ECOSat Communications Subsystem: RF Division Progress Report 1

by

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Chapter 1 ECOSat Communications Subsystem: RF Division

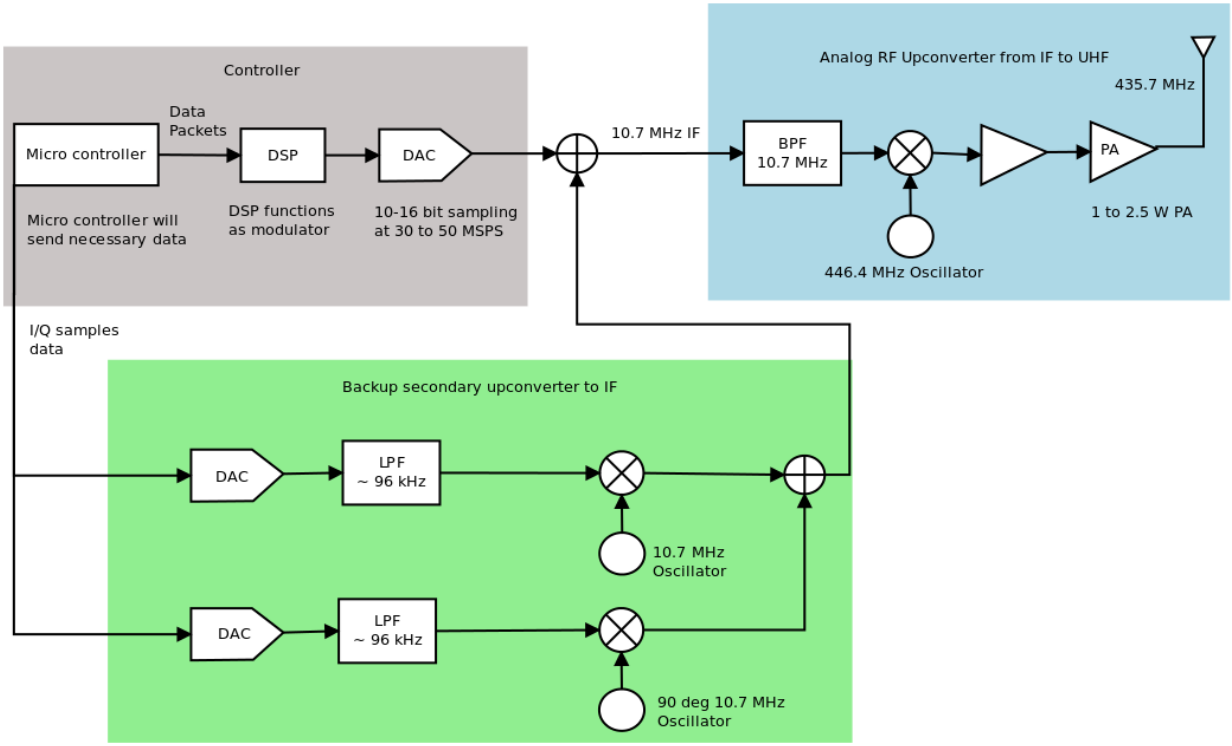
Project title: ECOSat Communications Subsystem: RF Division

