

Undergraduate Research Report
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Project: Determination of the absolute time measurement resolution and spatial resolution of the GPS technology

Students participated: Rozmin Daya, Andrew Peppard, both physics majors.

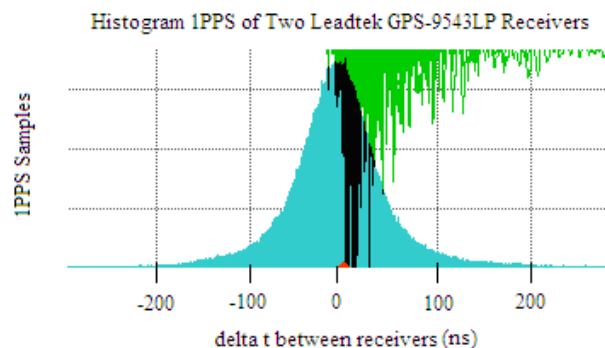
Project period: fall semester of 2005 and spring semester of 2006.

Benefits to the students:

1. To understand how GPS receivers measure absolute time and space coordinates.
2. To understand how to measure time resolution without a better time reference.
3. To learn basic electronics circuit design, schematics capturing and PCB layout (with Protel).
4. To learn how to conduct experiments, taking data.
5. To understand data analysis that including statistic concepts.

Status Report:

A method is decided on how to measure the time and spatial resolutions with the students involved. A readout circuit is designed and the PCB is laid out by Andrew Peppard using the tool Protel. Ye's startup covers the material cost. Measurements are carried out by Rozmin Daya and Andrew Peppard. The following plot shows the screen capture of the oscilloscope for time measurement.



Data analysis is carried out on the time resolution and we find that the GPS module can provide an absolute time measurement with 45 ns resolution. This is good for many physics measurements, like those in cosmic shower array experiments. The spatial data analysis will continue when the new semester starts.

From this project, the students learned how to solve problems in research when straight forward solutions were not present. They learned to design the measurement, carried it out, and followed it up with data analysis to obtain the results. They also learned to use

tools that are popular in industry to design and layout PCBs. They learned some concepts of data acquisition and statistical data analysis. They were encouraged to find solutions by themselves, instead of being told or taught the solutions. I believe this project provided the students with trainings that complement what they learn in classrooms and will greatly benefit them in their future studies.

The result has been summarized in an essay submitted to the university student journal *discourse*, but was not accepted. According to Daya, she has not seen any scientific papers published by *discourse*. We suggest that SMU set up student journals to publish research results from graduate and undergraduate student research.

A more complete paper is being worked on and is planned to be submitted to journals outside of SMU. This will be the first publication for the two participating students in a scientific journal. The publication itself will greatly help the students in their future career building.

The essay for *discourse* is attached to this report.