Team Avalanche
Project Proposal

PSU ECE Senior Capstone 2024

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1. Executive Summary

Team Avalanche, in conjunction with Galois, is developing a low-cost, efficient avalanche transmitter for safety training in winter outdoor conditions. Focused on simulating distress signals, the transmitter will emit a specific frequency range, aiding search and rescue practice. With an emphasis on affordability, efficiency, and easy assembly, the design aims to facilitate field testing for various mountain rescue groups. The project's key features include cost-effectiveness, operational efficiency, and user-friendly assembly, aligning with the crucial need for effective search and rescue training in avalanche scenarios. The transmitter, designed exclusively for training purposes, represents a valuable tool for outdoor recreation teams to refine their skills in simulated avalanche emergencies.

2. Background

Team Avalanche is a Portland State University (PSU) senior capstone project group. We will be working alongside Galois as our industry sponsor. Our project will be overseen by Joshua Mendez as the faculty advisor from PSU. Team avalanche has been tasked with creating an avalanche beacon for mountain rescue training.

Our industry sponsor is Galois. Galois is an engineering firm headquartered in Portland, Oregon with offices throughout the country. Galois specializes in the research and development of new technologies in the computer science domain. They have successfully utilized Rigorous Digital Engineering (RDE) practices for the development of complex cyber-physical systems relevant to national security. They develop solutions for clients such as DARPA, Department of Defense, Department of Energy, Department of Homeland Security, Intelligence Community, and NASA, among others. Galois' mission is to transform research into real-world application of systems that achieve a balance between the privacy/cost/speed to ensure reliability and trustworthiness.[1]

Avalanche transceivers, sometimes also called avalanche beacons, have been present on the market for roughly 50 years.[2] They are small portable electronic devices that are worn by people in avalanche prone environments, particularly by anyone who enjoys snow sports such as skiing, snowboarding, and mountaineering. Modern transceivers operate on an international standard frequency and are constantly sending out a transmission at 457kHz. In the event of an avalanche burial, search and rescue teams or others in the surrounding area can switch their transceivers into search mode to receive all transmission signals in the area and indicate where a burial victim may be located. Since the first 10 minutes are the most critical in locating and rescuing those buried by an avalanche, the dependability of these devices along with the thorough training of search and rescue teams are of the utmost importance.

The downside of commercially sold transceivers is the cost that ranges between $300 and $600 USD. This makes it cost-intensive for search and rescue organizations to have a sufficient number of transceivers to both simulate multi burial scenarios and search for victims, often relying on team members' personal devices, borrowing from others or using older transceivers.

There exists a need for a low-cost transmission-only device that could be easily produced and acquired in larger quantities. This would primarily aid in simulating multiple burial scenarios where many devices are buried in snow while SAR teams utilize their commercial transceivers to locate them.

[1] Galois About Us (https://galois.com/about/)
[2] History of Avalanche Transceivers (https://en.wikipedia.org/wiki/Avalanche_transceiver)

Examples of modern commercially available avalanche transceivers.[3]

3. Project Overview

Our team has been tasked by Galois to design an avalanche transmitter for training in multi-burial scenarios. This transmitter will continuously send out a 457 kHz carrier modulated by a 1 Hz square wave (interrupted continuous wave modulation), which rescue teams use to locate individuals trapped in an avalanche. While existing beacons have the transmitter and receiver functionality, this project focuses on designing only a transmitter to be worn by simulated victims, which removes the cost associated with the receiver functionality and makes it more affordable to incorporate in avalanche search and rescue training.

4. Research

4.1 Open Source Projects

While no existing open source projects similar to ours are readily available, the team may utilize open source projects to aid in the development of this project.

The team is going to use schematics available online or in datasheets for the power supply module, antenna and transmitter circuit. The team will research, select and combine schematics in line with the requirements listed in this proposal and document and align with Galois on all design choices and trade-offs.

4.2 Commercial Off-the-Shelf Products

The primary commercial off-the-shelf (COTS) product to be used throughout this project will be a modern functioning commercially available avalanche transceiver. This will be used as a source for product design, as well as to test and verify the ability of commercial transceivers to detect and locate our transmitters.

Team Avalanche plans to investigate the use of off the shelf components for the project. Currently the team has not chosen any specific components, only general classes of components and examples of existing components. Below is a list of the current proposed off the shelf components:

- Integrated frequency synthesizer - This would be a great way to produce the frequency at a low cost with high reliability compared to building the circuit.

