MECH420

Sensors and Actuators

Laboratory Exercise #4:
Dynamic Transducer Characteristics – Frequency Domain

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Part A: Static Transducer Transfer Characteristic

1. The voltage signal of the LED sensor for the different loading conditions is calculated and then the calibration relation

   $|\Delta x/\Delta V| = 1.57$ mm/V

   is used to determine the platform displacement:

   Average values and standard deviation for all voltage values measured for the different positions:

weight [g]	force [N]	V_LED [V]	x [mm]	k [N/mm]
0	0	5.13	0	-
414	4.06	5.35	0.346	11.7
829	8.13	5.58	0.708	11.5

   The stiffness is around $k = 11.5$ N/mm. This is the value measured over the widest range. (An average of Delta x / Delta N over the two ranges would also be acceptable.)

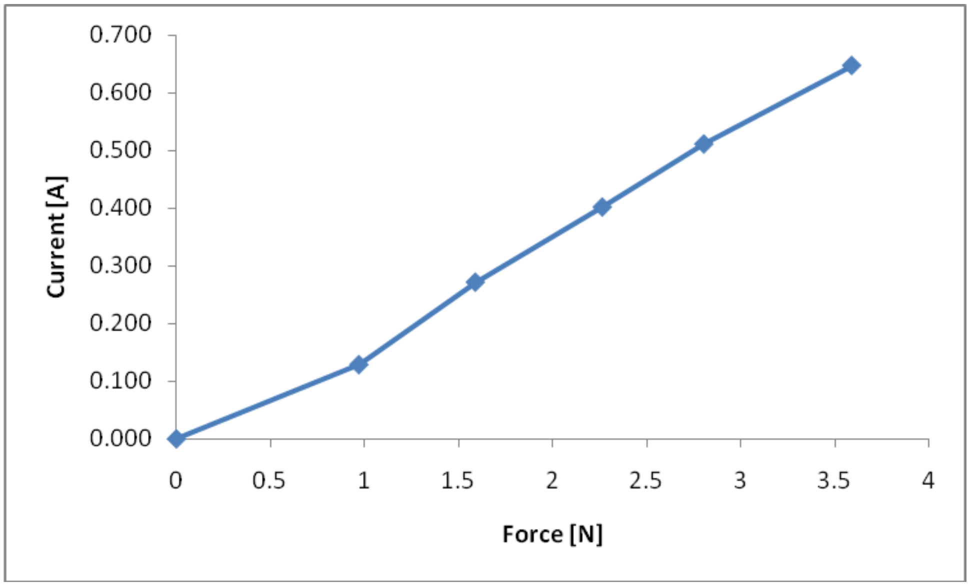
2. After removing the DAQ bias, the quantities displacement, coil current and coil resistance can be found:

voltage [V]	LED Sensor [V]	V_V [V]	V_I [V]	x [mm]	I [A]	V [V]	R [Ohm]
0	5.13	0.035	-0.0275	0.000	0.000	0.00	-
0.5	5.18	0.505	-0.0017	0.084	0.129	0.47	3.65
1	5.21	1.035	0.0269	0.138	0.272	1.00	3.68
1.5	5.25	1.525	0.0529	0.197	0.402	1.49	3.71
2	5.28	1.939	0.0748	0.244	0.511	1.90	3.72
2.5	5.33	2.464	0.1020	0.312	0.648	2.43	3.75

   The average coil resistance is $R = 3.7$ Ohm.

