University of technology
Laser and optoelectronics eng. Dept.

LASER APPLICATION COURSE
4TH YEAR
LEC.12

Example11[9]:

A depth sounder on an aircraft estimate the time of plan-to-sea floor pulse trip by 1.5μsec & time of plane-to-water surface pulse trip 1μsec. What is the depth of sea?

Solution:

$$D = \frac{C}{2}(T_F - T_S) = \frac{3x10^8}{2}(1.5x10^{-6} - 1x10^{-6})$$

$$D = (1.5x10^8)x(0.5x10^{-6}) = 75 \ meters$$

Laser Doppler Velocimeter (LDV)

- Laser Doppler Velocimeter (LDV) is an interferometric technique for velocity measurements on solid, liquid and gas which determines their instantaneous velocity by observing the Doppler effect on a laser beam diffused by the object surface[4].
- Before entering into the in-deep explanation of LDV the understanding of its basic component is needed. Therefore the Doppler Effect, Piezoelectric Effect and the Acousto Optic Modulator (AOM), should be discussed

Doppler Effect

- Is the change in the measured frequency of a wave due to the motion of the source relative to the observe. If the source is moving towards the frequency increases (wavelength decreases), & it decreases when the source is moving away. The true source frequency remains the same but more waves arrive at the observer per second when the source is moving toward the observer than when it is moving away. In the case of electromagnetic radiation, if v is the relative velocity of the source & f is source frequency, then the measured electromagnetic wave frequency is:

$$f' = f\left(\frac{c}{c \pm v}\right). \quad (3.6)$$

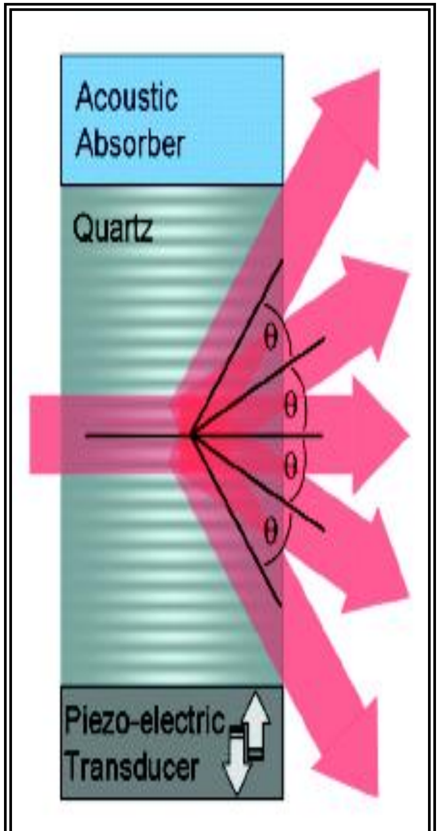
$$f' = f\left(\frac{c}{c \pm v}\right) \approx f\left(\frac{c \mp v}{c}\right) = f\left(1 \mp \frac{v}{c}\right) = f + f_d \quad (3.7)$$

$$f_d = 2f\frac{v}{c} = 2\frac{v}{\lambda} \quad (3.8)$$

Note: if the source moving toward the observer the sign in Eq.3.6 is (-), and if it is moving away from the observer (+).

PIEZOELECTRIC EFFECT

- A piezoelectric material is one that produces an electric charge when a mechanical stress is applied (the material is squeezed or stretched) and it worked as **sensor**. Conversely, a mechanical deformation (the material shrinks or expands) is produced when an electric field is applied then it **transducer** [10].
-



Acousto Optic Modulator (AOM)

- An acousto-optic modulator, also called a Bragg cell, uses the acousto-optic effect to diffract and shift the frequency of light using sound waves. A piezoelectric transducer is attached to a material such as glass and an oscillating electric signal drives the transducer to vibrate, which creates sound waves in the glass. These can be thought of as moving periodic planes of expansion and compression that change the index of refraction. Incoming light scatters off the resulting periodic index modulation[5, 11].

