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MITLL High Ball

Anemometers for Dynamic Ultra-Lightweight Craft

I. Introduction

Every day millions of Americans watch their local weather station's tv channel to learn about the weather. The meteorologists usually have colorful easy to read time lapses for different variables like heat, precipitation, UV exposure, and wind. For some professions it's extremely important to consider the day's weather conditions. Depending on the profession it could just mean to wear boots and a rain jacket or for others it could be life or death. It's especially important in avionics and more so the lighter the aircraft. To create the colorful time lapse weather maps, meteorologist use a combination of doppler radar and remote weather recording stations aggregated with each other. Within the remote recording stations there are a multitude of gauges and sensors; With one of them being the anemometer.

II. Background

The anemometer is a device used for measuring the speed of wind. [2] They are often deployed at weather stations and other locations where wind speed is important like airplanes or helicopters. There is a wide range of existing products available on the market, for just about any price point and accuracy. For instance, you can order a \$20 anemometer for a middle school science class room or a \$500-\$10,000 one for a weather station. The most respectable brands include Campbell Scientific, Met One, NRG, and R.M. Young. There are many different types of anemometers on the market with many different features from being heated (for icy areas), wind direction, air quality sensors, and pollen level sensors.

Anemometers use a wide variety of different methods to collect wind speed and direction including three cup mechanisms, propellers, vanes, 2-D ultrasonic sensors, 3-D sonic sensors, hot wire probes, and continuous-wave lidar systems. Three cup mechanisms and propellers utilize moving parts and only measure wind speed. Whereas a hot wire probe anemometer measures wind speed with static parts. Vanes exclusively measure wind direction. The 2-D and 3-D sonic sensors measure both wind direction and speed; the 3-D sonic sensor measures also in the z plane. The continuous-wave lidar system allows for remote wind measurements at 10 user specified heights between 10-200 meters. [5]

III. Windspeed for Dynamic Objects

For aircraft (as well as boats) Pitot tube static anemometers are used to measure flow (windspeed in this case), the design takes advantage of differential pressure measured by pressure transducers to

calculate the flow. However, it isn't practical for a light payload high altitude balloon. The hot wire probe fits the balloon's application the best with a weight as light as 1.5 grams. The hot wire method takes advantage of a standard transient dynamic technique that is based on the temperature change in a defined distance from a linear heat source. [4] The thermal conductivity can be derived from the change in temperature at the same defined distance. [3] Therefore, being able to measure the wire temperature via the heat lost from being cooled by wind, this temperature differential is converted into fluid velocity. [1] [4] A prime example for the High Ball project is the Modern Device Wind Sensor Rev. P.[6] The Rev P has hardware compensation for ambient temperatures, which is important at cold temperatures at high altitudes. [6] The Rev P. utilizes PTC thermistors which in comparison to their older model the Rev.C require a higher voltage to heat the element to operating temperature. The sensor requires an 8 volt supply; This higher voltage allows the Rev P. to heat to a higher temperature which allows the sensor to sense hurricane speed winds (0-150 MPH) without over saturation. [6] For convenience of use the temperature sensor analog output is 3.3 volts so that it can be easily paired with the increasingly common 3.3V requirement for microcontrollers. [6]

IV. Building Blocks

Implementing the Rev.P would require a small amount of programing and a microcontroller like a mBed or a TI launchpad. To further solidify wind measurements a tri-axis accelerometer could be included with minimal effort. A supply voltage of 10-12 volts is reasonable for the High Ball project. The Rev.C itself only demands around 40 mA of current. Due to the nature of high altitude balloons the system would have to be soldered to a protoboard, wired correctly, and encased in a custom protective case that does not inhibit the function of the device and must also provide sufficient protection from the environment. Implementing the Rev.P and accelerometer will provide the high altitude balloon with information vital to it's surveying and communication tasks.

References

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