3. Force for the different coil voltages / currents

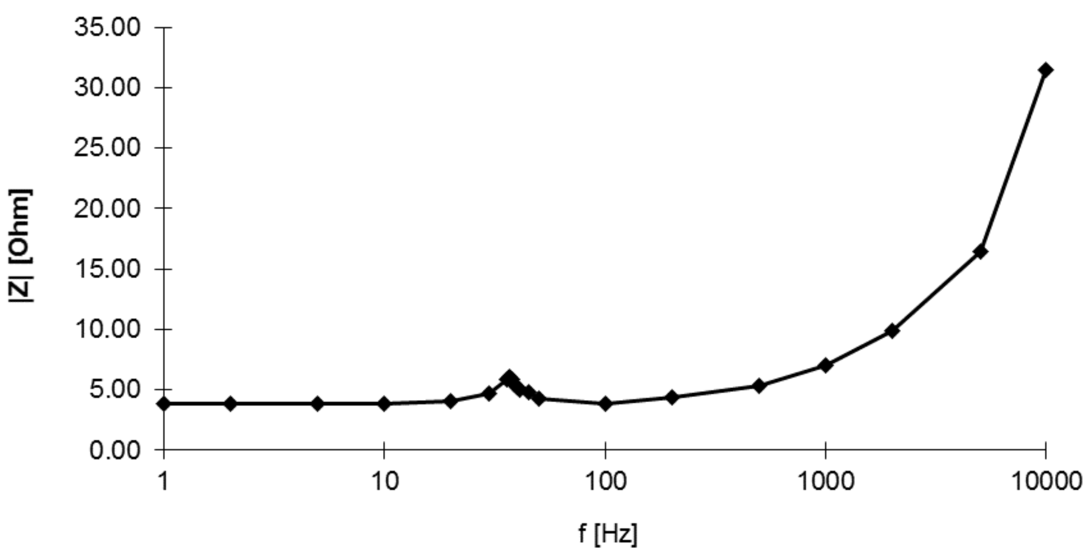
x [mm]	I [A]	V [V]	R [Ohm]	F [N]	Bl [N/A]
0.000	0.000	0.00	-	0	-
0.084	0.129	0.47	3.65	0.97	7.52
0.138	0.272	1.00	3.68	1.59	5.85
0.197	0.402	1.49	3.71	2.26	5.62
0.244	0.511	1.90	3.72	2.80	5.48
0.312	0.648	2.43	3.75	3.59	5.54



This leads approximately to a factor *Bl* = 5.5 N/A.

Part B: Dynamic Transducer Transfer Characteristic

1. Impedance spectrum



2. Transfer function for x:

$$x = \frac{Bl}{k - \omega^2 m} I$$

3. Mechanical resonance of the system

The input impedance of the system

$$Z = V/I = R + j\omega L + j\omega \frac{(Bl)^2}{k - \omega^2 m}$$

yields a resonance at low frequencies from the mechanical system. The resonant frequency

$$f_p = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$$

at f_p = 37 Hz allows determining the effective mass of the platform at

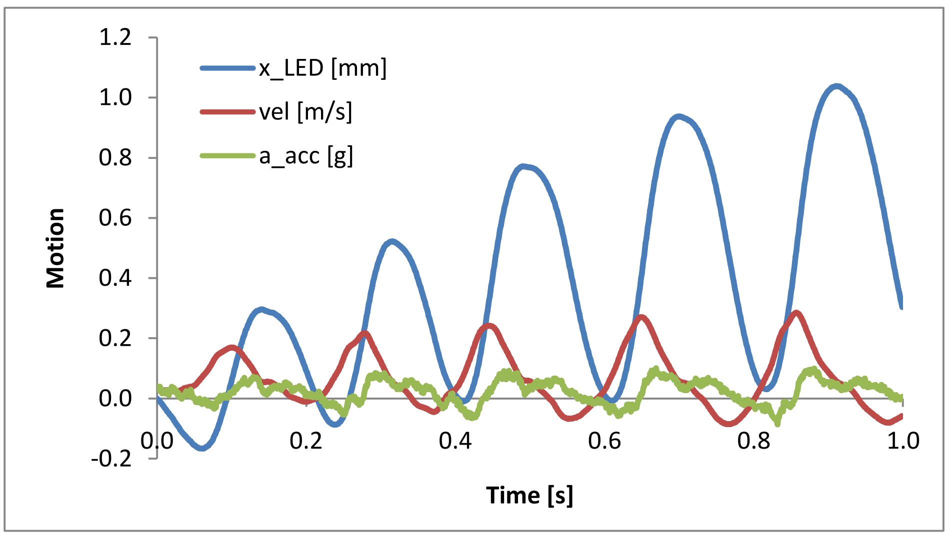
m = 213 g.

4. Verification of the system parameters:

The additional mass M = 2 x 207 g leads to a new resonant frequency f_p' = 22 Hz, which is the exact value found experimentally.

Part C: Motion Sensing with the Voice Coil Transducer

1. Motion signals:



2. The velocity signal is 90° out of phase with respect to both, the displacement and acceleration signals. Displacement and acceleration are in phase, which shows that the convention for the direction was not followed consistently – the acceleration signal was used as measured by the sensor without taking the sensor mounting orientation into account.