Experiences constructing an earth field magnetometer with A-Level students

Ian Robinson
www.starfishprime.co.uk
i.robinson@starfishprime.co.uk

June 29, 2013

Abstract

Progress report on an A-level Physics to project build and interface an earth-field magnetometer to monitor auroral changes due to solar activity.

1 Introduction

As part of a lunchtime Science Club (S.T.E.M. in management speak) one AS-level Physics student has been building an earth-field magnetometer using inexpensive flux-gate magnetometers. She has a working circuit after some 10 hrs work and will be testing and installing installing the magnetometer from September 2013. It is intended that the system will be interfaced initially to a P.C. and later to a single-card computer such as a Raspberry Pi or Arduino to stream data in real time to the web.
The whole project should cost no more than £120 (easily rather less), keep approx 5 students busy in a STEM club for a year and generate lots of good publicity to keep management types happy. Some of my students are using these physics projects for their EPQ qualification. The benefit to student's C.V and UCAS applications is potentially very high. I see no reason why there projects should be limited to A-level and could easily be introduced to a much younger age group.

2 The Hardware

We chose to use FGH-3h fluxgate magnetometers from Speake and Co [1]. As the first project of this type we went with assembling a pre-designed circuit available as a kit from Speake for £75. The instructions provided could be better and I suggest referring to Carl Moreland's excellent article on both earth-field and gradiometer configurations [2]. Students may become easily disheartened whern their circuit dos not work first time. I recommend students start by simply connecting the sensor to a 5V supply and an oscilloscope using a breadboard to see the typical output. The FGM-3h give a pulse output of approx 150 kHz in the earth's field and can then be rotated in xyz to show 3d variation in the earth's field.

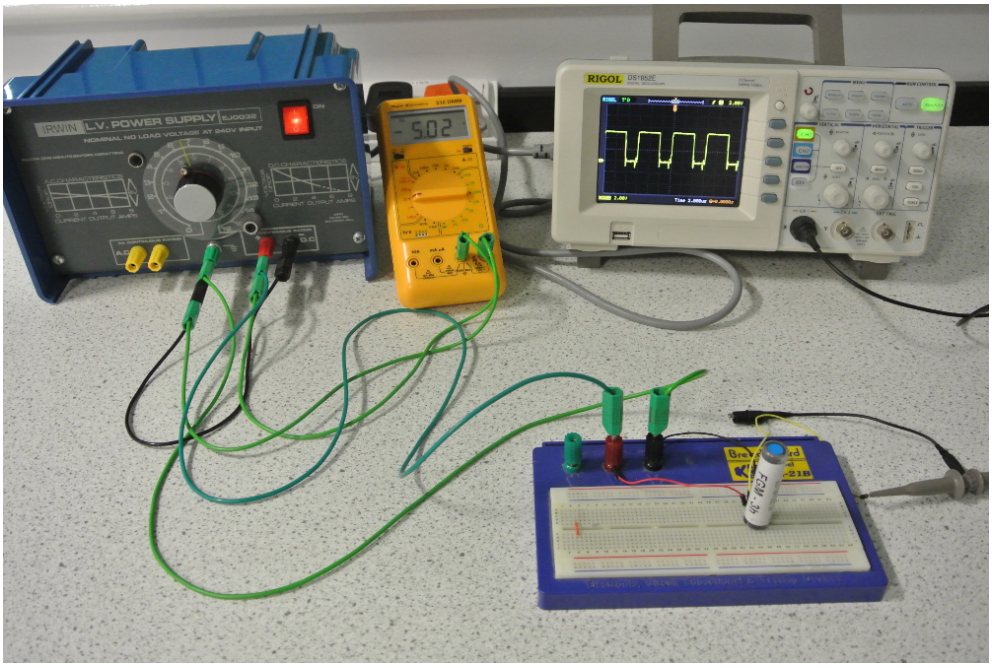

Figure 1: Simple Testing

3 The Project

I imagine that this project will go through a number of stages, roughly

- Testing the FGM
- Constructing the interface board
- Trial installation of sensor outdoors
- Construction of a thermally stable enclosure
- Installation underground
- Interfacing to PC and digital strip-recorder
- Embedding in web page
- Interfacing to single-board computer
- Looking at data

There could then be follow-up projects designing our own interface board.

