An Undergraduate Intern's Experience With Industrial Instrumentation and The Effect on Teaching

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Abstract

A simulation of the Time Keeping System(TKS) on the Global Positioning System satellite was developed to duplicate the characteristics of the hardware. This software aided in the design and testing of the hardware. This paper discusses the instrumentation and the testing of the TKS hardware and associated software by an undergraduate engineering student. It includes the problems she had, how she changed the simulation to match the hardware, and how this experience helped further her Engineering education.

The TKS consisted of a hybrid analog/digital phase locked loop controlling a Voltage Controlled Crystal Oscillator, with an atomic clock reference. The engineering development model and the final hardware/software combination had minor differences. The Student had to design the tests, the test setup, and run the tests on a system accurate to one second in thirty-one centuries.

The undergraduate student's internship experience at ITT not only helped her in her studies the following year, but allowed her instructor to observe the development of an Electrical Engineering student, between her sophomore and Junior year of college, in an actual industrial environment. This resulted in a modification of the teaching techniques used by the instructor in classes taken by sophomore engineering students.

Introduction

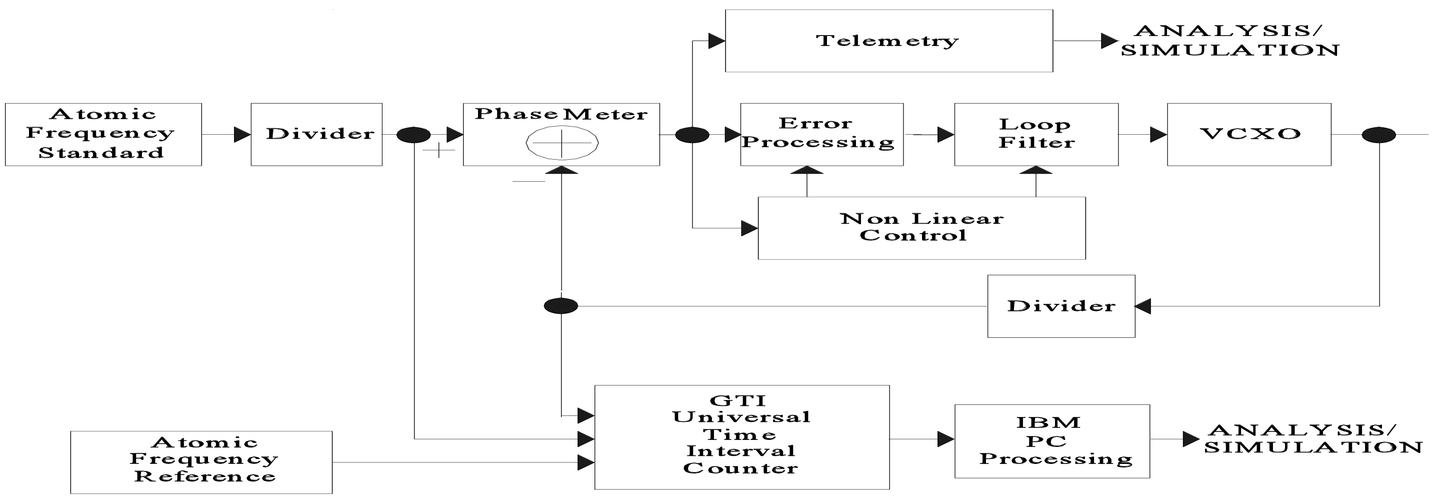
Companies usually support internships for students between their junior and senior years of college. This is done for two reasons: the first is that they feel that students between their sophomore and junior years do not have a sufficient engineering background and the second is that they use the internships to evaluate whether or not they want to hire the student after graduation.

The professor wanted the company to hire students between their sophomore and junior years for three reasons: the first was to see if they have a sufficient background to perform useful engineering work for a company; the second was to see how the experience would affect the interning student's attitude toward engineering and studies; and the third was to see how those students would affect other students with whom they came into contact once they returned to the college environment.

