



Control of RF Components within a Passive RF Tracking System

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Background and Motivation

This project aims to explore and develop the control mechanisms required to program Radio Frequency (RF) components used within the passive RF tracking system – a method of tracking RF sources without the need for transmitting and receiving a reflected signal. The goal is to develop the accuracy, reliability, and efficiency of the passive RF tracking system by optimizing the control of the RF components within the system. The project will involve the design, simulation, and testing required to develop the system. These key stages will then be used to implement the control algorithms and techniques researched to develop the device control and system performance.

Threat Warning and Countermeasures Group's Maritime Countermeasures Team has been developing a passive RF tracking system for use in a variety of trials to track and observe RF sources to carry out studies and tests to obtain the RF transmissions for use in wider ongoing research. The system needs to be reprogrammable by the user, via inputting key parameters, for versatility across multiple frequency bands for a multitude of test scenarios. The component programming method needs to be physically small and compact to be integrated into an enclosure mounted on the Pan-Tilt head hosting and aiming the RF tracking capability.

Existing Literature

Many modern systems are built around the electronic controllers that perform device functions which make up the whole system. Some can be very simple enabling basic automation tasks, whereas others can be sophisticated by utilising complex signal processing to extract data from incoming signals. Control systems can be categorised as either open-loop or closed-loop^[1] control systems. Within these two categories, Electronic control systems can be further categorised into Discrete, Analog, Digital, or Programmable Logic Controller (PLC) systems.^[2]

Some modern systems have replaced existing computer type PLCs^[3], such as: Schneider Electric Zelio Logic Series, Mitsubishi Electric FX3U Series, Siemens SIMATIC S7-1200 Series, and ABB PNQ22-FBP.0 Series. This is a recent development as microcontrollers have developed into the single chip small computing devices. Microcontrollers have become more capable^[4] featuring larger internal memory, and faster operating speeds; allowing for the development of more complex control programmes while reducing the physical size of the whole system.

A specific microcontroller methodology is Driver IC controllers^[5]. The Driver types include: Display, Motor Control, LED, Wireless Communications, Power, and Automotive. Examples of simple driver controllers are a motor driver^[6], used to communicate the speed and direction of the motor actuation^[7]. An LED driver^[8] used to control the operation, colour and intensity of emitted light.

Embedded control systems are integrated into a larger product, typically to automate and control of the operation of the product. The embedded control systems are design to be compact, power efficient, and reliable – expected to operate for extended periods of time without requirement for maintenance and repair.^[9]

In this project the type of embedded device driver that will be recreated will be a multi-stage Character Device Driver to receive data and distribute it to the relevant device via the intermediate chip in the data flow chain^[10]. This will receive characters as a data transmission stream consisting of

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the Yttrium Iron Garnet (YIG) filter programming and Frequency Synthesiser strings; these include a value 6-18 for the filters and Fxxxx string for the synthesiser.

Aim

To develop control code for each device within the system. Design and prototype a circuit board to power and host the programmable ICs used to handle the data transmissions for each of the devices within the system.

Objectives

- **Analyse Control Methods:** Review and assess existing control methods for the variety of RF components being used within the system. Establish the best methods of programming and controlling the devices within the system.
- **Simulate and Validate Control Strategies:** Use simulation tools to test and validate the proposed control strategies in various scenarios. This will be used to test researched data transmission protocols to determine the best method of data flow throughout the system.
- **Design Control Algorithms:** Develop the control algorithms required to program each of RF components, focusing on signal integrity. This will also extend to the hardware used to transmit the signals; focusing on noise reduction.
- **Implementation:** Based on previous prototype iterations an embedded PCB will be designed and developed to power and control the whole system, it will then be integrated the system enclosure.
- **Test in Real-World Conditions:** Evaluate its performance in real-world conditions, with the intention of further evolving the prototype into a more resilient and reliable system capable of withstanding sustained use during testing and trial work.

Methodology

- **Literature Review:** Conduct a review of existing literature on system control circuitry for electronic and RF devices and components. Identify potential communication protocols to use for each type of data transmission within the system and best practices for each protocol implementation.
- **Simulation:** Utilize simulation software tools such as Proteus to design the controller circuitry data flow layout with the aim of testing many data protocols to understand which method is best for each stage of the data transmission. This is to verify and analyse the performance of each protocol type.
- **Algorithm Design:** Develop control algorithms through simulation using a range of communication protocols to transmit data throughout the system, such as: USB, UART, SPI, I2C, and UDP/TCP. This also includes handling all the system input and output data necessary for programming the devices to allow ease of use by any system operator in a fast-paced trials environment.
- **Prototype Development:** Build a prototype system to test the data protocols proposed to program and control the RF devices, with the aim to evolve the system into an enclosed PCB distributed system to ensure reliability and resilience for use in trials environments.