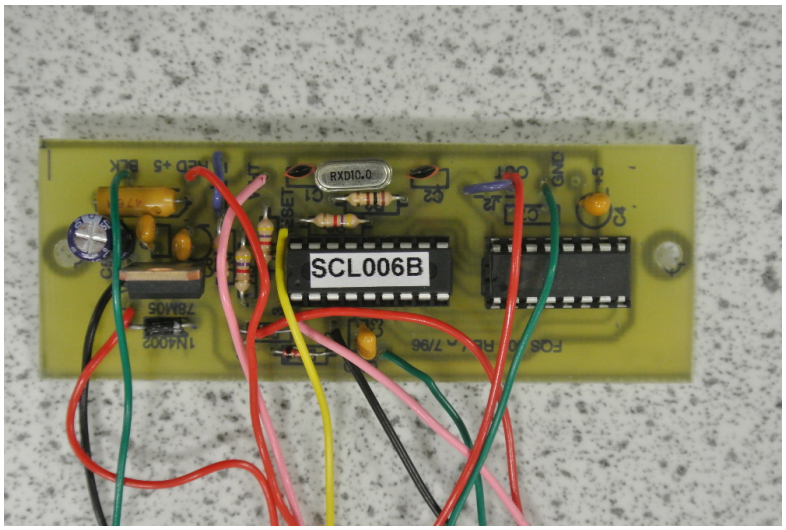

Figure 2: Speake interface board soldered up

4 Impressions

Attendance and continuation is entirely voluntary but has been close to 100%. Students have grown in confidence and are generally happy to get stuck-in and try to understand the circuit operation themselves.
Avoiding the temptation to start with hours of teacher-led theory students were given simple circuit board projects to complete and helped with their soldering skills[6]. They then started on one of a number of projects, usually in groups of 3-4. Groups were encouraged to divide up the task of understanding the background amongst themselves and generally got on with this without the need for much teacher input except in project management. Feedback from, those who have described their projects on UCAS forms and subsequently at interview have been very positive indeed as have comments from visiting academics.

5 Other Projects

I have groups of students working on:-

- Portable magnetic anomaly detector (gradiometer) using Speake sensors.
- Lightning Detector [4]
- Tesla Coil (bit iffy on the H.T. front!)
- Sudden ionospheric disturbance meter (monitoring V.L.F. submarine bands) [5]
- Radio telescope using PIC chip as A/D convertor

6 About me

I am an A-level physics teacher of some 20 yrs experience with a long interest in hands-on project work. I put my weekend efforts into the general promotion of projects such as these via the I.O.P. I have a range of projects at various stages of development including NMR Spectroscopy and advanced mathematical & physical computer simulations. I am seeking to promote such projects being used nationally especially with a school or college acting as a 'hub' running outreach work in local secondary/primary schools and with links to universities.

I also have strong interest and experience in computational physics at school/A-level and am a doctoral candidate in computational physics.

Please feel free to contact me if interested in any of these as I would be happy to share my experiences.

Note: I am actively seeking employment in the North East England or overseas.

References

[1] *Speake and Co,*
`http://www.speakesensors.com`

[2] *Carl Moreland,* Building a Fluxgate Magnetometer
`http://www.geotech1.com/pages/mag/projects/fmx1/fmx1.pdf`

[3] Discussion of the FGM and installation notes
`http://www.reeve.com/FGMSensors.htm`

[4] Lightning Detector
`http://members.home.nl/fkooiman/lightning/`

[5] SID Detector
`http://www.backyardastronomy.net/sid_receiver.html`

[6] Some of the starter kits
`http://www.rapidonline.com/Education/Velleman-Love-Tester-Kit-70-4054`
`http://www.rapidonline.com/Education/Dual-white-LED-Stroboscope-kit-73855`
`http://www.rapidonline.com/Education/Dual-super-bright-flashing-LED-lights-kit-74568`