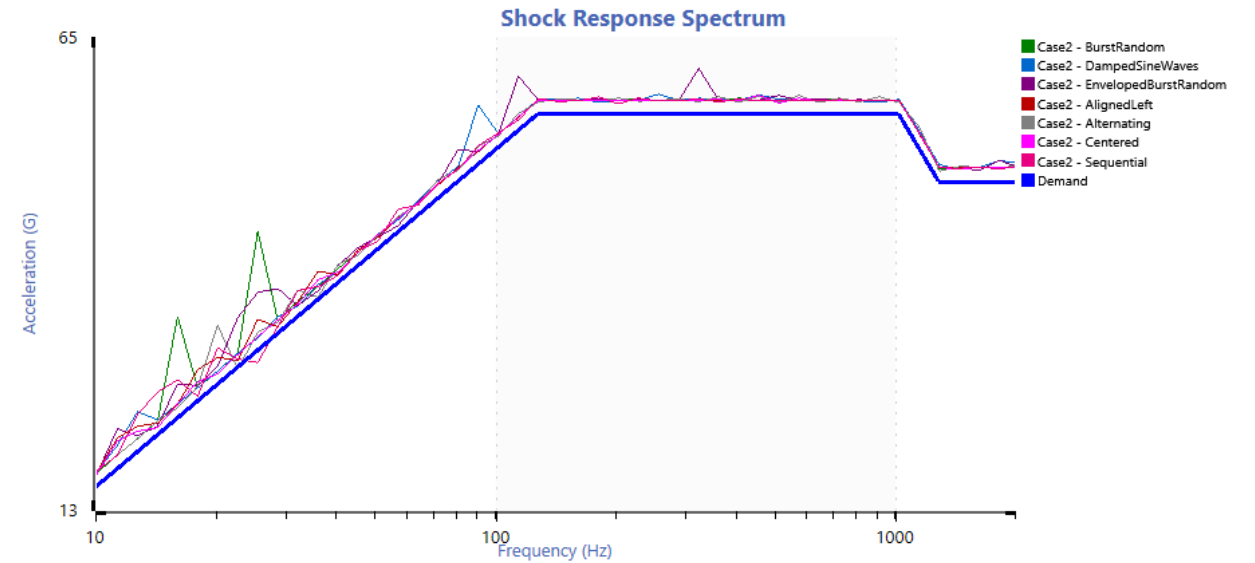
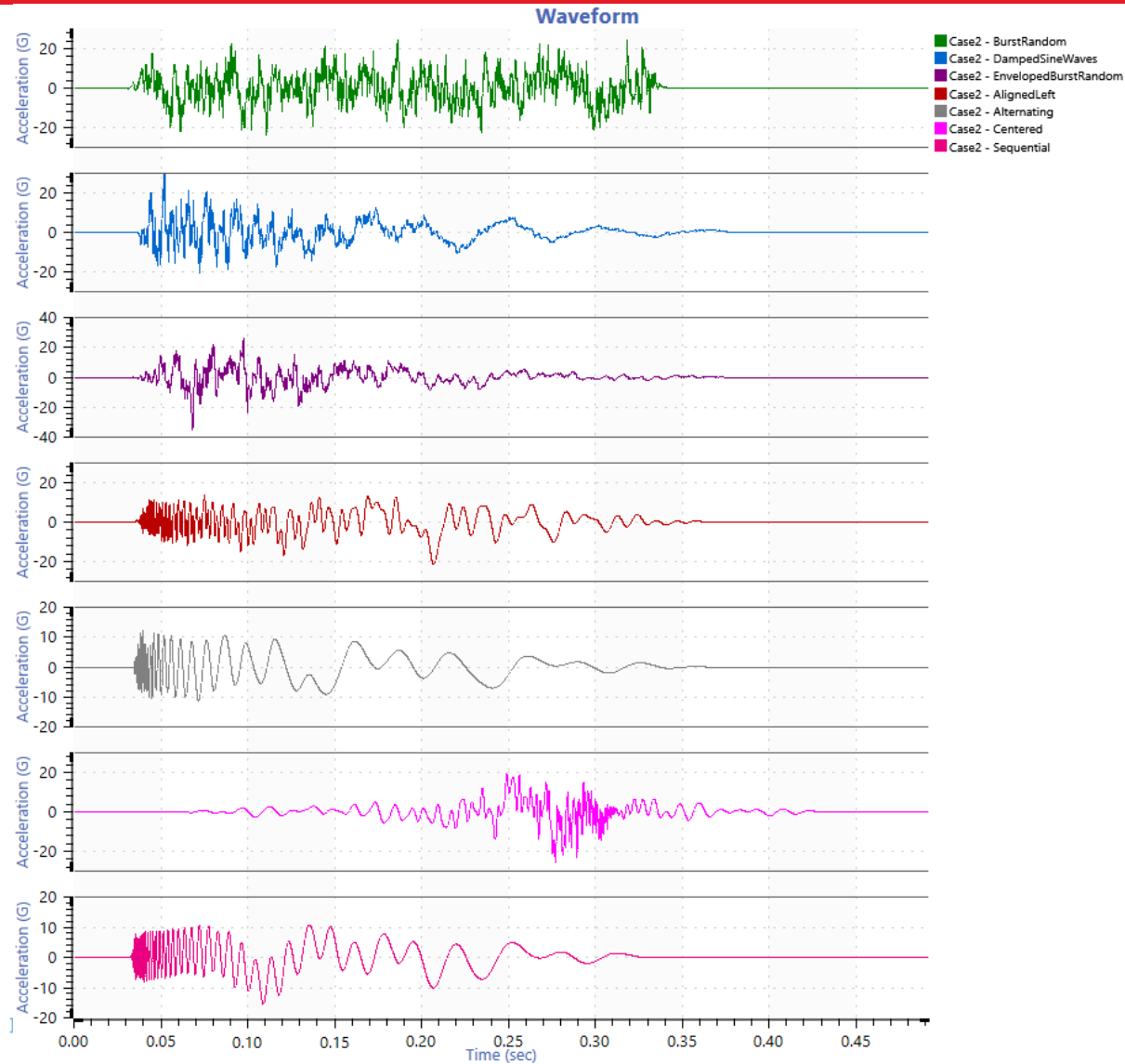
Questions:

- What is  $T_e$ ?
- What is the pulse shape?
- What is the expected AVD?