Engineering Task

A simulation of the Time Keeping System (TKS) of the Block IIR Global Positioning Satellites was developed in order to verify the design before building the engineering development model. In addition, it was used to evaluate the design of the nonlinear controls required to minimize random transients and disturbances. Individual subunit algorithms were used to duplicate the hardware subunits of the TKS in the simulation. The 16,000 line computer program was compiled and run in Power Basic. After the design phase was completed, payload hardware was manufactured and tested.

The TKS consists of a hybrid analog/digital phase locked loop driven by an atomic clock(see Figure 1).



The atomic frequency standard outputs a signal of about 13.4MHz. A counter then divides this frequency down to approximately 1.5 second reference epochs. A voltage controlled crystal oscillator is controlled by a phase locked loop to output 10.23 MHZ. This output is divided down to 1.5 second system epochs. The reference and system epochs are then compared by a phase meter which generates a digital phase error. The phase error is then modified and filtered to generate a voltage controlled oscillator(VCXO) command which forces its output to the desired 10.23 MHZ.

The Time Keeping System Instrumentation Block Diagram

Figure 1

The TKS loop serves two purposes; it translates the input atomic frequency to the desired system rate of 10.23

MHZ and it controls the phase noise combining the clean long term stability of the atomic frequency standard and with the clean short term stability of the voltage controlled crystal oscillator providing a clean, stable timing signal for the GPS satellite.

After the design phase was completed, payload hardware was manufactured and tested. Valid payload testing would have to wait up to two days after powering up the voltage controlled crystal oscillator. An initial test required about four hours to determine if official testing could start. A method was needed to insure that testing would start as soon as possible and not tie up a test engineer running four hour tests for the two days. An assignment was given to the intern to research the problem to try to come up with a procedure to minimize the waiting time and not require a test engineer during that waiting time.

Internship

ITT A/CD decided to hire an undergraduate student during the summer to work with its engineers to solve the problem. Carol Cummiskey, a TSC sophomore, was hired for the summer. She was chosen for an internship for several reasons. The first was that she had the qualifications to do the work. The second was that she had worked on an ITT grant(in a different area) during the spring semester so that ITT was familiar with her previous work. And the third was that she was gregarious and would share her experiences with other students.

Internship task

The task given to the undergraduate was to assist in designing of an unattended test to observe the stability, or lack of stability in the TKS hardware, and then to modify the TKS simulation to match behavior of the production payload under test.

When the output of the simulation was compared to the output of the production hardware, the intern found a difference. The intern had to find the causes of the difference, modify the simulation to make the simulation and the hardware agree, and come up with an automatic hardware test. She changed the simulation of the voltage controlled oscillator to match her test data during a warmup, modified the simulation to match the algorithms in the production computer software, added front end software to make it more user friendly, and finally wrote a test report for ITT.

Results For The Interning Student

The ITT engineering task emphasized how computer simulations improve engineering efficiency during design. The use of this simulation at ITT showed how much more robust the implementation of a design can be when it is simulated first. Using the simulation, one can verify where external influences and nonlinearities play a role in hardware deviations from the ideal model. When this particular problem was first presented, the TKS simulation offered one explanation: an internal oscillator problem. All other possible causes of the problem were simulated and rejected because they showed up under other conditions, other than during a voltage controlled crystal oscillator warm up. Therefore, the thermal effects on the circuitry and the crystal within the voltage controlled oscillator were the probable causes. When this error source was further analyzed, a thermal model of the error was postulated. With this model in the simulation, the error source was verified and a means of reducing the payload testing became self evident.

In the process of performing her engineering task, the student learned that engineering courses were only part of her education. She recognized that liberal arts courses are also important. It was necessary to obtain the cooperation of people in other organizations within ITT. She was not just dealing with engineers, she was dealing with technicians from quality assurance, integration and test, information management, and manufacturing. Without their cooperation, she could not have accomplished her task.