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- **Testing and Evaluation:** Perform experiments to test the prototype system performance ability to cope with all form of inputs and interferences. These include different character inputs and input types, external noise interference, as well as signal types and conditions.

Project Risks

- **Damage to Equipment:** Causing damage to high-cost test and measurement equipment would delay testing while new equipment is sourced, and the cause of the issue is established.
- **Sourcing Components:** Some components may be difficult to source or have long lead times meaning these components need to be identified as quickly as possible to ensure that they do not become a choke point in the project timeline.
- **Scope Creep:** A poorly defined design brief will lead to scope creep which will lead to an increase in project timelines and product complexity meaning that the scope creep will ensure that the project never gets completed.
- **Project Schedule Risk:** This risk account for both foreseen and unforeseen delays within the project timeline. The potential timeline risks could include holidays, component lead-times, illness, stop work orders, and tasks taking longer to complete than expected.
- **High Costs:** this is due to poor budgeting and would be a larger contributor to being unable to complete the project within a given time period.
- **Resource Risk:** This risk accounts for not being able to access the required resources need to carry out the tasks making up the project, and in-turn delaying tasks and extending deadlines.

Resources Required

Available Resources

- Standalone Laptop
- University Desktop Computer
- Corporate Issue Laptop
- Corporate Issue Memory Stick
- Proteus 8 Professional – PCB Design and Circuit Simulation Software
- KiCAD 8.0 EDA – Schematic Capture & PCB Design Software
- Number One Systems Easy-PC PCB Design Software
- SamacSys Library Loader
- CCS Compiler – PIC-C C Compiler

Resources to be Sourced

- Solder Wire
- Bench Power Supply
- Banana Plug cables and Crocodile Clips
- PIC Programmer
- Frequency Synthesiser
- Spectrum Analyser
- Oscilloscope
- Various Coaxial Cables
- Wire (to make Cables)

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- MPLAB X Integrated Development Environment (IDE)
- Soldering Iron
- Crimp Tools
- Molex Crimp Components
- Solder Reflow Oven
- Surface mount Pick and Place Station