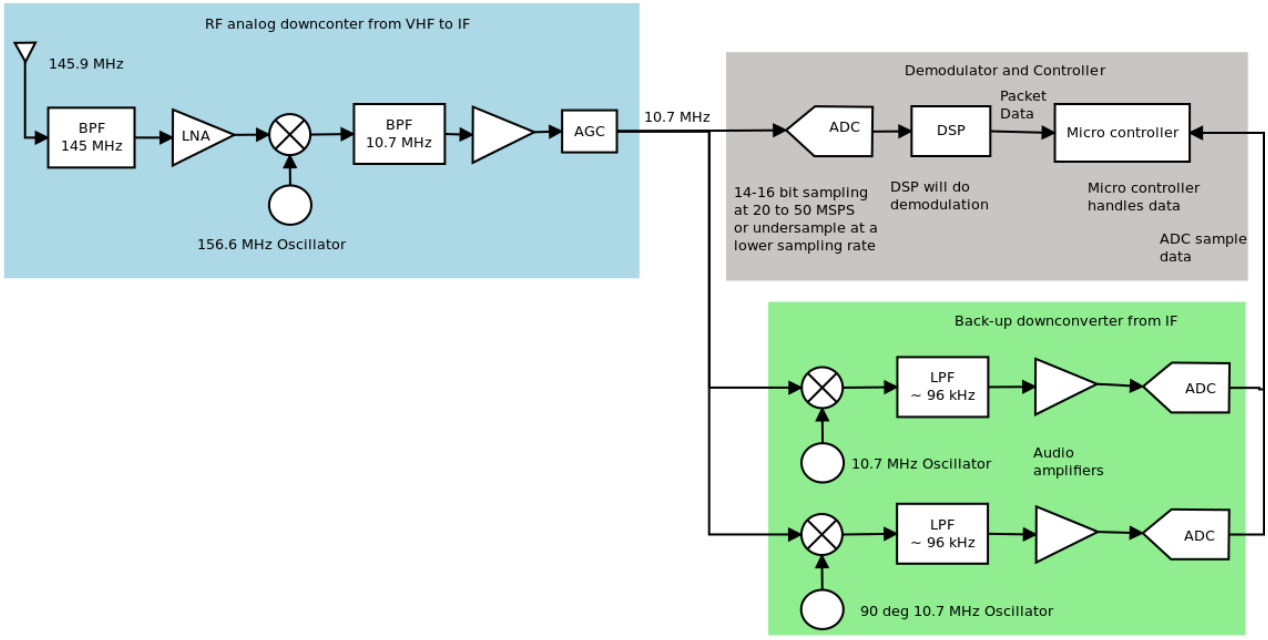
Supervisor: Peter Drissen

The University of Victoria ECOSat team is competing with 11 other Canadian universities in Geocentrix's Canadian Satellite Design Competition. The nanosatellite to be designed is 3U in size (approximately 10 by 10 by 30 cm) and must execute two missions, one of which must be scientific in nature. One of ECOSat satellite's missions will be to measure diamagnetic properties of pyrolytic graphite which will help with materials research for future space applications such as propulsion mechanisms. The second mission will be an OSCAR (Orbiting Satellite Carrying Amateur Radio) which will relay amateur operator messages around the world. The competition has been going for almost two years and is currently in its last stage with the final hardware delivery deadline in mid-September. Each of the satellite's subsystems is in the process of being built which includes the communications subsystem.

The communications subsystem is a large part of the satellite as it not only must receive commands from the ground and send back telemetry and status data but is also at the heart of the OSCAR which the satellite will be carrying. The communications system will be based on software-defined radio (SDR) which allows the flexibility of modulating and demodulation of signals in software. However, the very-high (VHF) and ultra-high frequency (UHF) signals cannot be synthesized directly from the processor as such tasks would be too computationally hungry. Instead, as with the vast majority of radios, the signals are first synthesized in baseband at low frequencies and then up-converted to the

final transmit frequency or down-converted received signals back down to baseband. To accomplish this task, radio frequency grade analog circuits are used. A block diagram of the current communications design is shown below, first the transmitter and then receiver.