[3] Avalanche transmitters sold at REI (https://www.rei.com/c/avalanche-transceivers)

- Crystal oscillator - This is used to provide a stable frequency. This would require more work and time to source and build if used as the primary frequency generator. However one would still be utilized as an external reference for the previous IC.
- Medium Wave Radio Transmitter - unlikely to be COTS, but will be constructed using COTS parts
- Bandpass or low pass filter to filter out unwanted harmonics.
- Antenna to send the signal out of the integrated circuit - made using COTS components
- Amplifier to amplify the signal from the integrated circuit to achieve the range noted in the requirements section - utilizing COTS components

4.3 Patents, Papers, Articles, Conference Proceedings

The transmitter technical specifications are subject to the European Telecommunications Standards Institute's three part standard for "Avalanche Beacons operating at 457 kHz" ETSI EN 300 718-1 V2.2.1 (2021-06) Technical Standard[4][5] and applicable FCC regulations for non-commercial low power transmitters.

The avalanche transmitter we are making is different from the standard transceivers that are made and used. While a transceiver transmits and receives signals we are only building a transmitter for avalanche search and rescue testing. With the lack of receiving signals for our project,, the patents, papers, and conference proceedings researched are not entirely accurate, however there is an overlap in information applicable to our project.

The U.S. Patent No. 6,484,021 and 6,246,863 of Hereford et al July, 14th, 2005 are relevant to our project design since we are making a transmitter similar to which this patent describes.[6] The patent lays out the apparatus having a housing, a radio signal transmitter, a microcontroller, and a flip lid switch to determine sending or receiving transmitted signals at the specified frequency. Our design will not need a switch to select between transmit or receive, but will have parts similar to those listed. This digital transceiver patent will help guide our team on what a commercial product would need to be operational. Both of these patents come with various strengths and weaknesses which we will weigh and determine the best design for our project.

A factor that was learned though the research was electronic interference (EMI). This interference can be caused by common devices such as cell phones, heated gloves, the biggest interference are smart watches. These devices can cause EMI which will disrupt transceiver searches which we will have to mitigate as much as possible. To test and account for EMI for our final prototype the use of such devices in a testing environment is paramount to making a successful product. Electronic devices as close as 30mm have been tested and proven to disrupt a transmitting signal's integrity.[7] Since the antenna designs have historically been of a magnetic base with copper wire wrapped around it this will be one of the main focuses in our testing along with the PCB's measured EMI and signal integrity.

When looking at conference proceedings about new innovations in short-distance data communications, photo-receivers have been a highly studied field. These signal receivers are meant to receive transmitted signals in a fast and low noise environment for short reach photonic applications. The optical range of signal is way outside our operating range for our transmitters, but the silicon-germanium-silicon-heterojunction-based avalanche photodetectors could produce insight into other semiconductor technology and material we can utilize to majorly improve performance, longevity, and energy use of our transmitter.[8]

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[4] ETSI EN 300 718-1 V2.2.1 (2021-06) (https://portal.etsi.org/webapp/workprogram/Report_WorkItem.asp?WKI_ID=57408)
[5] ETSI EN 300 718-2 V2.1.1 (2018-01) (https://portal.etsi.org/webapp/workprogram/Report_WorkItem.asp?WKI_ID=10666)
[6] Abandoned CA patent application referencing patents (https://patents.google.com/patent/CA2443751A1/en)
[7] From: Meister, Dammert "The Effect on Consumer Electronics on Avalanche Transceivers" (https://arc.lib.montana.edu/snow-science/objects/ISSW14_paper_P4.13.pdf)
[8] Silicon-Germanium Avalanche Receivers (https://ieeexplore.ieee.org/abstract/document/9540259)

5. Product Design Specification

The sections below comprise the product design specifications in the development of an avalanche transmitter to be used in SAR training.

5.1 Concept of Operation

The purpose of the device is to aid search and rescue teams in training for locating individuals buried in avalanches. The device shall emit a signal detectable by avalanche transceivers at the standardized frequency of 457 kHz as established by The European Telecommunications Standards Institute (ETSI).

Existing avalanche beacons have both transmitter and receiver functionality. A transmitter-only device is proposed to provide a lower cost option to be distributed and used in training by SAR teams when searching for simulated victims. This low-cost option will be extremely valuable when training for multi-burial scenarios that necessitate multiple avalanche transmitters.

