iVIBE® Performance Tests – Vibration

iVIBE can be fitted with two tri-axial accelerometers. A micro-machined silicon (MEMS) device as standard and, optionally, a high sensitivity piezoelectric device. Both accelerometers are sampled 1000 times per second and their readings digitally filtered.

A fixed low pass filter has a -3dB point at 450 Hz. A variable high pass filter has user selectable -3dB points of 0.3 Hz, 0.5 Hz, 1.0 Hz, 2.0 Hz and 4.0 Hz.

The MEMS device has a noise floor of about 1 milli-g RMS, the piezoelectric accelerometer has a noise floor of about 20 micro-g RMS.

The MEMS accelerometer can also be used to measure tri-axial static tilts with a resolution of 0.001 g.

iVIBE may be used to measure the following:

- static tri-axial tilt expressed as a fraction of g.
- tri-axial RMS acceleration in X, Y, Z directions and true resultant R
- tri-axial RMS velocity in X, Y, Z directions and true resultant R
- tri-axial PPV (peak particle velocity) in X, Y, Z directions and true resultant R
- dominant frequency of vibration in X, Y, Z directions and true resultant R

Signals from both accelerometers are processed using identical algorithms and the performance of these algorithms can be checked by applying an electrical stimulus in place of the piezo accelerometer. Typical results are given in what follows.

The sensitivity of the iVIBE stimulus input is 1mV = 1milli-g, full scale is 350mV rms.

The acceleration due to gravity is taken as g = 9810 mm/sec/sec.

150mV RMS sine wave stimulus (X, Y or Z axes), high pass filter = 0.3 Hz

This table shows the response of iVIBE to a 150mV RMS sine waves of various frequencies and the relative response in dB. The high pass filter is set to 0.3 Hz

Frequency Hz	iVIBE rms milli-g	Response dB
500	95.4	-3.9
450	106.2	-3.0
400	114.6	-2.3
300	130.0	-1.2
200	141.8	-0.5
100	149.8	-0.0
50	150.8	0.0
25	151.1	0.1
20	151.5	0.1
10	151.5	0.1
5	151.1	0.1
2	151.1	0.1
1	147.0	-0.2
0.5	121.8	-1.7
0.30	106.8	-3.0
0.25	90.9	-4.3
0.2	72.3	-6.3

iVIBE small signal response with 15mV RMS sine wave stimulus

Stimulus Frequency Hz	iVIBE RMS accel. milli-g	iVIBE RMS velocity mm/sec	iVIBE PPV mm/sec	iVIBE frequency Hz	iVIBE HP filter Hz
100	14.93	0.22	0.36	104	4.0
100	14.95	0.22	0.42	104	1.0
10	15.11	2.36	3.48	10.1	1.0
10	15.18	2.38	3.79	10.1	0.3
5	15.18	4.74	7.14	5.1	0.3
2	14.89	11.81	17.35	2.0	0.3
1	14.74	22.03	31.64	1.1	0.3

Note, 1.0 milli-g represents an acceleration 9.81 mm/sec/sec.

For a sinusoidal stimulation, the velocity **v** is the acceleration **a** divided by the angular frequency. That is

velocity= acceleration x 9.81 / (2 x π x f) mm/sec

So for a 100 Hz sinusoidal acceleration of 15 milli-g RMS, the velocity is calculated at 0.23 mm/sec. This is close to the iVIBE measured value of 0.22 mm/sec.

Similarly, for a sinusoidal wave, the peak particle velocity (PPV) will be √2 times the RMS value of the sine wave, in the above case PPV=0.31 mm/sec. The measured PPV value is 0.36mm/sec, the 0.05 mm/sec overshoot probably caused by low frequency noise on the stimulus signal.

Note that for sinusoidal signals, the RMS velocity and PPV are inversely proportional to the vibration frequency. So at 1.0 Hz the theoretical PPV = 31.1 mm/sec for a 15 milli-g excitation, which compares well to the iVIBE measured value of 31.64 mm/sec

iVIBE large signal response with 150 mV RMS sine wave stimulus

This table illustrates the accuracy of the IVIBE measurements over a range of frequencies. Not that the maximum PPV reading is about 300 mm/sec before the reading saturates. This extreme vibration is unlikely to be encountered in practice. The table clearly shows the effect of the high pass filtering and how halving the stimulus frequency doubles the PPV value. The measured dominant frequency becomes distorted as high pass filter roll off frequency is approached.

Stimulus Frequency Hz	iVIBE RMS accel. milli-g	iVIBE RMS velocity mm/sec	iVIBE PPV mm/sec	iVIBE frequency Hz	iVIBE HP filter Hz
100	148.8	2.26	3.32	104	0.3
100	148.8	2.25	3.31	105	0.5
100	148.8	2.25	3.31	105	1.0
100	148.8	2.25	3.25	105	2.0
100	148.8	2.25	3.22	105	4.0
10	151.2	23.7	33.87	10.1	0.3
10	151.2	23.65	33.62	10.1	0.5
10	151.2	23.5	33.34	10.2	1.0
10	149.2	22.92	32.53	10.3	2.0
10	142.2	20.93	29.65	10.8	4.0
5	150.7	47.41	66.62	5.1	0.3
5	149.8	47.185	66.62	5.1	0.5
5	149.7	45.75	64.93	5.2	1.0
5	141.6	42.15	59.34	5.3	2.0
5	120.2	30.35	42.68	5.6	4.0
2	149.2	118.62	165.25	2.0	0.3
2	149.5	110.06	158.875	2.1	0.5
2	138.35	99.25	138.375	2.2	1.0
2	107.05	59.65	86.06	2.8	2.0
2	57.7	17.65	25.125	5.2	4.0
1	147.2	212.25	312.25	0.9	0.3
1	138.2	198.37	271.75	1.1	0.5
1	103.8	118.10	171	1.4	1.0
1	60.3	36.00	49.75	2.6	2.0
1	21.2	4.25	6.14	7.2	4.0

Note PPV full scale is about 300mm/sec

iVIBE pulse response

The response of the iVIBE to a single 100mV stimulus pulse of 5 ms duration repeated every 1 second was measured. The pulse is equivalent to an acceleration of 100 milli-g or 981 mm/sec/sec for 5 milliseconds. The resultant velocity is the acceleration multiplied by the time duration, so the calculated velocity generated by the pulse is 4.9 mm/sec. Because there is just one pulse this is the PPV.

With this single pulse stimulus, iVIBE recorded a PPV=4.84 mm/sec and an RMS acceleration of 7.242 milli-g. The calculated RMS acceleration is 7.07 mm/sec.

Instead of the single rectangular pulse we can also apply a single cycle of a 100 Hz sine wave. A continuous 100Hz 150mV RMS sine wave generates a calculated RMS velocity of 2.34 mm/sec and calculated PPV=3.31 mm/sec. The iVIBE measured values are given in the table in the previous section, i.e. PPV=3.31 mm/sec.

If the waveform truncated to a just single cycle, iVIBE measures a PPV=6.48 mm/sec. In good agreement with the calculated answer PPV = 6.62 mm/sec (which is twice the PPV of the continuous sine wave).

NOTES

Revision History

- Issue 1, 18 October 16, original