# IMPLEMENTATION OF ACOUSTIC DOPPLER CURRENT PROFILER FOR MEASUREMENT OF VELOCITY OF WATER

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**ABSTRACT:**

**This paper gives design of Acoustic Doppler Current Profiler. It is used for measuring the water profile. This can be mounted on the walls of bridges, below the underwater vehicle and can be fitted at the bottom of the water column. It gives readings not just at the bottom or top surface but gives throughout the water column. Basic principle used in this is Doppler Effect. This design is working on the 40 KHz frequency. New additions can also be done for the removal of noise etc.**

**KEYWORDS: ADCP, Frequency Shift**.

**INTRODUCTION:**

Acoustic field is important field in research from past years. Various processing are done on acoustic signals for various applications like finding defects in metal, medical fields etc. One more purpose among all the applications is to find the velocity of water. There are many different techniques by which velocity is to be measured. But Acoustic Doppler Current Profiler is becoming famous because of ease. Its use is not only restricted to the velocity measurement of water. This can be used for underwater vehicle tracking, level measurement, volume measurement etc.Reservoir loses its capacity (volume) due to various materials getting dumped after rainy season. So Doppler technology can measure changes which are happening due to these materials.The basic principle used in ADCP is Doppler Effect. Using this Doppler Effect principle frequency shift is calculated and according to the frequency shift velocity of water is calculated.Previously in 1999 Acoustic Doppler Current Profiler's were with fan-shaped transducer for the measurement of oceanicsurface currents [i]. Operating Frequency was 300 kHz. The usable horizontal range varied with wind speed from about 120 m to 190 m.

Then in 2000, trawl resistant ADCP's were found out which was bottom mounted [ii]. It was operated on 75-kHz for current measurements in coastal waters.This ADCP was having round shape and was having protection against impacts. It was having weight up to 640KGs. So was again bulky. Then attempts were made to decrease the size and for giving accuracy. Memory units for continuous velocity observations were also added.

**MEASUREMENT PRINCIPLE:**

Acoustic Doppler Current Profiler uses Doppler Effect principle. It says that when sound wave is going towards the observer then it is having higher frequency than when it is going away from the observer. Suppose acoustic wave is going into the water with frequency $F_0$ .Suppose the reflected wave reflecting from particles in the water is having frequency $F_S$. So the Doppler shift is $F_D = F_0 - F_s$ [vi].

Velocity will be given as,

$$V = F_D \times C / (2F_0 \sin\alpha)$$

Here, $F_D$ is Doppler frequency shift, C is speed of sound in water, $F_0$ is the frequency of transmitted acoustic wave and α is the angle of the beam.

**TECHNIQUE:**

Figure 1 gives the design of ADCP. This is having components as ultrasonic transmitter, ultrasonic receiver, amplifier, display and microcontroller.Firstly microcontroller gives trigger pulse to ultrasonic transmitter. So after triggering ultrasonic transmitter generates an ultrasonic wave. Now when wave strikes to particles in the water it is reflected back. It is received by receiver. It has small amplitude, so it is given to amplifier.There is frequency shift between transmitted and received wave. This frequency shift is measured by the microcontroller.This frequency shift is used to calculate velocity of water. It is displayed on the LCD display.

