SONORAN

ULTRASONIC CAVE MAPPING PLATFORM

PSOC DESIGN CONTEST 2002

entry #287

ABSTRACT

Even though we associate someone who is "as blind as a bat" as a person with poor imaging capabilities, the bat (*Chiroptera)* arguably has the best "vision" of all mammals. The bat's high frequency "vocal" capabilities are so far advanced that its perception is orders of magnitude more precise that today's most sophisticated naval sonar. Based on advances in industrial-quality ultrasonic transducers and MEMS-based inertial measurement sensors, we can now mimic the bat's integrated sensory capabilities for echolocation in a model to probe the bat's native dwellings: caves and tunnels.

Cave mapping has taking on many forms in the past (most of them manual, using a tape measure and compass). However, as the demand to probe and map the deepest crevasses of our world grows for industrial and tactical purposes, a faster and automated method is needed. A platform that can accurately measure cave and tunnel dimensions has industrial applications in mining, drilling, and drainage, as well as in geological studies and in military reconnaissance. The small, untethered, self-contained nature of a platform could allow the device to travel further into the subterranean realm that current GPS-based systems allow and where the environment is too hazardous for human agents.

This project presents such an ultrasonic cave mapping platform, which combines an ultrasonic ranging system, a scanning solar assembly, and a six degree-of-freedom inertial navigation system (INS) capable of taking precise measurements of cave and tunnel dimensions as the vehicle (drone) upon which it is mounted navigates the cave or tunnel. The INS is capable of measuring speeds up to 45 miles per hour, with rotational rates up to 300 degrees/second; the ultrasonic ranging system can probe up to 35 feet with 1% error. The serial output of the platform can be directed at a control computer to make navigation decisions as well as reconstructing the output data.

The drop-in flexibility of the PSoC allows for such advanced applications as:

- configuring the platform to run as a slave and using the ultrasonic ranging data to continuously recalibrate the navigation system
- configuring the platform to run as a master to direct the vehicle down the center of a cave or tunnel, using controlled reverse and forward motion to further calibrate the navigation system
- coupling the INS with GPS and using the former in a "gap-filling" mode to interpolate between two points
- quickly adding gas, humidity, temperature, and PIR sensors to create a complete survey of the target environment

