A Traverse System
Microcontroller based design and realization of a two degree of freedom Laser Doppler Velocimetry

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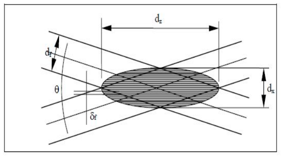
Abstract: Laser Doppler Velocimetry (LDV) offers precise measurements of fluid flows regardless of its flow regime. The relatively low cost, ease of use, and expandability of LDV make it suitable for a wide array of fluid dynamic, vibration, and fluid structure interaction experiments. Challenges often faced when interfacing these highly precise optical equipments with physical phenomena is creating a robust, simple, and precise control system. The field of Mechatronics blends mechanical, electrical, and programming components together to assist in creating robust control architecture for the particular measurement system. In this report we present a novel two degree of freedom electro-mechanical optical traverse for precisely controlling the motion of a laser probe. We illustrate a simple calibration method , and the results.

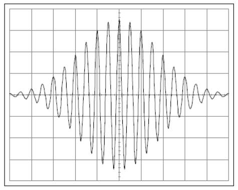
Problem Overview- What is LDV?

- Offers precise measurements of fluid flows regardless of flow regime
- Laser Probe emits beams of light that intersect to form a small control volume
- Through this volume seeded particles on the order of microns pass through

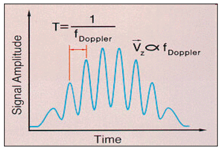


df=:width of incident beam, dz:length of control volume,dx:width of control volume, θ: angle of incidence, and δf: is the minimum grid size

- If on average the level of seeding is less than one particle per signal burst we speak of a burst type doppler signal
- A typical burst type signal can be seen to the right with the DC part removed by a high pass filter
- The flow processor or "brain" of the LDV correlates these signal bursts to velocities at discrete points

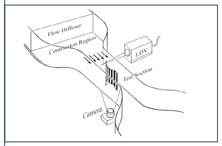


- The picture on the bottom left shows the relationship between the frequency of the signal and the velocity of the flow
- Doppler frequency is proportional to particle velocity



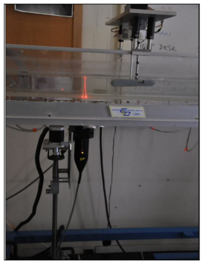
Practical Applications of LDV in the DSL

- Flow visualization of Heavy Flags oscillating in water (see Figure 4. courtesy Shelley et al)
- Flow physics of the free locomotion of robotic swimmers as well as live fish
- Drag computations and understanding of a geometrically scaled submarine



Experimental LDV and Heavy Flags set up

Bio-mimetic robotic swimmer propelled by an ionic polymer metal composite (IPMC) and a passive fin

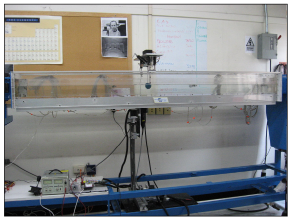


LDV set up with custom built force balance for flow physics analysis

Project Goals

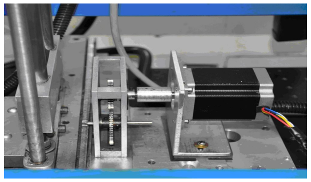
To design and realize a two dimensional electromechanical traverse to guide a laser probe within a water tunnel

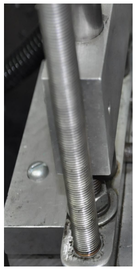
- The traverse must have a precise resolution~1mm
- Should have automatic and manual modes
- Capable of self calibration
- Expandable



Electro-Mechanical Design & Realization

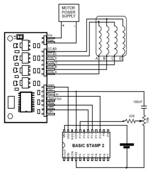
- Lead Screw Assembly
- Motor driving rack and pinion
- Rack and pinion

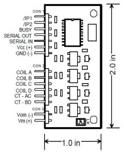


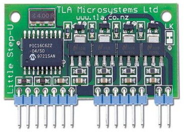


Little Step-U

- Power Requirements: 4.5 to 5.5 VDC
- Communication: Serial
- Dimensions: 1.96 x 0.98 x 0.15 in (50 x 25 x 4 mm)
- Operating Temperature: +32 to +158 °F

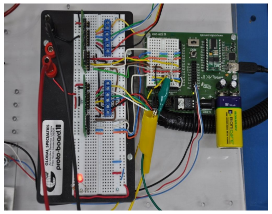






The Circuit System

- 2 Little Step-U
- BS2 microcontroller
- BOE breadboard
- ProtoBoard III breadboard
- 9V battery
- Lodestar DC Power Supply



Electro-Mechanical Design & Realization (con't)

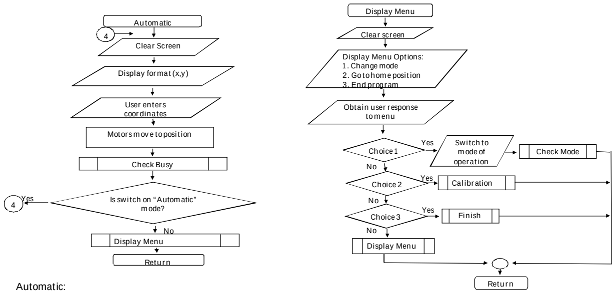
Further work includes:

-optical encoders

-limit switches for feedback control

-printing a circuit board

Software Design & Realization

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Automatic:

DO

    DEBUG CLREOL,20, 44                    'clears previous user entries.

    DEBUG CRSRXY, 20, 13, " Enter the coordinate (x, y): "
    DEBUGIN DEC x_RevSteps, DEC y_RevSteps

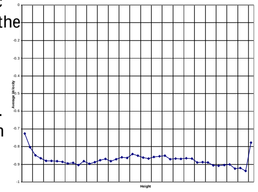
    'motor goes horizontally  to absolute location.
    SEROUT 10,baud,["{D", DEC x_RevSteps, " }"]
    GOSUB CheckBusy

    'motor goes vertically to absolute location.
     SEROUT 11,baud,["{D", DEC y_RevSteps, " }"]
     GOSUB CheckBusy2

LOOP WHILE sp3tSwitch0 = 1
GOSUB Display_menu
```

Research

Fluid flow data was processed in order to understand the progression of the boundary layer of the flag in the static case, and also to understand a planar velocity grid after the flag in the fluttering case.



Based on our measurements from this experiment, we concluded that water flow in the water tunnel is laminar. The flow velocity will be different at different heights. In addition, there are points in the flow field where friction will be minimized between different layers of water

Further Applications

The system can also be used to examine the flow physics of several objects of interest. We have a submarine which has been decreased to a scale suitable for the water tunnel. Drag Data for this scaled submarine can be computed at different angles of attack by either noting the incoming velocity or approximating a similar geometry with a known drag coefficient, or by doing a systematic three dimensional boundary layer growth analysis and use momentum integral equations to resolve the drag.

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