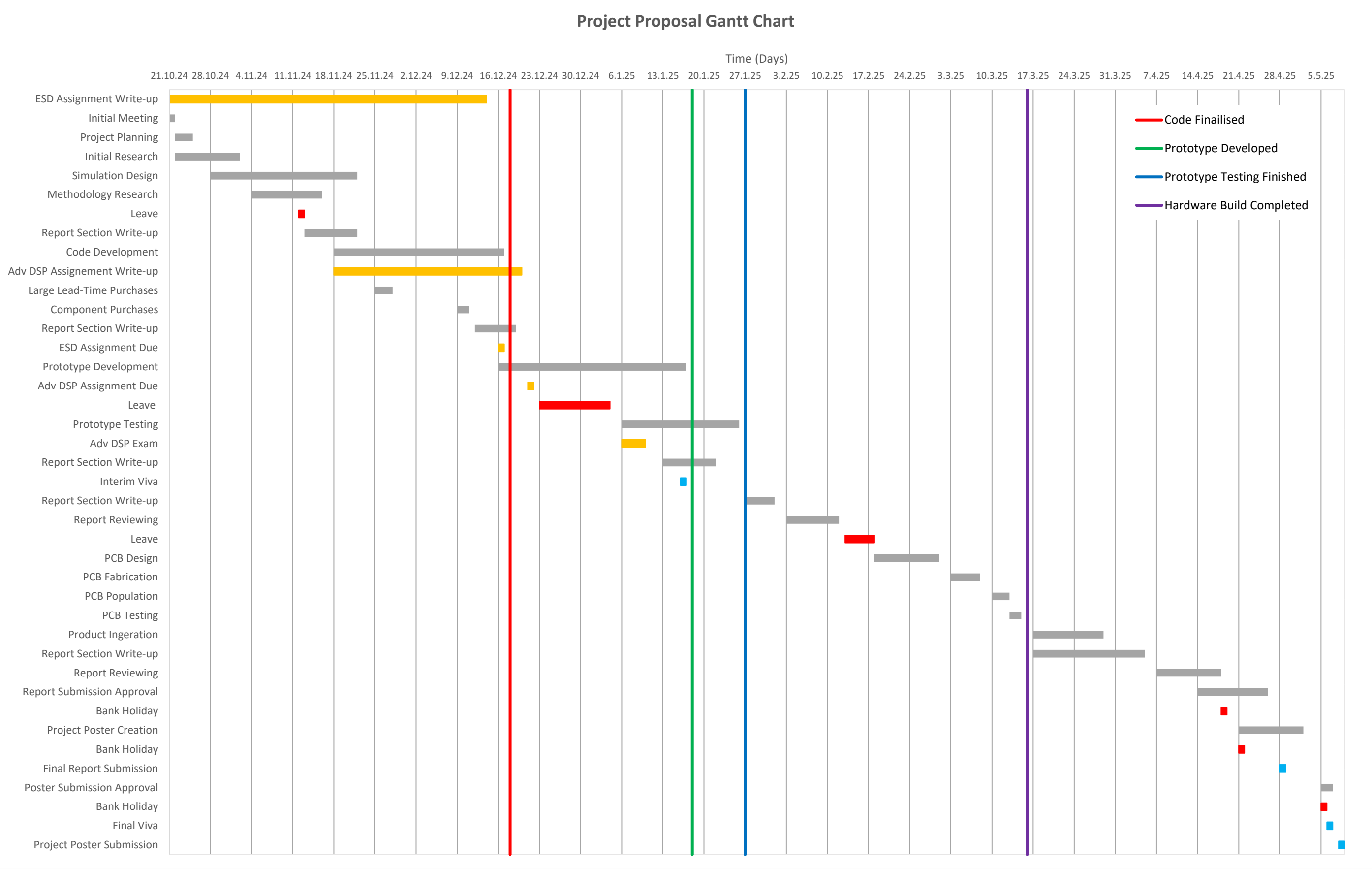
Timeline

Task	Duration	Completion Date
Literature Review	4 weeks	16-11-24
Simulation Design	3.5 weeks	22-11-24
Code Development	4 weeks	17-12-24
Code Finalisation	-	18-12-24
Prototype Development	4.5 weeks	18-01-25
Prototype Developed	-	20-01-25
Prototype Testing	3 weeks	25-01-25
Prototype Testing Finished	-	27-01-25
PCB Design	2 weeks	08-03-25
PCB Manufacture	2 weeks	15-03-25
Hardware Integration Completed	-	16-03-25
Product Integration	2 weeks	29-03-25
Report Write-ups	1–3 week stints	04-04-25
Report Reviewing	2 weeks	26-04-25
Poster Creation	1.5 weeks	03-05-25

Conclusion

In this project the aim is to produce a controller to programme the RF devices making up the RF chain of the passive tracking. The controller will be a PCB hosting the PIC microcontrollers that will make up the control circuitry and data transmissions. The project will research data transmission protocols to establish the most efficient data transmission methodologies through simulations and prototype testing. The controller will offer fast, efficient, and more reliable control of the components within the RF chain integrated into the system as a whole.

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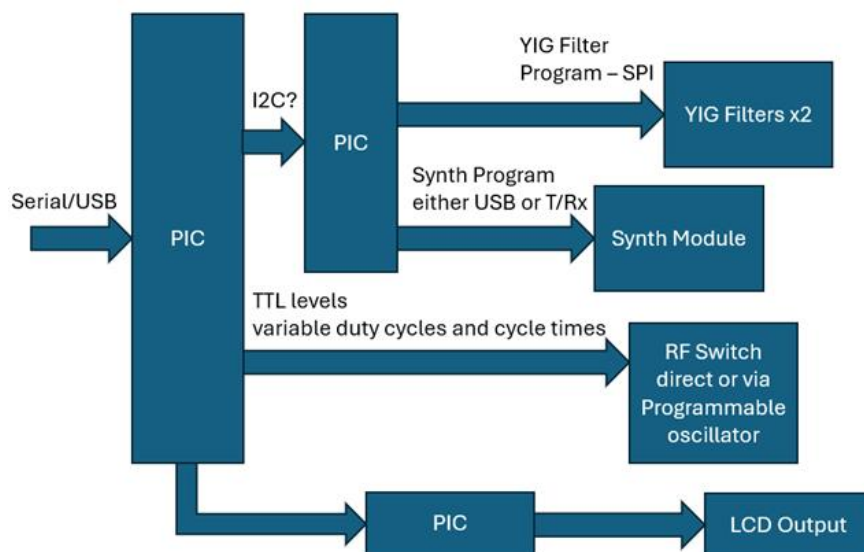
References