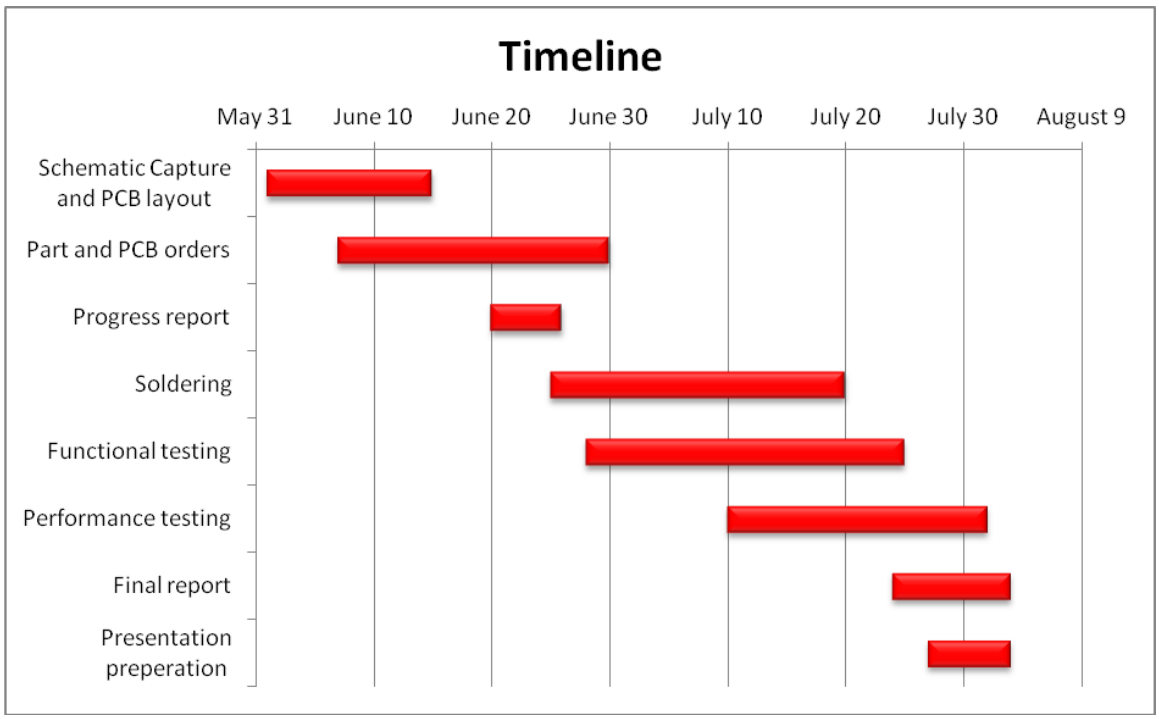


The proposed project is to complete both the up-converter and down-converter RF analog boards shown above in blue in the transmitter and receiver block diagram, respectively. Completion includes finishing the design, building and then testing the boards.

As this project is an ongoing venture, a preliminary schematic and board layout has already been produced for both the up-converter and down-converter boards. The tasks to be completed include:

- Finishing up the schematic capture, board layout and part selection
- Ordering the parts and the PCB boards
- Soldering components on to boards
- Functional and performance testing

A Gantt chart is shown below of the tasks and associated timeline for the project. Major milestones will include final circuit and PCB design completion, component soldering completion and board and design testing completion.



All of these tasks will be done in cooperation with other members of the communications team and the satellite team as a whole. Synchronization between teams is crucial to complete satellite integration.

By the end of the term, functional RF up-converter and down-converter boards are to be delivered. Also, key performance parameters such as power consumption will be measured to make sure the design will integrate well with the rest of the satellite design. Project progress and final results will be documented as well in the form of a final report and presentation.

Biography

Jarrah is currently a fourth year electrical engineering student. Originally from northern British Columbia, he moved to Victoria for post-secondary education. He is currently taking courses in the communications, digital signal processing and microwave and optics and will likely specialize in microwaves and photonics. Also, past co-op work include various board-level verification and debugging, digital logic and analog design and validation, extensive documentation and photonics research. Jarrah has experience in many schematic capture and PCB layout packages, circuit simulators and software and firmware development environments. However, his experience in electrical and electronics spans far before university, having broad knowledge in a variety of domains and done numerous projects namely in embedded development. This includes microcontrollers, digital logic and analog audio design both in theory and on PCB. Many types of test equipment have also been used including power supplies, power analysers, oscilloscopes and spectrum analysers. Interests mainly lie in high frequency analog and digital hardware and system design.

For this project, he has been part of and has contributed to the ECOsat project for many months and knows how the satellite team is organized and how the project is progressing, including most subsystems. Along with the breath on knowledge already acquired prior involvement in ECOSat makes Jarrah particularly well suited for this project. This will allow our project to start with little delay and help meet the project deadlines.

Kris Dolberg is a fourth year electrical engineering student planning to specialize in digital signal processing and mechatronics. Kris was born in Ottawa, and grew up in Victoria. After finishing high school in 2006, Kris attended Camosun College where he took two years of general studies. He enrolled in the University of Victoria's engineering program in 2008. Originally planning study mechanical engineering, he chose to study electrical after completing first year do its better fit for his interests.

Kris has previously completed two co-op work terms. The first was in the IT department of Odlum Brown Limited, a Vancouver-based investment firm. The second was working for UVic's own VENUS project.

He has been involved with ECOSat since 2011. Aside from the work for ELEC 399, Kris is currently designing the drive circuitry and redesigning the coils for the satellites magnetic torquers.

Upon graduating, he plans to move to Germany and pursue a career in control system design. In his spare time, he enjoys playing guitar, philosophizing, swing dancing, biking, cooking, and indoor rock climbing.

Chapter 2 Seminar Review

In the first seminar, Dr. Lu explained the structure and marking scheme of the ELEC 399 class. This seminar took place on May 10, 2012.

The second seminar took place on May 15, 2012. Two employees from Fortinet gave a presentation on their company. Fortinet is a network security firm. During the presentation, it was stated: "Anything that has a network, we need to protect." The presenters talked about Fortinet's products, which include hardware and software for the hardware. The company designs ASIC processors for their applications. The presenters explained how their quality assurance process works. They stated that there are generally two major software releases per year to keep up with the fast pace of the security industry.

The third seminar took place on May 22, 2012. The seminar was given by Bette Kirchner. Kirchner explained how to use the databases of scholarly articles that could be accessed through the McPherson Library website.

Kirchner listed a number of useful resources and databases that engineers and engineering students would find helpful such as Knovel, Compendex, IEEE Xplore, ICM Digital Library, Inspec.