Frequency (Hz)	Amplitude (Gpk)
10	14.0365
128	50
1024	50
1290	39.72
2300	39.72



# CASE 2



# CASE 2



## OVERVIEW

- All solutions meet the required response spectrum (RRS)
- Significant range of AVD and TE

Case #	Synthesis Type	Accel (G)	Vel (in/s pk)	Delta Vel (in/s pk)	Disp (in pk-pk)	Te (mS)	TE (mS)
1	Damped Sine Waves	28.66	28.49	40.18	1.61	585.49	449.20
1	Alternating	10.31	22.68	43.84	0.65	736.30	393.62
1	Env Burst Random	24.89	27.60	45.64	0.52	759.33	503.97
1	Burst Random	26.41	26.08	46.64	0.69	970.63	944.73
1	Alinged Left	12.24	25.75	49.63	0.62	869.91	711.74
1	Sequential	8.52	28.27	51.03	0.71	818.17	537.14
2	Damped Sine Waves	29.93	33.63	55.46	1.32	298.75	178.80
1	Centered	19.82	33.44	61.49	0.75	712.01	341.70
2	Enveloped Burst Random	35.90	32.84	63.10	0.81	293.08	131.38
2	Alternating	12.15	41.84	66.67	0.95	291.34	212.19
2	Sequential	15.61	41.28	68.74	1.60	277.99	204.51
2	Burst Random	24.65	40.01	69.87	0.93	298.30	296.30
2	Centered	26.30	45.32	70.59	0.98	290.67	94.29
2	Alinged Left	21.61	39.05	71.68	1.06	291.12	236.25

Variable	Min	Max	Range
Acceleration (Gpk)	12.15	35.90	23.75
Velocity (in/s pk)	32.84	45.32	12.48
Displacement (in pk-pk)	0.81	1.60	0.79
Te	277.99	298.75	20.76
TE	94.29	296.30	202.01

# CASE 3 – TYPICAL SRS TEST SPEC



## BREAKPOINT TABLE, # OF PULSES, Q/DAMPING, Te, TE

Requirements:

- Breakpoint table
- # of pulses
- Damping = 5% (Q=10)
- $T_e < 300 \text{ mS}$
- $TE < 30 \text{ mS}$

Questions:

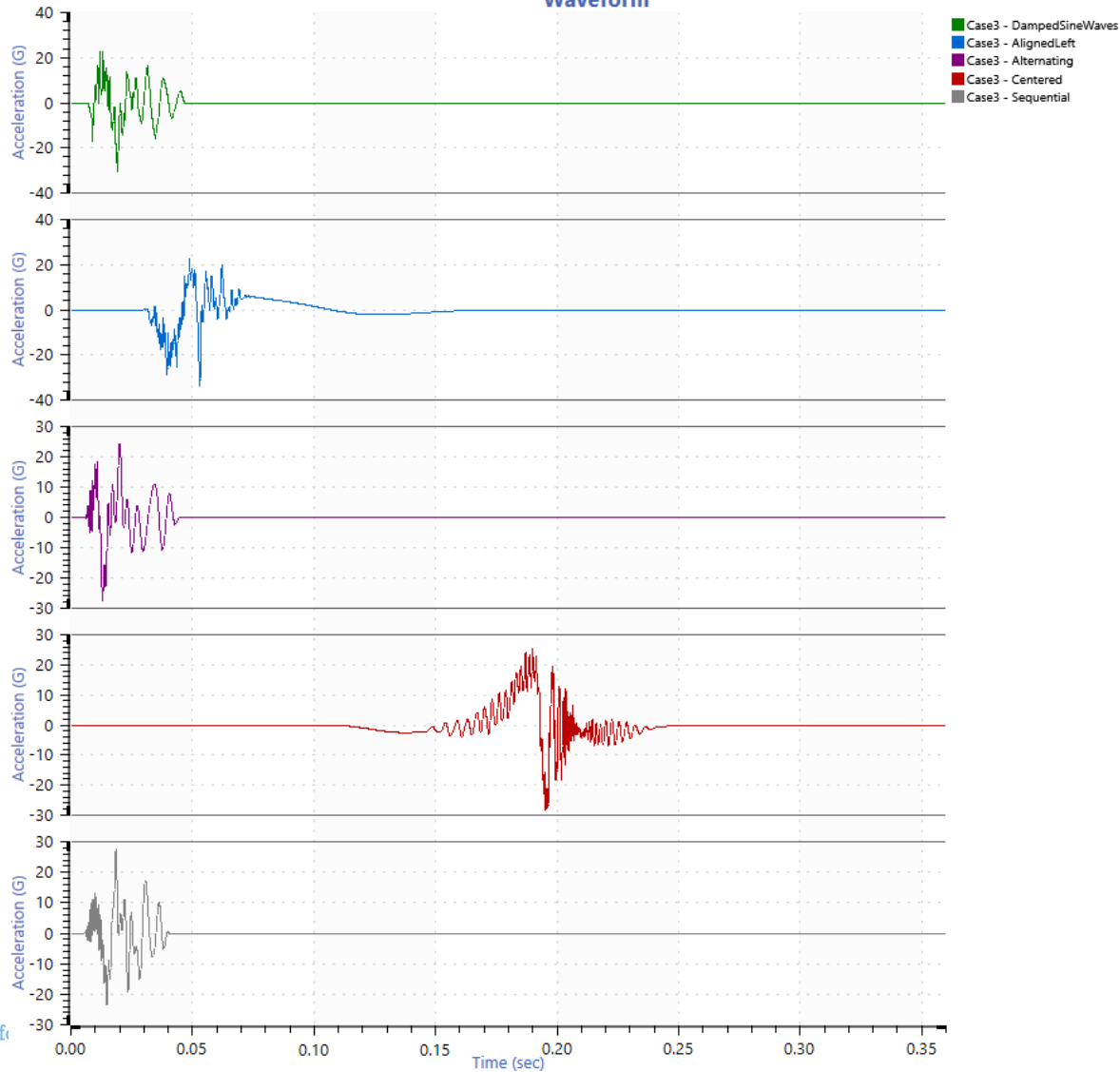
- What is TE?
- What is the pulse shape?
- What is the expected AVD?

