A FEEDBACK CONTROL SYSTEM WITH A LASER INTERFEROMETER FOR EXACT AND REAL-TIME VIBRATION MEASUREMENT

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This research focus on exact and real-time vibration measurement using a PI (Proportional Integral) feedback control system in a Michelson interferometer with a Helium-Neon (He-Ne) Laser light source. The interferometer can measure a vibration of the object in real time by giving the reference PZT a voltage which is generated by the feedback control system using a signal processing circuit system. The sinusoidal phase-modulation frequency is 10 kHz. A multiplier and a low-pass filter (LPF) with a cut off frequency of 400 Hz function to extract a fundamental frequency component of the interference signal. The measured vibration waveform is calculated as the sum of two measured waveforms obtained from the controller output signal and the feedback signal in the feedback system, respectively.

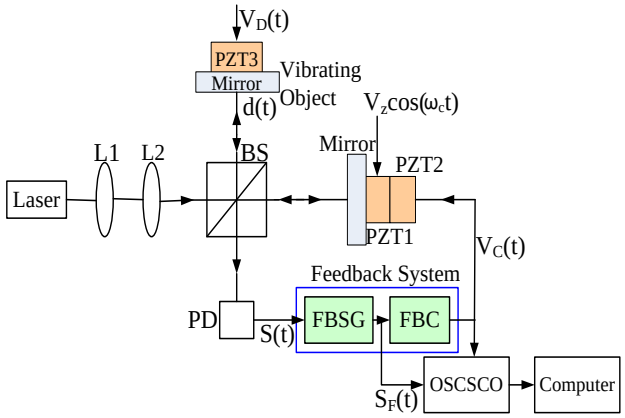

Fig 1. Laser interferometer for vibration measurement with a feedback system.L1 and L2: lens, PZT: piezoelectric transducer, FBSG; feedback signal g enerator, FBC: feedback controller, BS: beam splitter, PD: photodiode, OSCSCO: oscilloscope

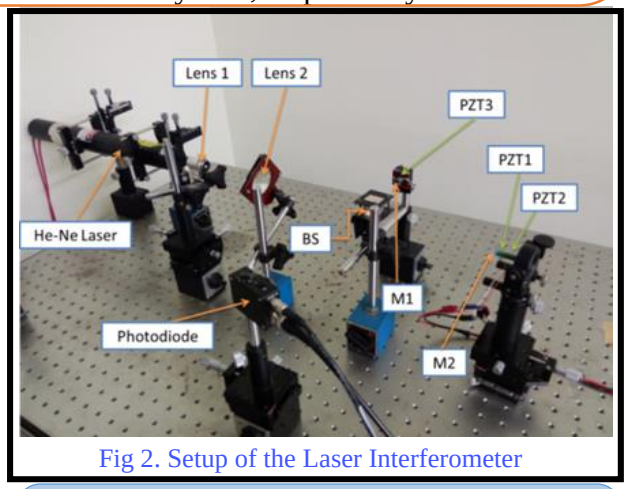

Fig 2. Setup of the Laser Interferometer

Evaluation of Vibration Amplitude:

$d(t)=(\lambda/4\pi)\alpha_D(t)=(\lambda/4\pi)[\alpha_C(t)+S_F(t)/K]$

$\mathbf{d(t) = d_C(t)+d_F(t)}$

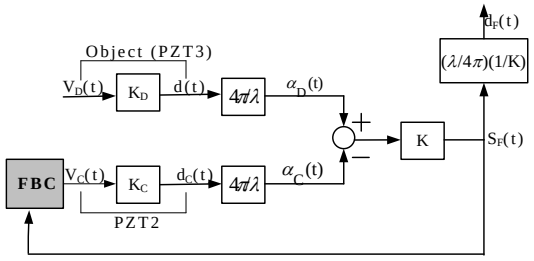

Fig 3. Flow chart of the feedback system

Applied voltage V_{DA} (V)	Given amplitude a_{DG} (nm)	a_C (nm)	a_F (nm)	Measured amplitude a_D(nm)	a_{DG}- a_C (nm)	a_{DG}- a_D (nm)
1.54	198.7	197.0	3.0	200.0	1.7	-1.3
2.46	317.3	310.4	3.8	314.2	6.9	3.1
5.25	677.3	659.2	10.6	669.8	18.1	7.5
8.00	1032	1017.3	13.2	1030.5	14.7	1.5
10.00	1290	1268.3	15.7	1284.0	21.7	6.0
12.00	1548	1527.5	18.0	1545.5	20.5	2.5
14.00	1806	1786.5	21.7	1808.2	19.5	-2.2

Table 1. Experimental Result at Different Voltage

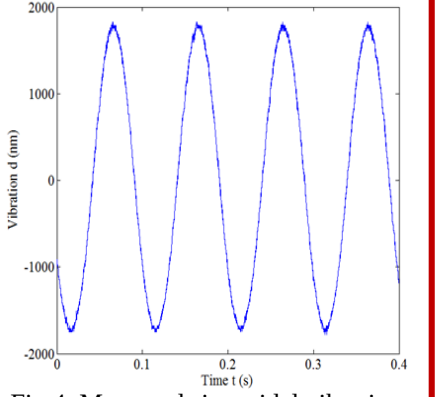

Fig 4. Measured sinusoidal vibration

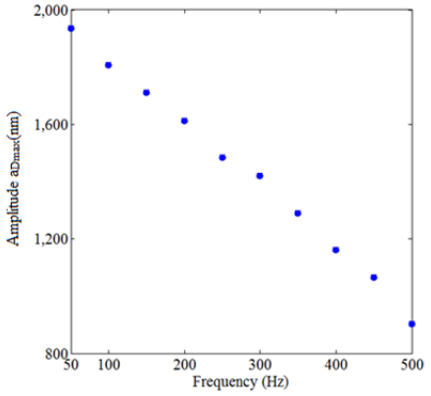

Fig 5. Maximum measurable amplitude

Conclusion:

1. Exact measured vibration amplitude with error less than about 8 nm at vibration frequency of 100 Hz.
2. The maximum measurable amplitude decreases from 1935 nm to 903 nm when the vibration frequency increases from 50 Hz to 500 Hz.