Guide to dataset for MSSP article: *Periodic responses of a structure with 3:1 internal resonance*

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1 Introduction

This document accompanies the dataset for the following article: A. D. Shaw, T. L. Hill, S. A. Neild, M. I. Friswell, *Periodic responses of a structure with 3:1 internal resonance*, MSSP, submitted. The data is free to use so long as the source is clearly attributed and the article above is cited in any published work.

The data files are grouped in folders with names relating to the figure numbers in which they are used. The data files are all in an easily readable text format, and most fields are self-explanatory.

In Section 2, the file format for each set of readings is explained. Then comments relating to each individual figure are presented in Section 3.

2 File format

Each file consists of a header section, followed by a series of entries which are repeated for each data point. Where a channel number is referred to, this is a number from 0 to 4 representing the different readings as defined in Table 1. Note that the data file also echoes many control parameters used during the test, to maintain a record of these parameters. The following sections present a sample data file entries, with annotations added in *italics*.

Channel #	Description	Symbol	Unit
0	Drive Signal		V
1	Force signal	f	N
2	Accelerometer 1	$\ddot{x}_1$	m s^{-2}
3	Accelerometer 2	$\ddot{x}_2$	m s^{-2}
4	Accelerometer 3	$\ddot{x}_3$	m s^{-2}

Table 1: Channel definitions.

2.1 Header lines

`Beginning sweep with following parameters:`
`Comments:`
`Number of steps: 151` *The number of steps planned for the sweep. Note that this number may not actually be completed; a sweep may terminate early either due to user intervention or because consecutive data points have failed to achieve the desired forcing signal.*
`Start freq (Hz): 9.000000E+0`
`End freq (Hz): 12.000000E+0`
`Reference Channel: 1` *This is the channel that is driven to the required input signal by the algorithm described in Section 2.4 of the article. This is set to channel 1 (Force) for all cases except Fig 11.*
`Fourier components used to solve output: 1,1,0,0,1,1,0,0,0,0`
Indicates the degree of harmonic control used, with a 1 indicating a harmonic component that is controlled. The harmonic components are presented in order: $\cos\Omega, \sin\Omega, \cos 2\Omega, \sin 2\Omega$ *etc.*
`Sensor Gains: 1.000000E+0,-4.448400E+2,-9.765620E+2,9.970090E+2,9.803920E+2`
Gains used to convert each voltage signal to physical units, with sign used to convey orientation.

2.2 Lines repeated for each data point

`##########################`
`Data point number:  0`
`Frequency (approx) (Hz): 9.0000E+0` *The frequency of the data point is described as 'approx' because the frequency is rounded down so that the exact period is an integer multiple of the sample period of* $T_s = 1/25600\text{s}$
`Relative Settling tolerance: 2.500000E-3` *Tolerance used in ensuring that response has settled to a steady state. A channel is deemed to have settled when* $||\vec{W}_n - \vec{W}_{n-1}||/||\vec{W}_n||$ *is less than this value, where* $\vec{W}_n$ *is the vector of fourier coefficients based on the fundamental forcing frequency. Note that for determining whether a signal has settled, 5 harmonics are always used regardless of the control option.*
`Max settling iterations: 200`
`Channels used to test settling: 0,1,0,0,1` *Indicates which channels were monitored for settling. This shows the option used for all readings except for Fig 11, where channels 1 and 4, ie. the force signal and the tip accelerometer, are used to check for settling.*
`Max relative change to X while solving: 50.000E-3` *This limits the relative magnitude of change to* $\vec{V}$*, the vector of voltage fourier components as described in section 2.4 of the article, that can be made in any one solver iteration.*
`Required fourier outputs:`
`1.600000E+0,0.000000E+0,0.000000E+0, ...` *Determines the Fourier components of the target excitation signal* $\vec{F}^*$*, with components specified in order*