Entry #287

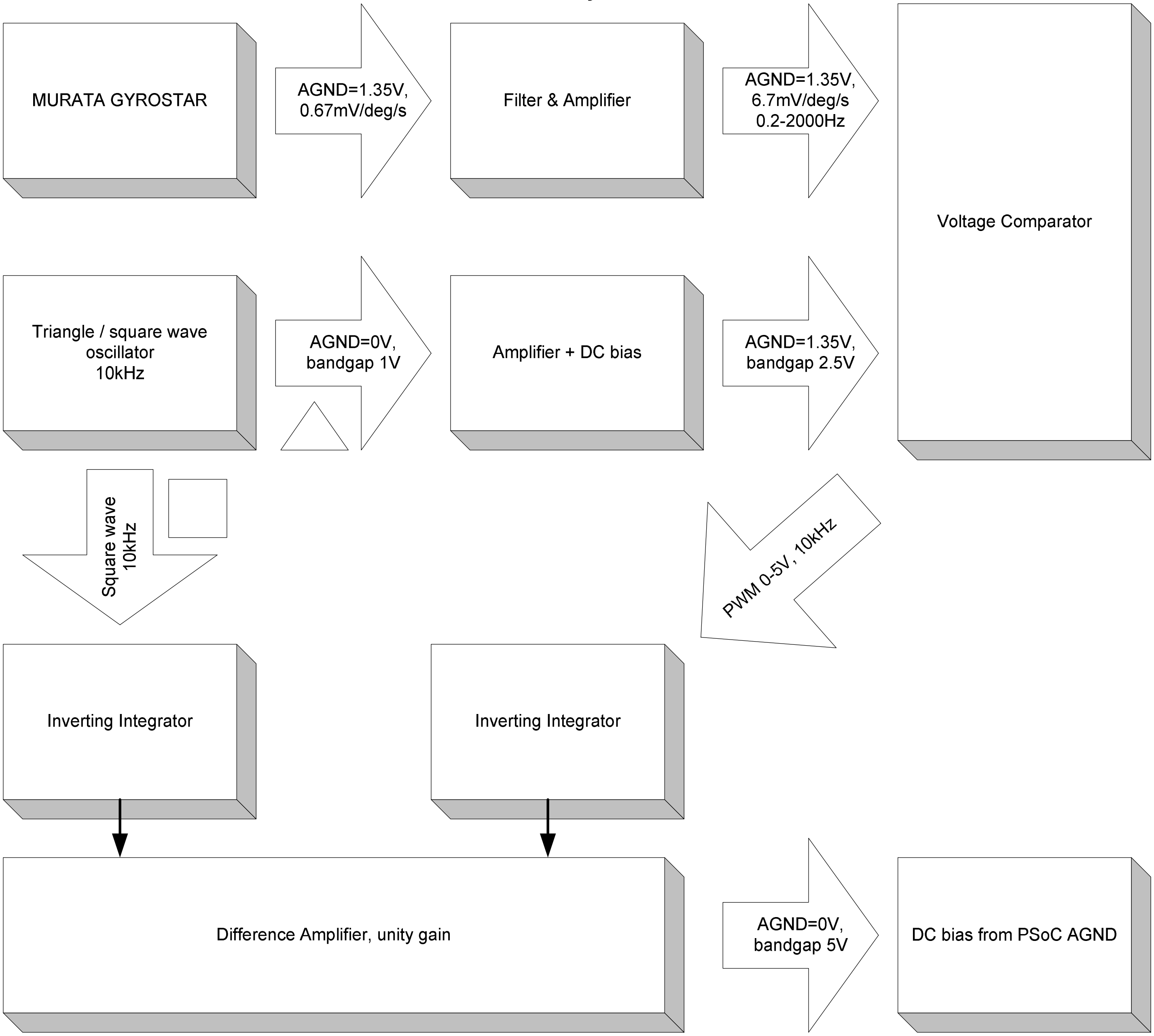


Figure 2. PWM-based comparative integrator flowchart for gyroscope.

Entry #287

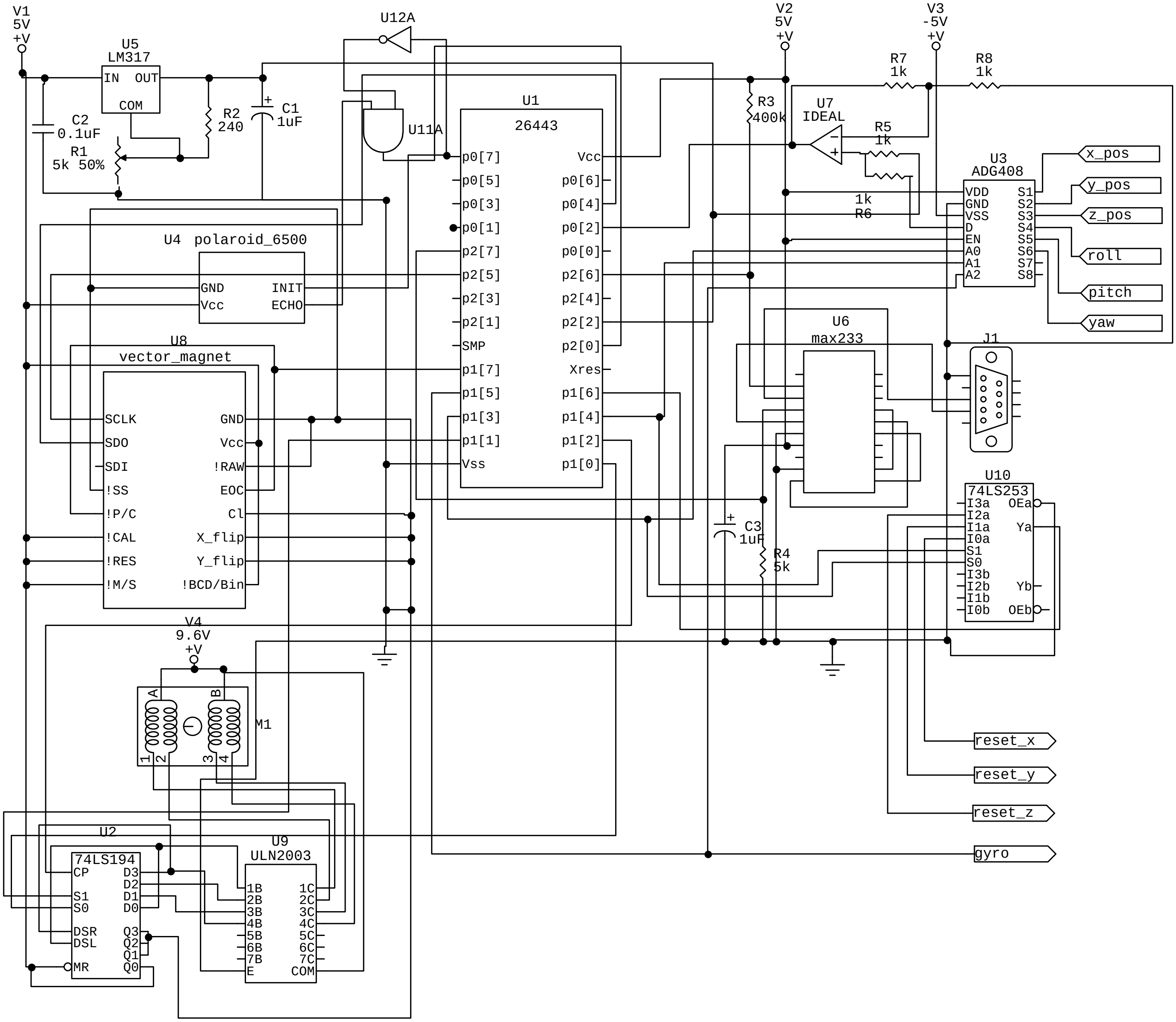
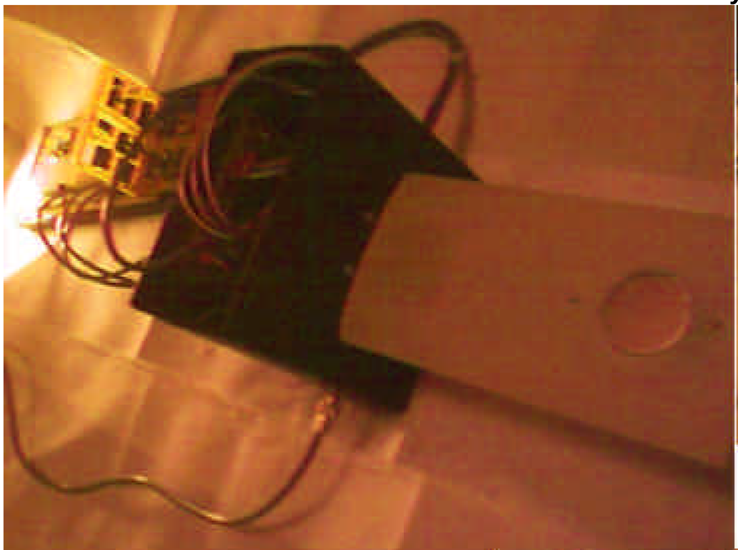


