

Altitude Measurement for Weather Balloon Altitude Control

Introduction

Altitude measurement has played an important part in aviation since the development of the first accurate altimeter in 1928 [1]. Other aerial vehicles have begun using altimeters for elevation control. Recent research suggests similar altitude control systems can be implemented into high altitude balloons [2]. High altitude balloons require small, lightweight measurement instruments, so altimeters are typically used. Typically, small measurement devices are less accurate than large designs, but altimeters can maintain accuracy by using microelectromechanical systems (MEMS). Additional methods of measuring altitude include GPS and laser altimetry. This paper reviews some commercially available altitude measurement devices and explains different altitude measurement techniques as well as how these devices are implemented.

Techniques for Altitude Measurement

Pressure Altimeter

The most common technique for determining altitude is measuring atmospheric pressure. Pressure altimeters use specifically calibrated barometers to determine altitude. These devices introduce inaccuracy when the atmospheric pressure changes due to factors other than altitude changes. For example, heavy fog or pressure fronts can change the atmospheric pressure while at a constant altitude. Most aircraft are equipped with adjustable pressure altimeters to account for variations due to weather and temperature changes [3]. Similar detectors are also used by skydivers, hikers, and climbers. Pressure altimeters can be implemented in many different styles. MEMS based altimeters lend themselves to limited space applications such as high altitude balloons [4]. Other altimeter implementations tend to be larger and not suited for balloon payloads.

GPS Altitude Measurement

It is also possible to measure altitude above sea level using GPS. Under perfect conditions, GPS altitude measurements can vary by ± 45 m [5]. When conditions are imperfect, such as poor signal or in an environment with many nearby objects, the measurement variation worsens. When compared to the analog altimeter, this is a severe drawback. Using post-processing techniques, it is possible to significantly improve GPS elevation accuracy at high altitude [6]. In certain applications, such as high altitude weather balloons, this may provide sufficient accuracy for an altitude control system. Another benefit of GPS devices is the ability to track position as well as altitude. Depending on the application, it may be a beneficial tradeoff to reduce the accuracy of the altitude measurement in exchange for reducing the number of measurement devices on the platform. This tradeoff is especially important on platforms

such as weather balloons due to the low payload limit. These devices are typically implemented on small chips about 1-2 inches in each dimension.

Laser Altimetry

NASA utilizes a unique, high precision laser altimetry system to create a lunar topographic map. Laser Altimetry allows elevation measurements without relying on atmospheric pressure [7]. This is a requirement for NASA's applications, but is cost prohibitive in most other situations. Laser altimetry is typically used for high precision topographical applications. This technique has been used to generate topographical maps of both Mars and the moon as well as to monitor variations in the polar ice-sheets [7, 8].

Commercially Available Components

One MEMS pressure altimeter is the MPL3115A2 [4]. This device is priced at \$14.95 and measures altitude within 30 cm [4, 9]. This device draws a maximum current of 2 mA at 2.5 V. At 5.0 mm x 3.0 mm x 1.1 mm, the altimeter can be easily incorporated into small designs [4]. The MPL3115A2 altimeter provides a small, low cost option for gathering altitude data.

A GPS counterpart is the GPS 15x by Garmin [10]. The device costs \$43.50 which is significantly more expensive than the pressure altimeter [11]. The GPS draws 66 mA nominal current at 3 V. While larger than the altimeter, it is still small enough, 23.88 mm x 42.93 mm x 7.84 mm, to be used on small platforms [10]. If the platform only requires altitude data, the pressure altimeter is the better option; however, if other position data is required, the GPS chip allows for the consolidation of position and altitude measurement capabilities.

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