Frequency (Hz)	Amplitude (Gpk)
10	14.0365
128	50
1024	50
1290	39.72
2300	39.72

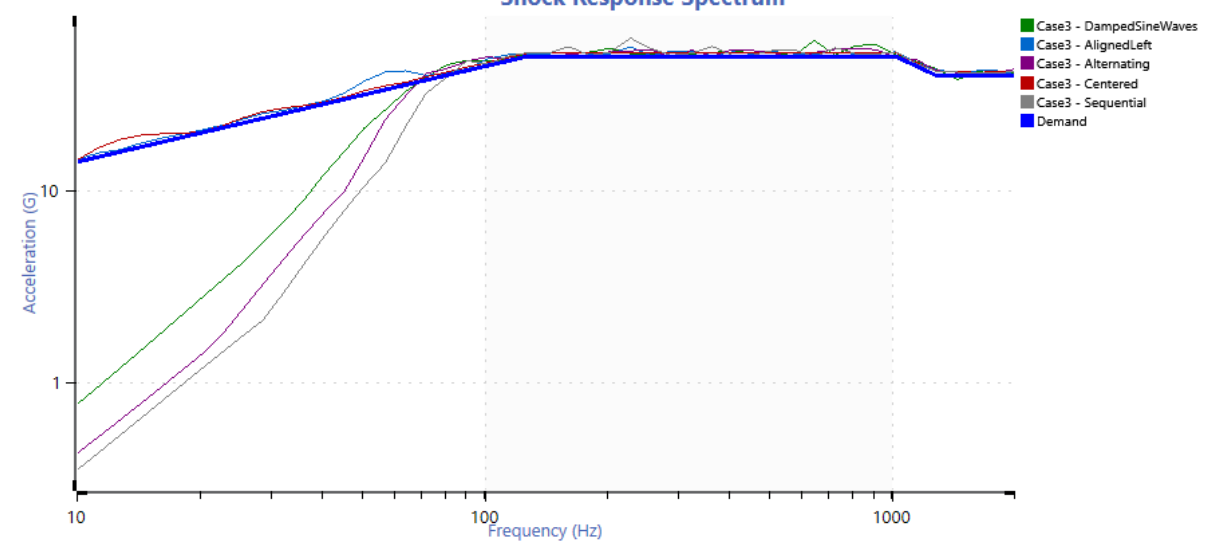
# CASE 3



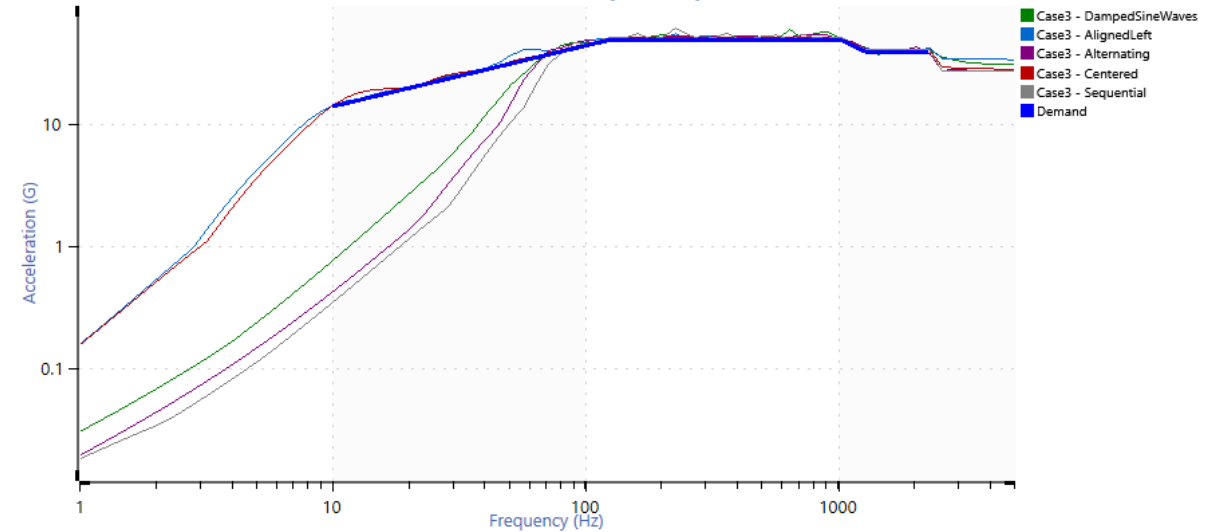
Waveform



Shock Response Spectrum



Shock Response Spectrum



# CASE 3



## OVERVIEW

- Only centered and aligned left meet the demand across the entire frequency range
- More options available if lower frequencies can be dropped