- [1] R. Y, 'What are Controllers? Types of Controllers', Electronics Coach. Accessed: Oct. 15, 2024. [Online]. Available: <https://electronicscoach.com/types-of-controllers.html>
- [2] 'Electronic Controllers and Their Role in Modern Electronics'. Accessed: Oct. 15, 2024. [Online]. Available: <https://hilelectronic.com/electronic-controller/>
- [3] 'What are the Differences Between PLCs and Microcontrollers? - Rowse Automation'. Accessed: Oct. 15, 2024. [Online]. Available: <https://www.rowse-automation.co.uk/blog/post/what-are-the-differences-between-plcs-and-microcontrollers>
- [4] T. Agarwal, 'Introduction to PIC Microcontrollers and its Architecture', ElProCus - Electronic Projects for Engineering Students. Accessed: Sep. 14, 2024. [Online]. Available: <https://www.elprocus.com/introduction-to-pic-microcontrollers-and-its-architecture/>
- [5] 'What Are Driver ICs in Electronics? - Electronic Components Distributor - SMBOM.COM', What Are Driver ICs in Electronics? - Electronic Components Distributor - SMBOM.COM. Accessed: Oct. 17, 2024. [Online]. Available: <https://www.smbom.com/news/13144>
- [6] 'MDC151-0501001 | Anaheim Automation, Inc.' Accessed: Oct. 15, 2024. [Online]. Available: <https://anaheimautomation.com/brushless-dc/brushless-drivers-controllers/brushless-speed-controllers-1hp-and-over/mdc151-0501001/>
- [7] 'What Are Motor Driver ICs? - Electronic Components Distributor - SMBOM.COM', What Are Motor Driver ICs? - Electronic Components Distributor - SMBOM.COM. Accessed: Oct. 17, 2024. [Online]. Available: <https://www.smbom.com/news/13023>
- [8] 'LED Driver IC for Lighting Applications - STMicroelectronics'. Accessed: Oct. 17, 2024. [Online]. Available: <https://www.st.com/en/power-management/led-drivers.html>
- [9] 'Control System Definition, Types, Applications, and FAQs'. Accessed: Oct. 22, 2024. [Online]. Available: <https://www.electronicsforu.com/technology-trends/learn-electronics/control-system-definition-types-applications-and-faqs>
- [10] M. J, 'Introduction to Device Drivers in Embedded Systems'. Accessed: Oct. 22, 2024. [Online]. Available: <https://www.emertxe.com/blog/embedded-systems-design/2024/08/09/introduction-to-device-drivers-in-embedded-systems/>

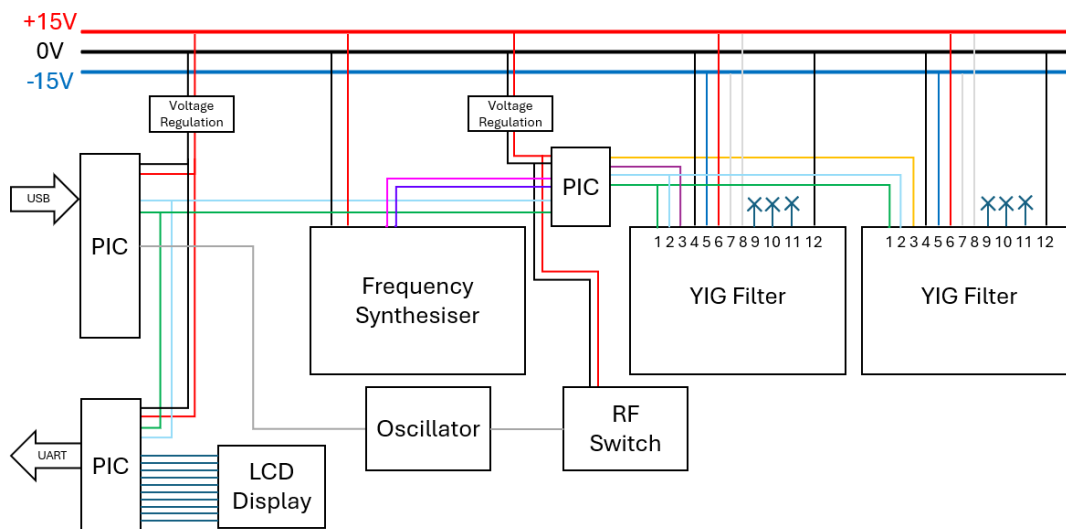
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Appendix

Data Flow Block Diagram



Wiring Diagram



Data Sheets

[Micro lambda Wireless YIG Tuned Bandpass Filter Drivers](#)

[Valon Technology Frequency Synthesiser](#)

[PIC Microcontroller](#)