NATIONAL CHENG KUNG UNIVERSITY

MECHANICAL ENGINEERING

STOCHASTIC DYNAMIC DATA - ANALYSIS AND PROCESSING

Measuring Instrument - Piezoelectric Accelerometers

Author:
ZHAO KAI-WEN

Supervisor:
CHANG REN-JUNG

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1 Introduction

Vibration adn shock are present in all area of our daily lives. They may be generated and transmitted by mechanical products, such as motors, turbines and machine-tools.
Besides, unpredictable vibration is often a major source of random signal to a system. So, an instrument to measure vibration precisely could be important. In the report, we would comprehend the operation of **piezoelectirc accelerometer** and analyze its specs.

Figure 1: Directional Accelerometers

2 Three-Stages Structure

The figure 2 is a standard setup of vibration measuring environment. It could be cataloged into three stages.

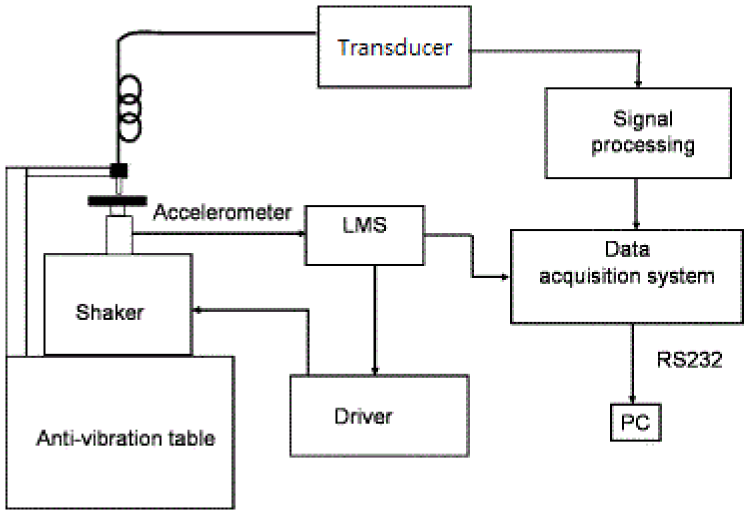


Figure 2: Measuring Setup

2.1 First Stage - Signal Transducer

In first stage, the subsystem could transform displacement signal to electrical signal. The mechanical conversion in this transducer is achieved through a seismic mass supported by a flexible piezoelectric material. The piezoelectric material generates a charge that is propotional to its deformation that the displacement of the mass relative to the base of the accelerometer.

Accelerometer is a classic dynamic system which contains spring, damper and mass. The dynamic equation could be clearly described

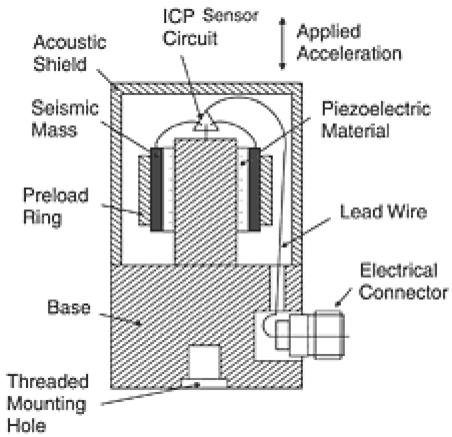


Figure 3: Transducer Stage

$$m\ddot{y}(t) + c\dot{y}(t) + ky(t) = f_{ex}(t)$$

The frequency response could be represented as

$$H(f) = \frac{c}{4\pi^2 f_n^2[1 - (f/f_n)^2 + j2\zeta(f/f_n)]}$$

where c is calibration constant, ζ is damping ratio and f_n is undamped natural frequency.

On practice, we would design ζ approximates 0.7 to avoid overshoot and, on the other hand, the system would not be too slow. In order to measure as wide range of frequencies as we can, set first mode f_n far is preferable.

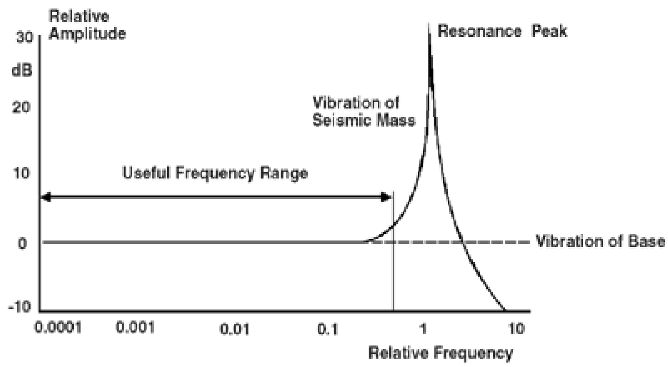


Figure 4: Bode plot of 2nd order system

2.2 Second Stage - Signal Conditioning

The signal-conditioning electronics convert the high-impedance charge signal generated by the sensing element into a usable low-impedance voltage signal that can be readily transmitted.