Case #	Synthesis Type	Accel (G)	Vel (in/s pk)	Delta Vel (in/s pk)	Disp (in pk-pk)	Te (mS)	TE (mS)
3.5	Sequential	27.45	12.20	20.08	0.06	32.67	28.03
3.5	Alternating	27.94	11.00	21.61	0.06	35.53	29.37
3.5	Damped Sine Waves	30.81	16.51	27.07	0.13	38.25	29.50
1	Damped Sine Waves	28.66	28.49	40.18	1.61	585.49	449.20
1	Alternating	10.31	22.68	43.84	0.65	736.30	393.62
1	Env Burst Random	24.89	27.60	45.64	0.52	759.33	503.97
1	Burst Random	26.41	26.08	46.64	0.69	970.63	944.73
1	Aligned Left	12.24	25.75	49.63	0.62	869.91	711.74
1	Sequential	8.52	28.27	51.03	0.71	818.17	537.14
2	Damped Sine Waves	29.93	33.63	55.46	1.32	298.75	178.80
1	Centered	19.82	33.44	61.49	0.75	712.01	341.70
2	Enveloped Burst Random	35.90	32.84	63.10	0.81	293.08	131.38
2	Alternating	12.15	41.84	66.67	0.95	291.34	212.19
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2	Burst Random	24.65	40.01	69.87	0.93	298.30	296.30
2	Centered	26.30	45.32	70.59	0.98	290.67	94.29
2	Aligned Left	21.61	39.05	71.68	1.06	291.12	236.25
3	Aligned Left	34.28	59.41	89.53	2.19	109.11	27.41
3	Centered	28.52	62.97	90.01	2.07	72.14	27.67

Variable	Min	Max	Range
Acceleration (Gpk)	28.52	34.28	5.76
Velocity (in/s pk)	59.41	62.97	3.56
Displacement (in pk-pk)	2.07	2.19	0.12
Te	72.14	109.11	36.97
TE	27.41	27.67	0.26

# CASES 4 & 5 – TYPICAL SRS TEST SPEC



## BREAKPOINT TABLE, # OF PULSES, Q/DAMPING, $T_e$ , TE, PEAK ACCELERATION, $\pm$ SRS

Requirements:

- Breakpoint table
- # of pulses
- Damping = 5% ( $Q=10$ )
- $T_e < 300$  mS
- $TE < 30$  mS
- Peak acceleration  $> 40$ Gpk (case 4)
- $\pm$  SRS in tolerance (case 5)

Questions:

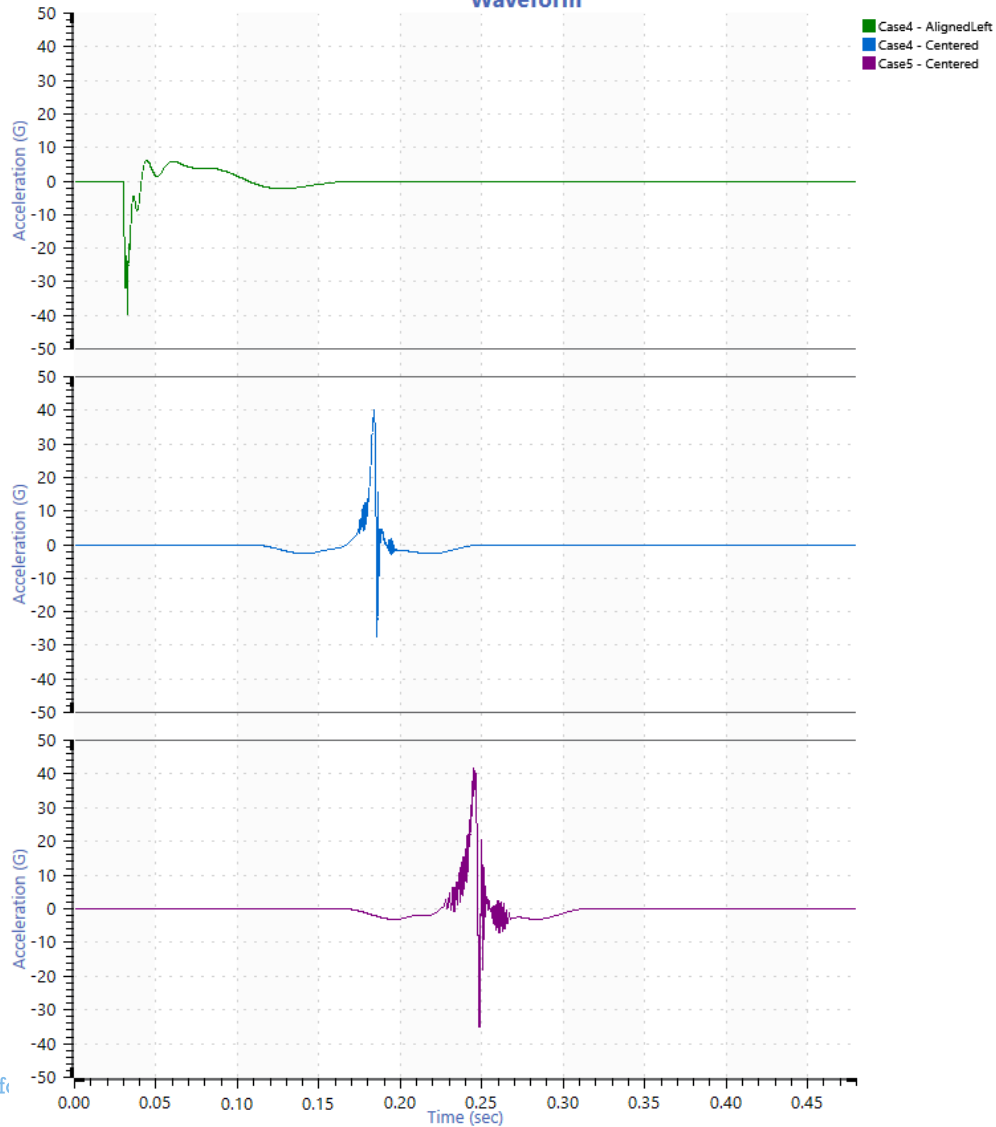
- What is TE?
- What is the pulse shape?
- What is the expected AVD?