ACOUSTO-OPTIC EFFECT

- The acousto-optic effect is the change in the refractive index of a medium caused by the mechanical strains accompanying the passage of an acoustic wave through the medium [5].
-
- ***Principle of operation*[4, 11, 12]**
- The **L**aser **D**oppler **V**elocimeter measures the ***frequency shift*** in the radiation **emitted** and the radiation **returning** as illustrated in Fig. 3.1 The first used of ***LDV*** was reported by Yeh & Cummings in 1964.
- In this technique the laser beam emitted toward the movement target through a beam splitter which split the beam in two direction the first go to the photodetector and the second toward the target. Then the reflected beam from the mobile target return to the photodetector. At this point the detector measure the frequency shift between the two beam.

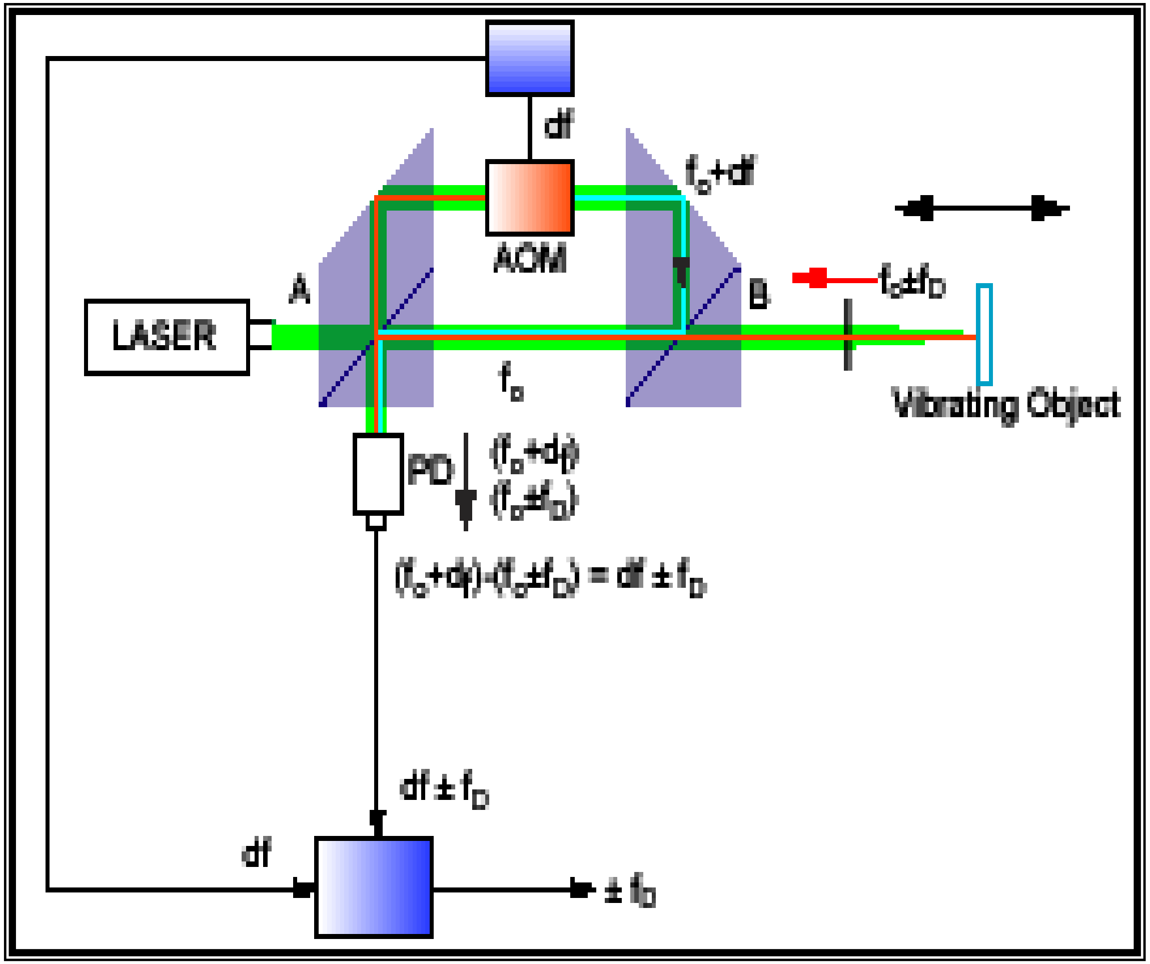


Figure 3.2 A heterodyne interferometer. The additional Bragg-cell produces a frequency shift in the reference laser beam[12].