

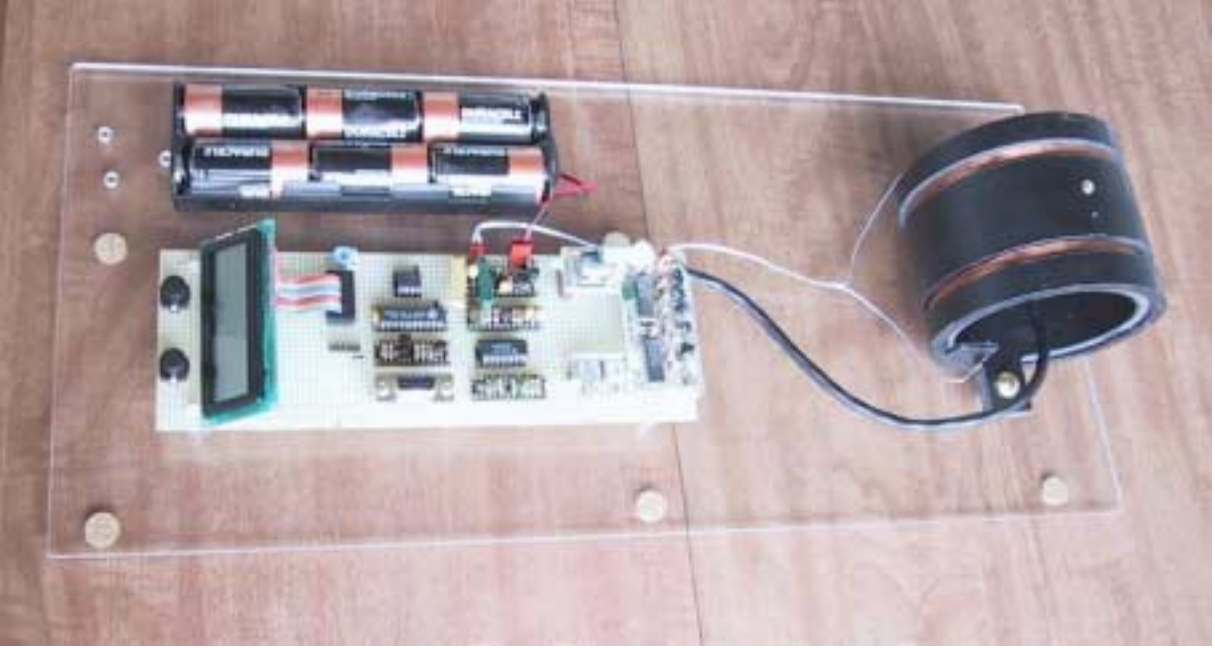
## Earth Field Magnetometer

The magnetometer measures the strength of the Earth's magnetic field. It is sensitive enough to pick up minute variations resulting from solar storms, which have been known to affect radio and power systems, and indicate the level of aurora activity. There are several components that contribute to a measurement made at the Earth's surface. The largest is the planet's own magnetic field, which is relatively constant. A daily variation resulting from atmospheric effects is less than 1% of the static field, and varies by latitude. The third component results from solar storms. This could be as small as 0.1% of the total field, making it quite difficult to measure.

The magnetometer uses a flux gate sensor and has an external electromagnet to cancel out the Earth's field. This allows the sensor to detect a null in the field, allowing the system to be extremely sensitive to even the slightest field variation, while not requiring any gain calibration of the flux gate sensor. A feedback loop adjusts the electromagnet current to null the flux gate output. The electromagnet consists of a Helmholtz coil, which is a special arrangement of two equally sized coils which creates an extremely uniform magnetic field at its center, with a flux density which can be calculated given its mechanical dimensions and coil current.

The hardware is built around a Cypress CY8C22213 PSoC, with its analog blocks controlling the flux gate/electromagnet feedback loop. A 12-bit ADC block feeds the electromagnet signal to the MCU, which takes a reading once a minute, then displays it on an LCD and stores it in an external 16Kx8 I2C EEPROM. An RS-232 level converter allows data to be downloaded to a PC. The 20-pin PSoC package has just enough pins for all the I/O. The system is powered by a 9V battery, which is fed through a 5V regulator and transistor so power can be removed from the external circuitry during sleep mode.

The software was written in C and assembler, and is relatively straightforward. The main routine wakes up and takes a reading once each minute, then displays it and stores it in the EEPROM. Since the internal low-speed oscillator used for sleep timing is only accurate to +/- 50%, it is calibrated against the main oscillator (which has 2.5% accuracy) before going to sleep. Pressing either button or receiving RS-232 data will also wake up the MCU, resulting in displaying a graph of several previous readings or downloading data to a PC, respectively. The LCD and I2C assembly routines were rewritten to shrink them to almost half their original size, allowing the entire project to barely fit into the 22213's 2K Flash memory.



Block  
Diagram

Cypress PSoC High Integration  
Challenge 2004 – Entry # C2953

Flux gate sensor