Obtaining approval of test plans required written procedures, as well as oral presentations both to the affected personnel and to the intern's immediate supervision. As a result, she realized the importance of the oral presentations and written laboratory reports that were required in the normal course work at Trenton State College. In other words, she was becoming a well-rounded engineer.

Results For Other Students

Students can obtain a realistic industrial experience using classroom simulations, internships and externships. However, class room simulations require a special effort by the instructor to add to the knowledge of the students who did not intern or extern. The class room simulation requires the design of several different subsystems, all interdependent, and all operating in a single system when connected together. The internship and externship experiences are best shared in a laboratory environment, where students work in groups. During the performance of the lab and the subsequent write up, the industrial experience is usually shared with the students who did not work in industry, and therefore did not gain industrial experience.

When a student comes from a technical military unit or from a technical industry, placing that student in a lab group with students who have never worked in industry also spreads knowledge of what the industrial environment is like.

In the semester following the internship, Ms. Cummiskey was enrolled in a communications course. Part of the course was to design and implement a LC-Oscillator. Most of the students in the class did not see the relevance of designing this oscillator. She shared some of the knowledge gained during the internship with her classmates, describing how oscillators are used for many purposes among them being the TKS in the Block IIR satellites. A fellow student sharing this application made the laboratory seem much more interesting and important than if that same information was supplied by the instructor. Also, in the lab, the instrumentation used to test the oscillators was less than ideal. Many students complained that in the 'real world' instrumentation would not be like this. She interjected that part of being an engineer in the real world is making limited instrumentation work. Instrumentation in industry is not ideal. From her summer experience, she saw that engineers must often improvise and improve upon what they have. Not every engineer's project in industry has access to capital budget funds to purchase the ideal instrumentation for testing. In fact, hardly any projects do.

Engineers in the real world pull oscillators out of closets, just as students do. The engineers tinker with the instrumentation until it works properly. Companies just do not have the capital budgets to buy the perfect equipment for every test that has to be performed, and neither do colleges nor universities. This tidbit gave the students the patience to work with the equipment and ‘make do’.

Students considered the simulation of their design as just something that the professor just wanted included in the report. However, when Ms. Cummiskey explained the use of simulation at ITT, how it helped verify paper designs, and how it helped pinpoint unforseen problems in the actual hardware, the students’ attitudes changed.

Incidents like this give students who are not fortunate enough to have internships, a similar type of insight that Ms. Cummiskey obtained at ITT. Some students cannot identify with their professor's experiences in the work force as easily as they can with a fellow student's.

Results for the Instructor

The instructor found that students who have finished their sophomore courses have had enough engineering and programming courses to absorb engineering explanations from engineers and perform analytic tasks beyond all but the most experienced technicians. If Ms.Cummiskey is a typical example, those students are able to analyze test results to determine possible causes of problems.

The knowledge gained by the intern has to be available to students who did not have an internship. Company condition simulations have to be used in my engineering courses to simulate company internships. I used to do an industrial simulation in a junior course that had an associated laboratory.

Based on the experience last summer, I have instituted an industrial simulation for the spring of 1996. The laboratory is associated with the circuit design course. The design task is simpler than the one used for the junior year, but will require close cooperation among all the students in the class to design portions of a system that have to work together.

One of the potential problems that a fellow instructor warned me about is a possible lack of maturity in some of the sophomore students which could cause problems in the performance of the coordinated lab. However, I have found that engineering students are more mature and goal oriented than other college students so that any immature students should be ‘helped’ by the more mature students. It will be interesting to see how this project evolves.

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MS. CAROL CUMMISKEYis a Junior in the School of Engineering at Trenton State College. She is working on a grant from ITT on the Global Positioning System. This past summer she worked on the testing and modelling of the Time Keeping System of the Global Positioning System Satellite Navigational Payload. She is active in College organizations, and is the Secretary for the Student Chapter of the IEEE.

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