According to Kirchner, it is important for a researcher to use UVic's library webpage to search for journal articles than to simply use an internet search engine to find an article. The reason for this being that UVic's library is subscribed to a large number of journals that only subscribers are allowed access to the full text of. This means that if a student uses the internet to search for an article, they may not have access to the full text

when the article is found. She explained that “inter-library loans” could be used, giving students access to articles not just at UVic’s library, but at many libraries across the country.

Kirchner explained the difference between a scholarly, peer-reviewed journal and a trade journal. When a paper is submitted to a scholarly peer-reviewed journal, it is “not automatically published.” Instead, 4 or 5 people who are experts in the field review the work. The paper may then be sent back to the original author for corrections. Once the paper is corrected, it is finally published. A trade journal does not go through this peer review process. Trade journals can be useful for non-technical research.

After explaining strategies to get access to academic papers, Kirchner moved on to explain ways to get information related to patents and standards. The first two search methods mentioned were Google Patents and the World Patents Database. Kirchner gave a number of useful tips for searching for patent information.

Kirchner next went on to talk about UVic’s library catalogue. She explained that when students and researchers use this electronic resource, they are searching through books (both physical and electronic), DVDs, CDs, and all other media formats other than journal articles available to the library. When a student searches for journal titles, they are simply searching to see if it is available.

Kirchner mentioned Refworks and Ennote. These are both electronic assistants for researchers. They allow for easier organization of bibliographic information.

One of the last things that Kirchner mentioned was that there was a database for tracking which articles were citing other articles. Naturally this is a useful and important tool for researchers. This database is called Web of Science.

Chapter 3 Textbook Review

For engineering projects within an organization to be successful, project management, must be structured first as to start, guide and end them. Systems Analysis & Design provides a guide to project and more broadly, company, management such that the right systems, often heavily reliant on information systems, are put in place to facilitate the success of projects. Part one focuses on the processes needed even before a project starts: the planning phase. This part describes the role of the systems analysis and information systems as well as project selection and management.

The success of a company is highly dependent on how well it chooses and manages projects. A company may have the necessary personnel and skills to make a product but if workers are not given tasks which are in-line with their skills or the wrong resources are purchased or the final product is late, its demise is unavoidable. This is where the system analysis and information systems come into play. The system analysis has a multiple of skills, including technical, business, analytical, communication, management and ethical, to help setup the necessary information systems to ease project development. These information systems are first planned, analysed, designed and then implemented. Depending on the company size, this flow may be performed by many analysts each leveraging their own strengths. If all goes well, the employees have the necessary tools to succeed in their projects.

Project selection is the first action that must be completed in the planning phase. Projects must be selected as part of a much broader project portfolio as companies will usually have many projects in their product management life cycle and a diversity of projects is important. These projects have a variety of risk and cost factors to be considered. Also, projects should align with the higher level company vision of where it is going. Once selected, a project plan must be constructed. A large part of the project plan is the project methodology: how the project will be developed as to ensure its success. Many methodologies exist including: waterfall development, rapid development and agile development. These methodologies dictate how a project is started, dived-up into tasks, developed, tested and finished, each with its own advantages and disadvantages. A project methodology or a combination thereof is chosen to best fit the characteristics of a project and maximise its success. The project must have staff to be assigned to tasks and plans put in place for people management. Management of people include reporting structure, reward system and conflict resolution. Finally, project management and control philosophy is chosen as to keep the project focused and continuously progressing.

The focus of the book is on software and information technology related undertakings which provide project management which is not usually encompassed in electrical engineering. This makes it hard at times to thoroughly understand the author. Also, these concepts are much more applicable to corporate entities than to comparatively much smaller student projects where teams are much larger with different departments. The team members are known to each other and have similar backgrounds which ease

communication, organization and management. However, some concepts can be applied and examples are as follows. Careful project selection is carried out to make sure the project to be undertaken is within our skill set. Tasks are selected and a timeline is planned to distribute the load with applicable time periods allocated. On past projects, a waterfall development cycle is usually carried out with some parallelization among group members. A waterfall development will be applied in this project as well. The other techniques may be considered as the project progresses. Overall, some value can be taken from the first part of this book and if nothing else, certain concepts reminded of.

Conclusion

As part of the ELEC399 Project, we are planning on finishing up the RF section of the communications subsystem of the ECOSAT project. This will include finishing the design, building up the boards and testing them to make sure they meet the requirements of the ECOSAT satellite. We have also underlined our skills to be used on the project which will help meet the deadlines outlined in our timetable.

Also included in our proposal are reviews of the first two seminars attended in this course. The first was from Fortinet, a network security company, and the second, a library research seminar. Finally, a textbook review on the first part of "System Analysis & Design" was written. This textbook outlines some of the tools needed for the management of people and projects which can be applied to our project.

References

G. Shelly, H. Rosenblatt, *Systems Analysis and Design*, 9th ed., Boston: Course Technology, 2012, p. 2-138.