Frequency (Hz)	Amplitude (Gpk)
10	14.0365
128	50
1024	50
1290	39.72
2300	39.72

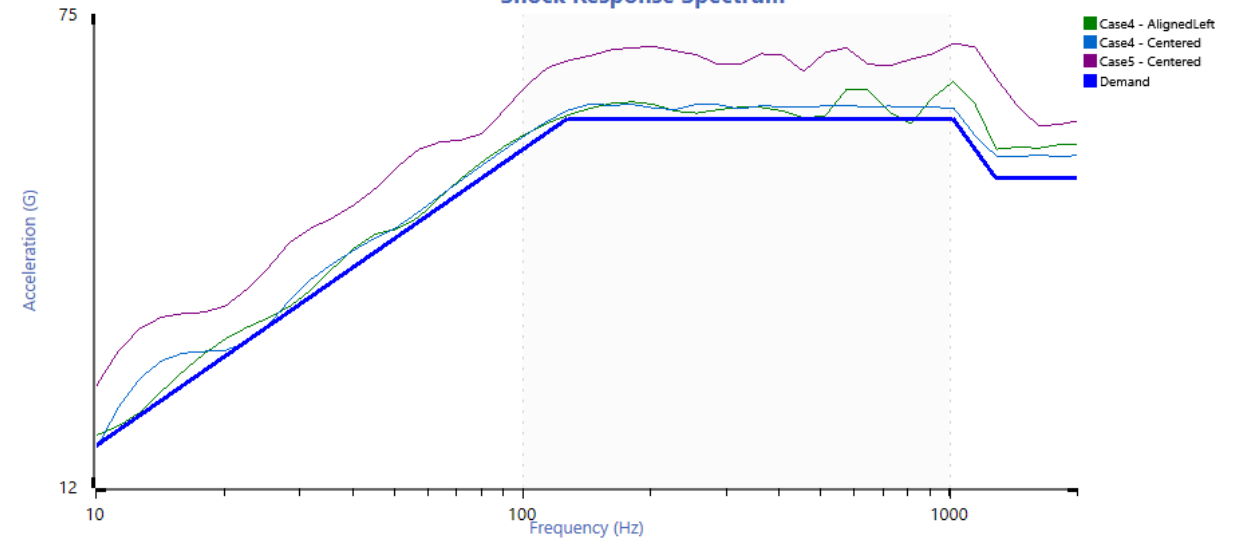
# CASES 4 & 5



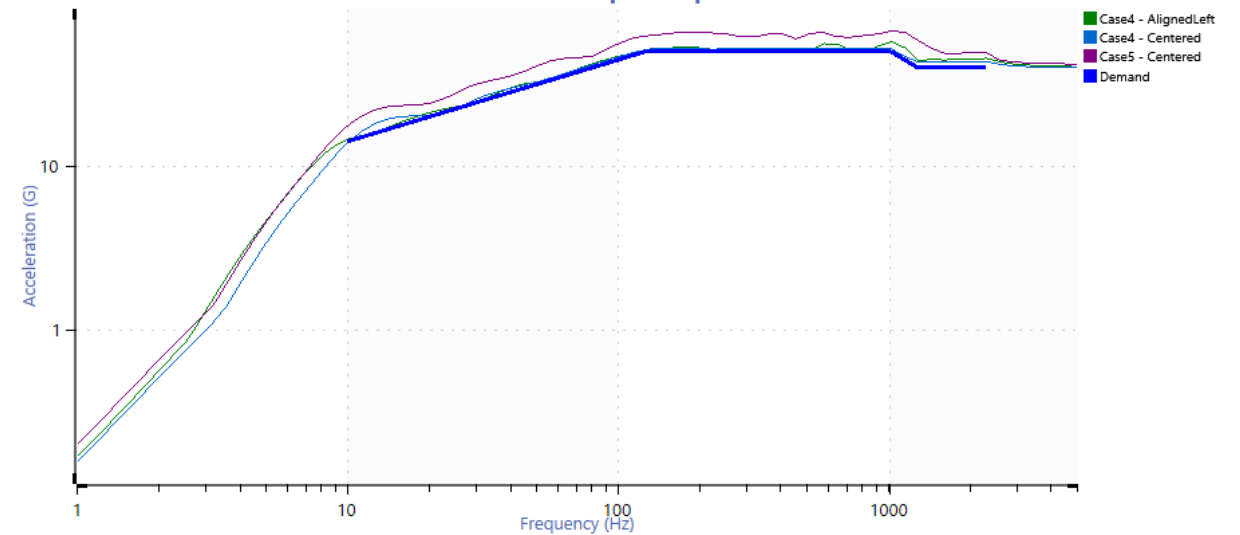
Waveform



Shock Response Spectrum



Shock Response Spectrum





# CASES 4 & 5



## OVERVIEW

- Centered and aligned left can meet the 40G pk requirement
- Aligned left is a very biased pulse resulting in a significant difference between + & -
- Only centered can be used to meet tolerances in both SRS + & -