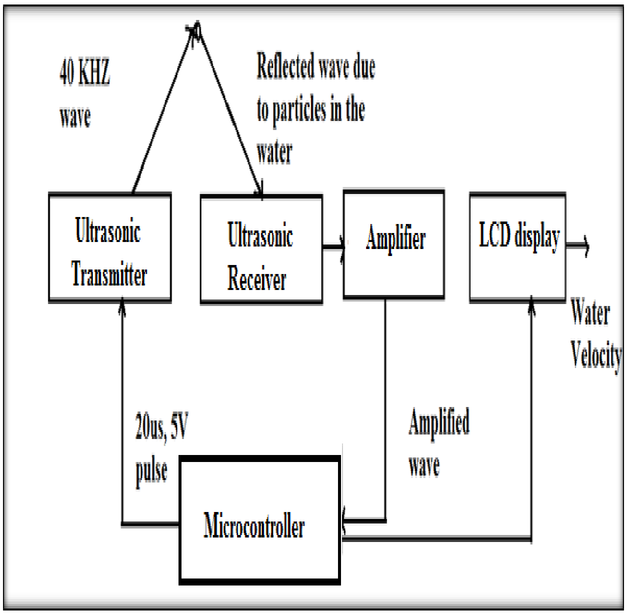


Fig. No.1. Block diagram of Acoustic Doppler Current Profiler

**CIRCUIT DIAGRAM:**

Figure 2 gives circuit diagram of ADCP. Wave of 20µs, 5V is generated from the microcontroller ATMEGA 8. It is given to the transmit pin of the ultrasonic transmitter from pin PC5 of the ATMEGA 8.When wave strikes on particles in the water it is reflected. Ultrasonic receiver receives this wave. But it is having less amplitude and distortions.So an instrumentation amplifier is used which is AD620N. Its gain can be adjusted between 1 and 10k using single pot. Two pins of receiver are connected to the inverting and non-inverting terminal of Amplifier. The output is given to ATMEGA 8. Controller counts the no of cycles which is the frequency.Frequency is displayed on the LCD through interfacing of microcontroller and LCD.Velocity of water is also given on the LCD.

**ALGORITHM:**

ATMEGA 8 is the controller used which controls all the units. Ultrasonic sensor of 40 KHZ is used. Assembly language can be used for the programming. By following steps the system is implemented. Refer figure 3.

- A 20µS, 5V pulse is generated through ATMEGA 8.
- This pulse is given to ultrasonic transmitter.

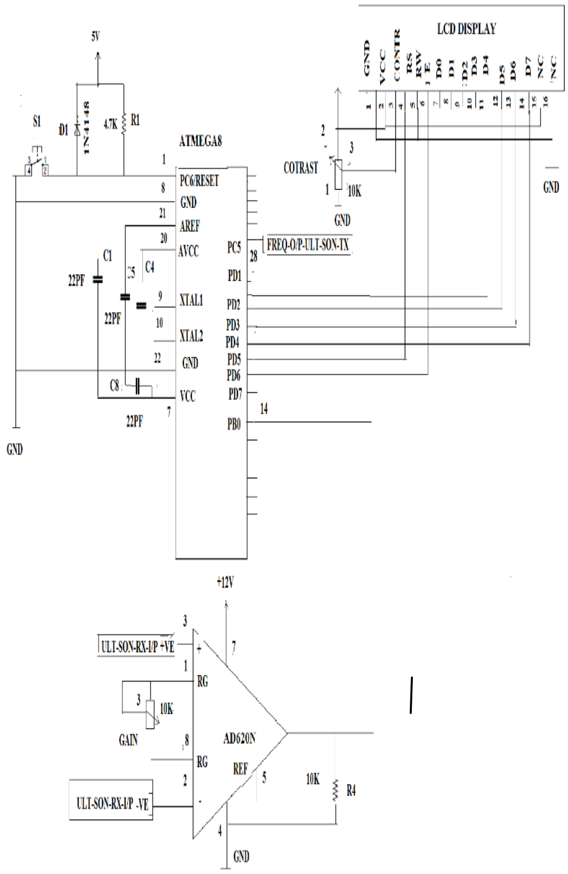


Fig. No.2. Circuit diagram of proposed system

- After receiving triggering pulse ultrasonic transmitter will generate a 40 KHZ ultrasonic wave and frequency will be displayed on the LCD.
- If frequency on the display is not giving 40KHZ reading then angle is to be adjusted.
- The reflected wave is received by the ultrasonic receiver.
- As amplitude is less of received signal, it is given to amplifier.
- Microcontroller ATMEGA will do the frequency shift and velocity calculations.
- Finally result is displayed on LCD which is water velocity.

**RESULTS:**

In order to observe results an ultrasonic sensor with frequency 40 KHz is taken. 10 consecutive readings are taken for different particles placed in the water. From these results it is observed that water particles coming towards the ADCP are having higher frequency. While particles going away from ADCP are having less frequency. This Doppler shift of frequency satisfies the principle of Doppler Effect. This shift will be required for the calculation of velocity of water which is given in the chart. It is given in table 1.