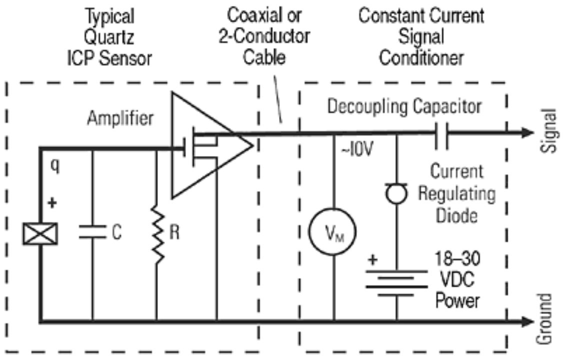
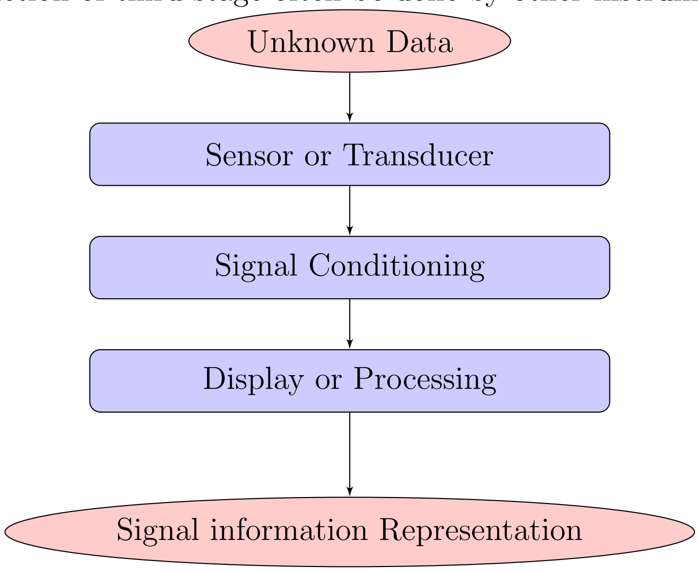


Figure 5: The schematic diagram of a typical accelerometer measurement system built-in signal conditioning circuitry

2.3 Third Stage and flow chart

The third stage usually means display or signal processing. In this case, the function of third stage often be done by other instruments like DSP or CPU.



3 Specifications of Acceleromters

I take an acceleromter from XSCALA company and list several specs we focused.

Figure 6: Appearance of Type 4371 Accelerometers

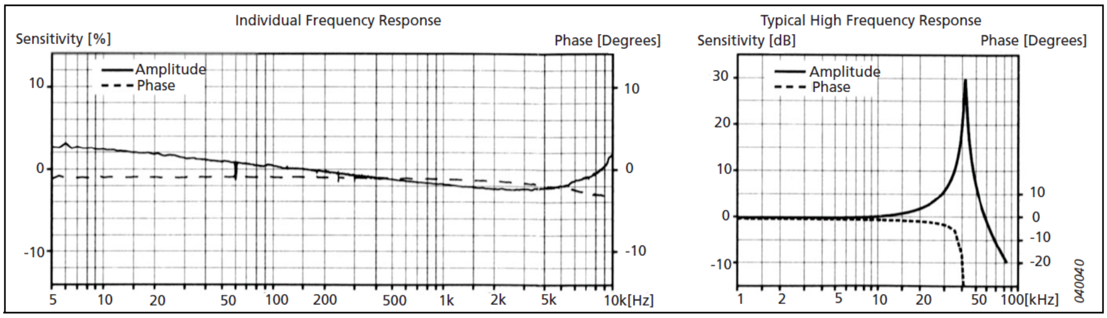


Figure 7: Dynamic Characteristics of Sensitivity and Bode plot

Specifications	Values
Charge Sensitivity	$9.8 \pm 2\%$ pC/g
Mounted Resonance Frequency	42 kHz
Amptitude Response $\pm$ 10%	$0.1 \sim 12600$ Hz
Max. Operation of Sinusoidal Vibration	6000 g pk

4 Acceleromters Today

Acceleromters are widely used not only in engineering but we could easily find in daily life. Smart phones definitely embedded accerlerometers. In such mirco sacle, the components are called MEMS. They are high-tech products and beautiful like art.

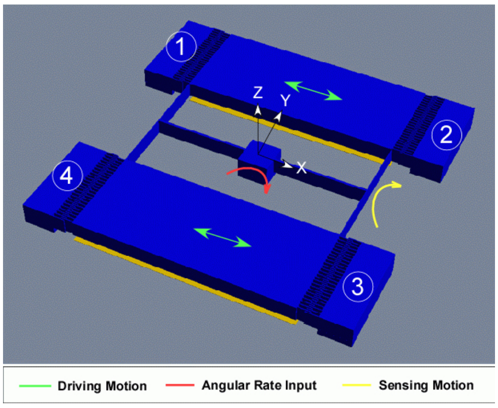


Figure 8: MEMS Element Simulation Diagram

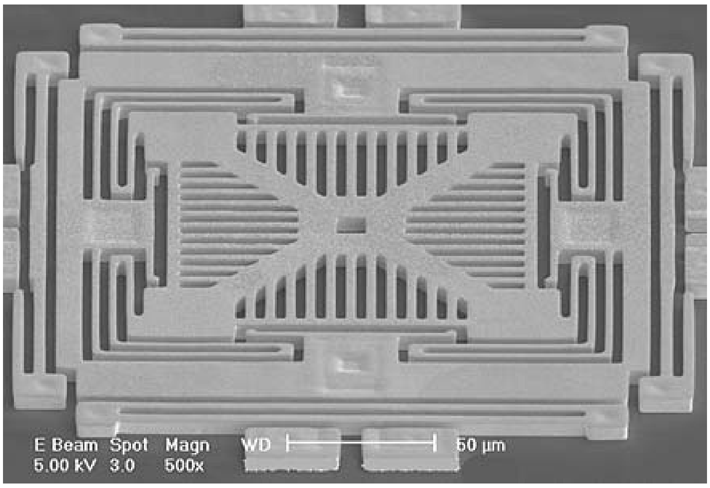


Figure 9: Acceleromters under microscope

References

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