Variable	Min	Max	Range
Acceleration (Gpk)	40.03	41.78	1.75
Velocity (in/s pk)	45.18	65.47	20.29
Displacement (in pk-pk)	2.03	2.61	0.58
Te	82.72	121.56	38.84
TE	4.11	13.88	9.77

Case #	Synthesis Type	Accel (G)	Vel (in/s pk)	Delta Vel (in/s pk)	Disp (in pk-pk)	Te (mS)	TE (mS)
3.5	Sequential	27.45	12.20	20.08	0.06	32.67	28.03
3.5	Alternating	27.94	11.00	21.61	0.06	35.53	29.37
3.5	Damped Sine Waves	30.81	16.51	27.07	0.13	38.25	29.50
1	Damped Sine Waves	28.66	28.49	40.18	1.61	585.49	449.20
1	Alternating	10.31	22.68	43.84	0.65	736.30	393.62
1	Env Burst Random	24.89	27.60	45.64	0.52	759.33	503.97
1	Burst Random	26.41	26.08	46.64	0.69	970.63	944.73
1	Aligned Left	12.24	25.75	49.63	0.62	869.91	711.74
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2	Alternating	12.15	41.84	66.67	0.95	291.34	212.19
2	Sequential	15.61	41.28	68.74	1.60	277.99	204.51
2	Burst Random	24.65	40.01	69.87	0.93	298.30	296.30
2	Centered	26.30	45.32	70.59	0.98	290.67	94.29
2	Aligned Left	21.61	39.05	71.68	1.06	291.12	236.25
4	Centered	40.03	45.18	74.30	2.03	82.72	8.04
4	Aligned Left	40.11	53.93	84.27	2.30	110.85	4.11
3	Aligned Left	34.28	59.41	89.53	2.19	109.11	27.41
3	Centered	28.52	62.97	90.01	2.07	72.14	27.67
5	Centered	41.78	65.47	100.70	2.61	121.56	13.88

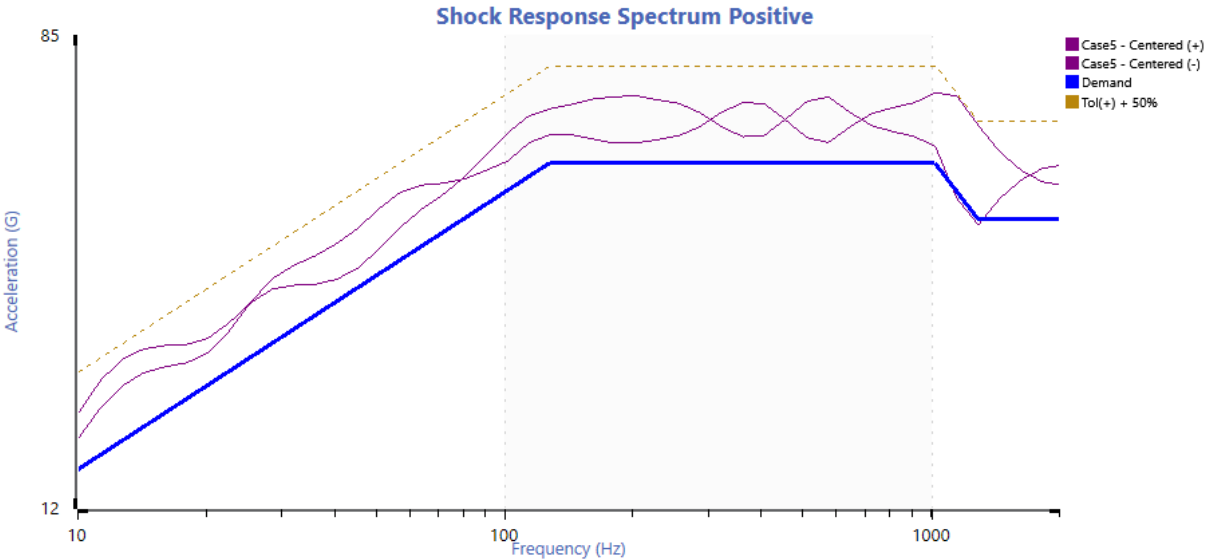
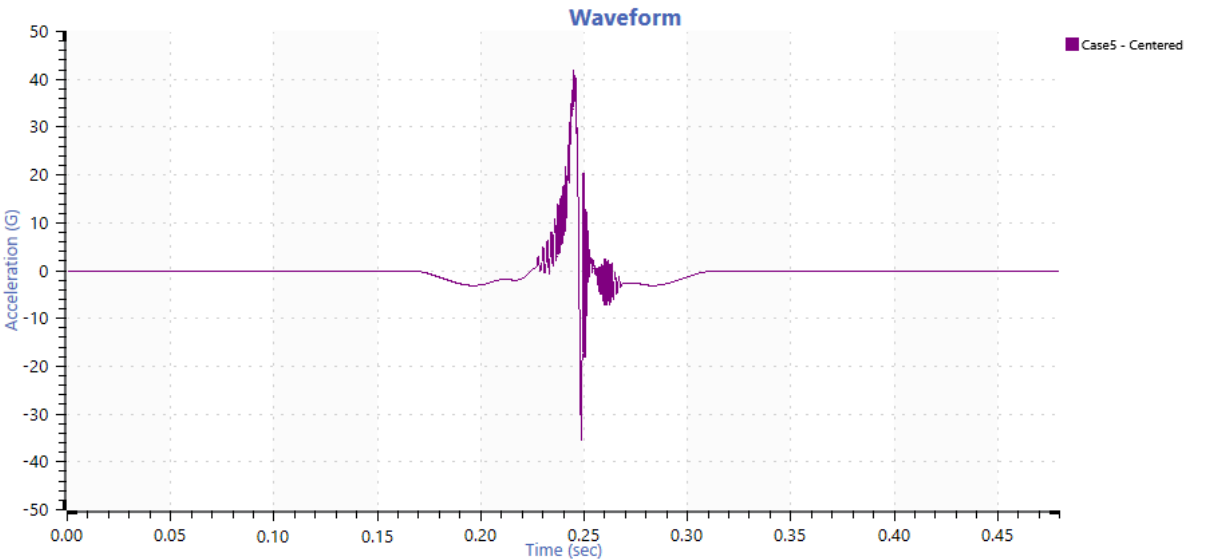
# CASE #5