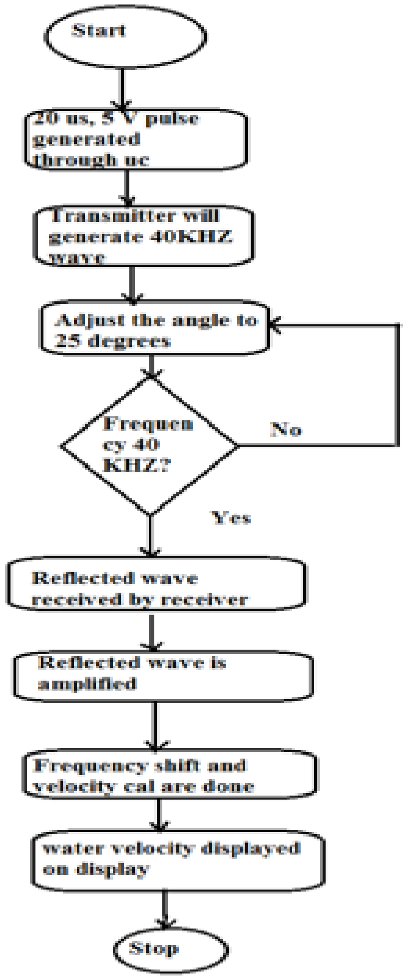


Fig. No.3. Flow chart of the system

**CONCLUSION AND FUTURE SCOPE OF WORK:**

Doppler shift principle also can be used to find velocity of water. It is observed that water particles coming towards the ADCP are having higher frequency. While particles going away from ADCP are having less frequency. From this shift of frequency calculation of velocity of water is done which is given in the chart. Noise factor can be calculated in future. Further circuitry for removal of noise can be designed.

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Table 1. Frequency and velocity on display

| Symbol | Frequency after reflection | Doppler shift | Velocity |
|---|---|---|---|
| 1 | 38.821KHz | 1.179 KHZ | 3m/s |
| 2 | 36.039 KHz | 3.961 KHZ | 9m/s |
| 3 | 39.64KHz | 0.34 KHz | 1m/s |
| 4 | 26.04 KHz | 13.96 KHz | 30m/s |
| 5 | 29 KHz | 11.00 KHz | 24m/s |
| 6 | 33 KHz | 7 .0 KHZ | 14m/s |
| 7 | 28.42 KHz | 11.58 KHZ | 28 m/s |
| 8 | 37.715 KHz | 2.285 KHZ | 5m/s |
| 9 | 39.98 KHz | 0.02KHZ | 0m/s |
| 10 | 27.14 Hz | 12.86 KHZ | 29m/s |

**REFERENCES:**

i. A. J. Plueddemann and E. A. Terray, "*Design and Performance of a Self-contained, Fan-Beam ADCP*", IEEE journal of oceanic engineering, vol 26, pp 252-258, 1999.

ii. Henry Perkins, Federico de Strobel, and Lavinio Gualdesi,"*The Barny Sentinel Trawl-ResistantADCP Bottom Mount: Design, Testing, and Application*", IEEE JOURNAL ON OCEANIC ENGINEERING, VOL. 25, NO. 4, pp 430-436, OCTOBER 2000.

iii. Michael R. Simpson,"*Discharge Measurements Using a Broad-Band Acoustic Doppler Current Profiler*", United States Geological Survey OPEN-FILE REPORT 01-1, 2005.

iv. Rao Zhong-yang, Feng Chun-yuan," *Fast and Accurate Frequency Estimation Algorithm for ADCP Carrier Frequency*", 2nd International Conference on Industrial Mechatronics and Automation, Volume.2.pp 236-239, 2010.

v. M. Jordan Stanway, "*Water Profile Navigation with an Acoustic Doppler Current Profiler*", oceans 2010 sydeny,pp 1-5.

vi. Rao Zhong-yang, Feng Chun-yuan," *Implementation of Coded Pulse Complex Correlation Algorithm on Broadband ADCP*", in proc CECNet, 2011, pp 410-413.

vii. A. M. Thurnherr," *Vertical Velocity from LADCP Data*",Proceedings of the IEEE/OES/CWTM Tenth Working Conference on Current Measurement Technology, 2011, pp 198-204.