Figure 5. Platform control circuit with PSoC. An external AGND is established with the help of a LM317. This AGND is added to each inertial measurement when it is multiplexed into the PSoC PGA via an ADG408. A Vector 2x dual axis magnetometer with 16bit measurements of the earth's magnetic field in (x,y) is connected as a SPI slave to the PSoC. The ECHO of the Polaroid ranging module (6500) and the INIT signal from the PSoC are ANDed to control the 16bit counter enable on the PSoC, which is designed to only run when an output is requested and an echo has not been detected. The 16bit counter runs on the 32kHz clock; the .5" resolution based on the counter is commensurate with the accuracy (1") from the ultrasonic ranging module. A 4bit shift register is loaded with "0x01" and shifts left or right depending on the input from the PSoC; the leading edge trigger from the incrementing subroutine pulse the clock pulse pin to rotate the scanning head. A MAX233 translates the UART output into RS-232 signals at 115.2 kbps.

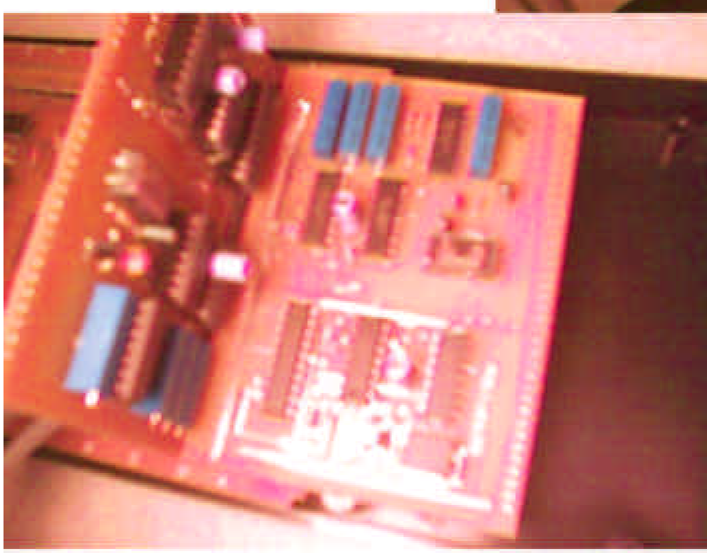
Entry #287



A)

B)

C)



D)

A) An overview of the platform. The motor, power conversion, and high voltage transducer circuitry is contained separately from the inertial navigation controller, which should be mounted closely to the center of gravity of the vehicle.
B) A top-down photo of the motor and scanner.
C)
D) Closer looks at the orthogonally-mounted inertial measurement boards. The three boards (each measuring [x,y,z] and [roll,pitch,yaw] respectively) are mounted on the control board containing the PSoC, multiplexer, and magnetometer compass.