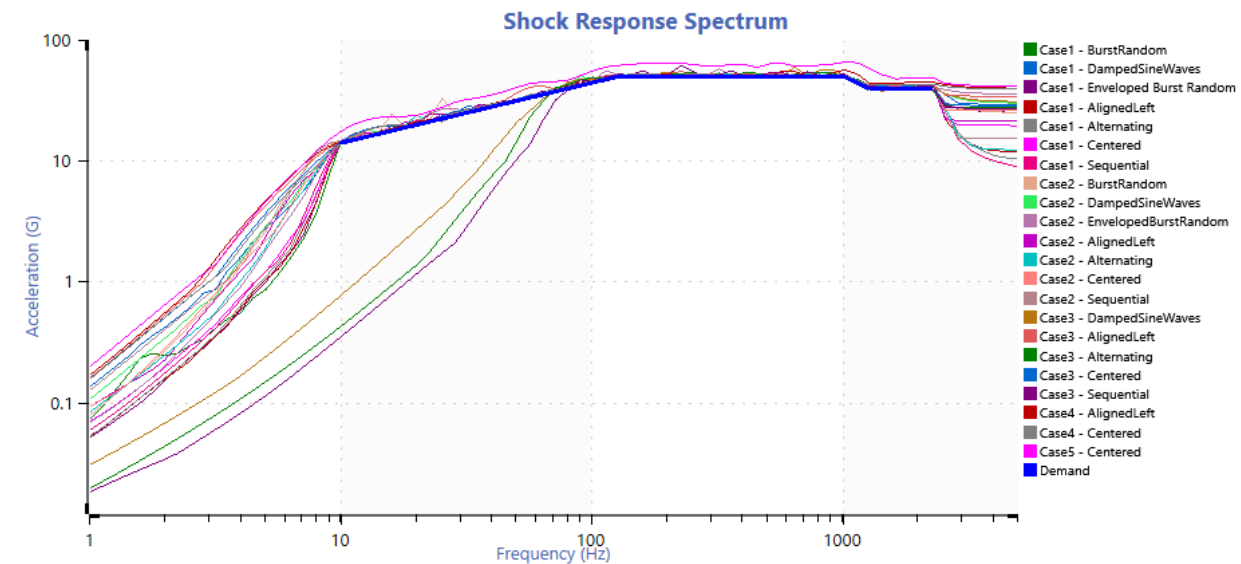
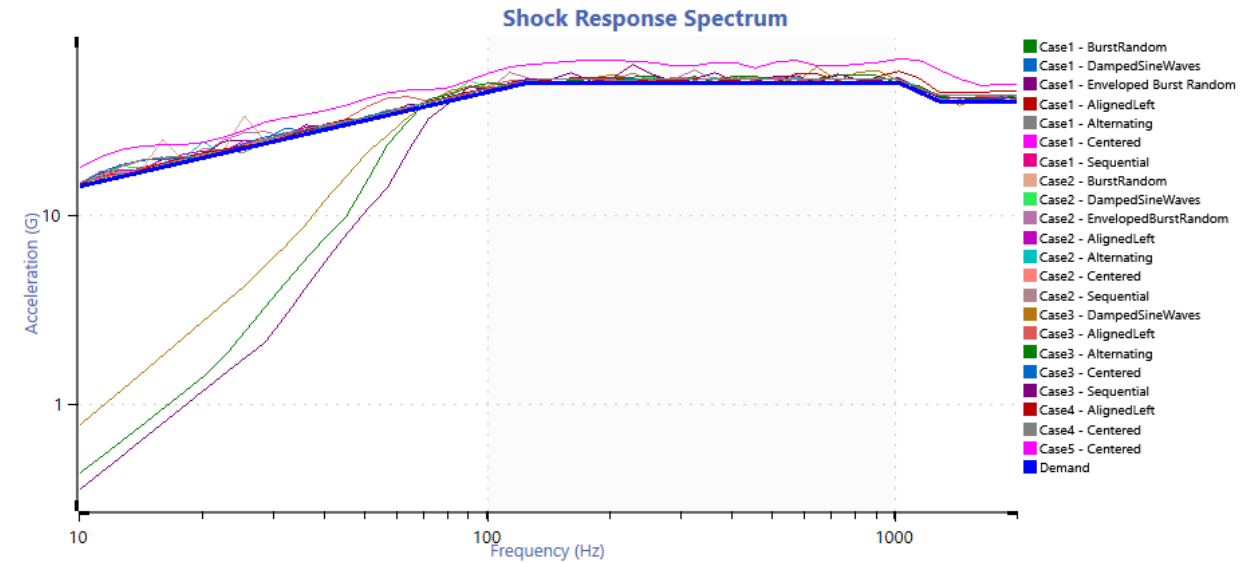
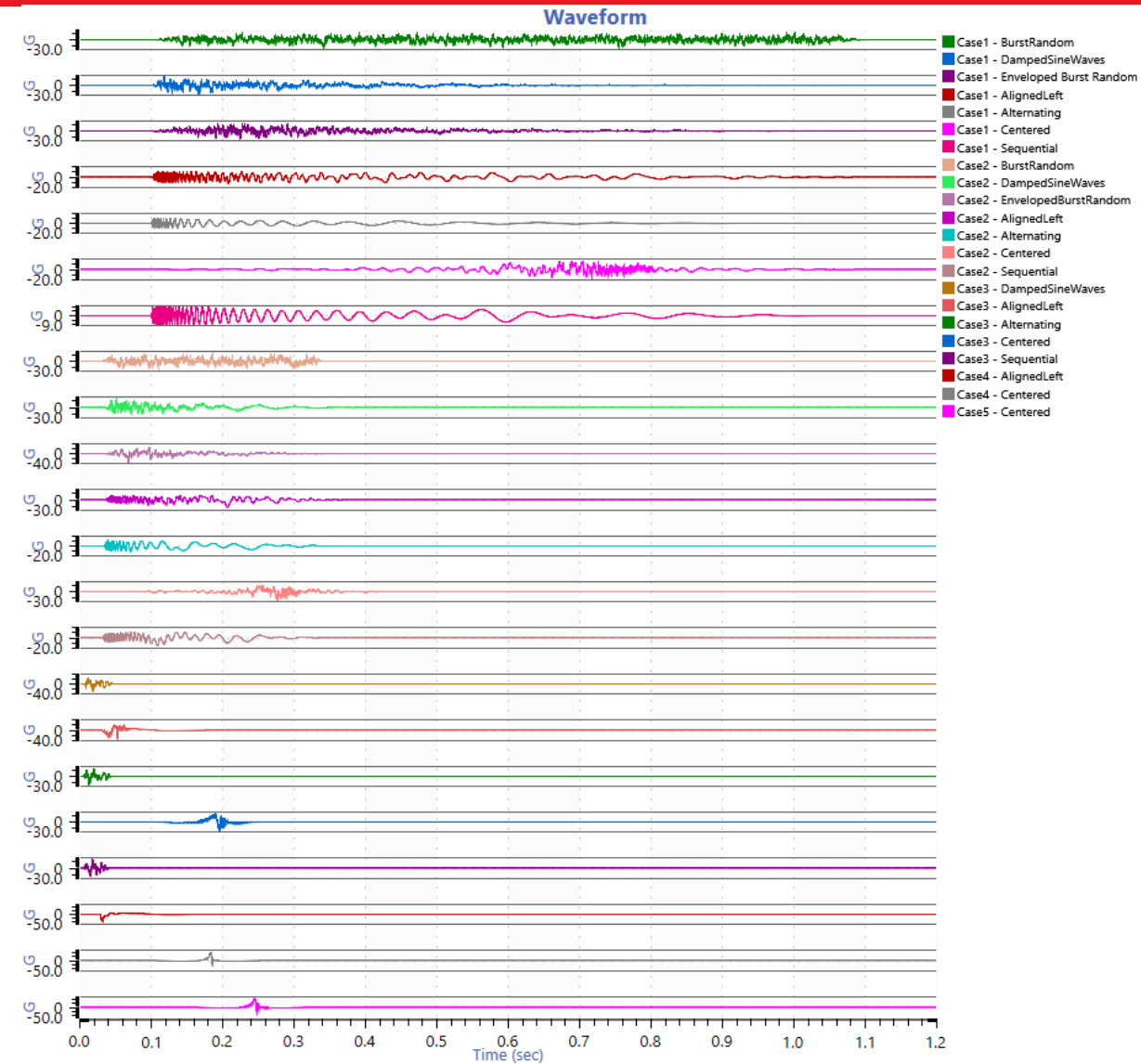
## OVERVIEW

Variable	Result
Acceleration (Gpk)	41.78
Velocity (in/s pk)	65.47
Displacement (in pk-pk)	2.61
Te	121.56
TE	13.88

Case #	Synthesis Type	Accel (G)	Vel (in/s pk)	Delta Vel (in/s pk)	Disp (in pk-pk)	Te (mS)	TE (mS)
5	Centered	41.78	65.47	100.70	2.61	121.56	13.88



# CONCLUSIONS



# CONCLUSIONS



## FULLY DEFINED REQUIREMENTS = TESTS THAT REPLICATE EXPECTED RESULTS

Poorly defined specifications:

- Lead to inconsistency across labs
- Result in wide variation of potential solutions
- Create conflicts when determining if a test can be run

SRS specs can allow for some variation:

- Minimum excitations frequency – at least  $\frac{1}{2}$  of primary resonance or 2 octaves below?
- Delta velocity requirements?
- Maximum frequency – driven excitation vs. measured response



## ANY QUESTIONS?

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