$\cos\Omega, \sin\Omega, \cos 2\Omega, \sin 2\Omega$ *etc. All components up to the 5th harmonic are listed, although some may be disregarded due to the choice made in the header field 'Fourier components used to solve output'. In this work all required signals are a pure cosine, so all values except the first component are zero.*
`Maximum solver iterations: 105` *Maximum number of attempts to achieve the signal described in the previous field.*
`Fourier fifo read timeout (ms): 500` *Indicates a hardware failure if this timeout occurs.*
`Solver tolerance: 10.0000E-3` *Relative tolerance used to determine convergence of solving routine, i.e. convergence is achieved when* $||\vec{F}^* - \vec{F}||/||\vec{F}^*||$ *is less than this value.*
`Relative perturbation size: 25.0000E-3` *Relative perturbation size used when using finite differences to calculate Jacobian matrices for solving routine.*
`x0:`
`-2.000000E-1,0.000000E+0,0.000000E+0. ...` *Determines the Fourier components of the initial guess for* $\vec{V}$*, the vector of Fourier components of the output voltage signal, with components specified in order* $\cos\Omega, \sin\Omega, \cos 2\Omega, \sin 2\Omega$ *etc. All components up to the 5th harmonic are listed, although some may be disregarded due to the choice made in the header field 'Fourier components used to solve output'. For points after the first point, this guess is taken from the signal used on the previous point.*

```
#####Results:#####
Time Complete: 11:28:19
Time stamp(s): 3509436499
Period (samples): 2845
```
Note - divide this period by 25600 to get the true period in seconds.
```
Fourier magnitudes (row=channel,col=harmonic):
2.356411E-1,4.998001E-8,3.057899E-3,5.500325E-7,5.511919E-7
1.596931E+0,2.637601E-2,2.163495E-3,6.151428E-4,7.064471E-4
4.020788E-1,4.544857E-3,1.429736E-1,4.286729E-3,3.873378E-3
2.894633E+0,6.430748E-2,8.561806E-1,1.810311E-3,3.167086E-3
9.307415E+0,1.723678E-1,2.688956E-1,6.665386E-3,8.918375E-3
```
Magnitudes are in physical units.
```
Fourier phases (row=channel,col=harmonic):
1.772621E+2,1.533334E+2,1.612205E+2,8.366038E+0,-1.353875E+1
0.000000E+0,1.248348E+1,1.605245E+2,5.268004E+1,1.897063E+0
-1.774184E+2,1.729100E+2,-1.596294E+2,1.715018E+2,1.482655E+2
-1.776871E+2,9.453255E+0,-1.599263E+2,6.659831E+1,-1.758385E+1
-1.773250E+2,9.426234E+0,2.262342E+1,-1.577763E+1,-1.520517E+2
```
Phases in degrees
```
Phase adjusted fourier components (row=channel,col=component[c1,s1,c2,s2...]):
1.596931E+0,0.000000E+0,2.575244E-2,5.701...
.
.
```
. *A 5×10 comma delimited matrix, where the row denotes the channel and each*

column denotes the Fourier component in sequence $\cos\Omega, \sin\Omega, \cos 2\Omega, \sin 2\Omega$ *etc.*
`Force signal in tolerance: 1` *If this field is zero, it indicates that the solving algorithm failed to find a solution.*
`Final Jacobian:`
`-7.535183E+0,3.735614E-1,2.434867E-2,2.791683E-1`
`-5.836971E-1,-7.280359E+0,-1.022137E+0,-1.187107E-1`
`4.364148E-1,-2.302805E-1,-7.072686E+0,3.661356E+0`
`-1.243781E-1,2.833107E-2,-3.748020E+0,-7.909389E+0`
Numerically estimated Jacobian, consisting of the partial derivative of each controlled Fourier component with regard to each controlled harmonic in the voltage signal. The size of this matrix is determined by the number of ones in header field 'Fourier components used to solve output'. If this field is empty, it means that the solver was within tolerance at the initial guess. `Settled signals:`
`1,1,0,0,1` *Indicates which channels were deemed to have settled adequately when the final reading was taken - if channels used to monitor settling are zero, then the point must have timed out while waiting to settle.*

```
Drive
8.972073E-2
8.925343E-2
8.878326E-2
8.831501E-2
.
.
```
Time series of drive signal, at sample frequency 25600Hz. Typically 1-3 forcing periods are recorded.

```
Force
-8.090113E-1
-8.085871E-1
-7.903451E-1
-7.682850E-1
-8.009509E-1
.
.
```
Time series of force signal in physical units.

```
Accel
-1.266598E-1,5.733456E-1,4.834754E+0
-1.350417E-1,5.267553E-1,4.757151E+0
-1.778825E-1,5.429193E-1,4.780525E+0
-1.350417E-1,5.400668E-1,4.776786E+0
.
.
```
Time series of accelerometers signals in physical units.

3 Comments on each figure

3.1 Figure 7

Each set of points consists of a sweep between 9 and 12 Hz, in either an upwards of downwards direction. Three different control strategies are used, as explained in the article, and this is reflected in each filename.

3.2 Figure 9

Similar to Figure 7 data, but now all sweeps use the same control strategy, but a different forcing amplitude, as reflected in the first part of the filename.

3.3 Figure 10

All sweeps start at 13Hz, following a 'kick' procedure to access the isola. The 'down' sweeps proceed down to 10Hz, the 'up' sweeps go up to 16Hz.

3.4 Figure 11

The time data presented in the article is from data point number 3.