Ideally after the completion of this project, this product can be manufactured and distributed to local avalanche SAR organizations such as Portland Mountain Rescue (PMR). In order to bring value to these organizations, the device must be low-cost, durable, portable, reusable, and simple to operate. In addition to functioning appropriately, it should also be easily detectable by commercially available avalanche transceivers.

The final design documentation shall be open-source and available for individual non-commercial use. The documentation shall include all the necessary information to manufacture the device, including, but not limited to, circuit diagrams, bill of materials, 3D models, assembly, test documentation, and user guides. Users shall bear all responsibility for creating the actual device and any modifications they introduce.

5.2 Stakeholders

The stakeholders for this project include:

- Galois - the industry sponsor for the team.
    - Led by Michal Podhradsky, with support from Ethan Lew, Frank Zeyda, and Joe Kiniry.
- Team Avalanche - the project team building the transmitter.
    - Team members: Allen Bakira, Dmitrii Fotin, Phil Nevins, Ken Sutter, Roberto Torres
- Faculty Advisor - Joshua Mendez
- Capstone instructor - Andrew Greenberg
- Portland State University - the institution overseeing the project .
- Search and Rescue Teams - An intended end user of the avalanche transmitter.
- Other snow professionals - Any rescue teams that may use the open source design in the future, including ski patrollers, mountain guides, and others.

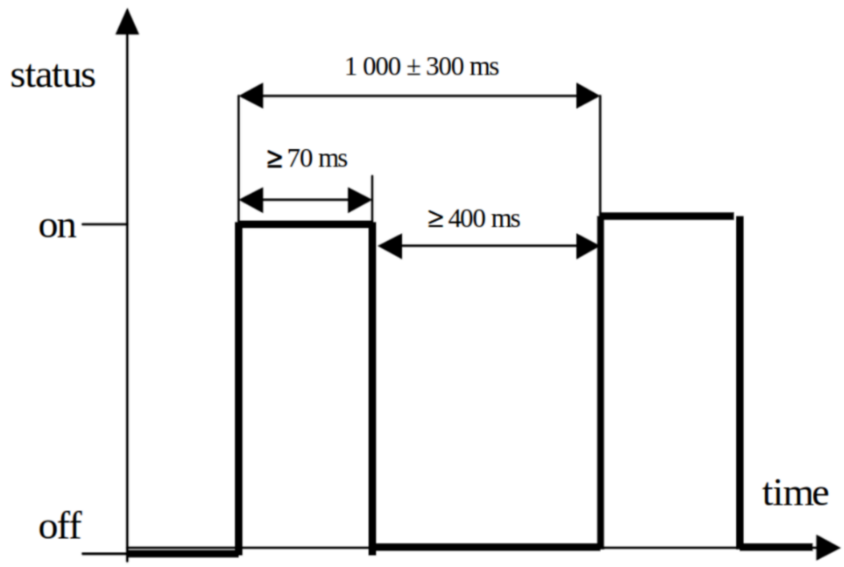
5.3 Requirements

1. The transmitter must broadcast at 457kHz
2. Students must review current FCC regulations of the transmitter frequency (if any)
3. The transmitter must be enclosed in an IP65 like enclosure (must survive in snow and cold)
4. The transmitter hardware and enclosure should cost less than $100 a piece (the cheaper the better)
5. The Transmitter must utilize an antenna
6. The Transmitter must utilize widely available batteries.
7. The transmitter Must have an on/off switch with a visual indicator.
8. The transmitter Must have a battery charge indicator.

5.4 Specifications

This product shall abide by the ETSI EN 300 718-1 V2.2.1 (2021-06) Technical Standard and sponsor requirements detailed below:

9. The transmitter is Capable of at least 200 hours of transmitting at a temperature of +10°C .
   9.1. A positive battery check must indicate the capability of at least 20 hours of transmitting at a temperature of +10°C.
10. The transmitter Operates at 457 kHz in transmit mode, broadcast a 1 Hz square wave with double sideband amplitude modulation with no modulating auxiliary carrier.
11. The carrier keying shall be:
    on time: 70 ms minimum;
    off time: 400 ms minimum;
    period: 1000 ms ± 300 ms (on time plus off time).



Modulated wave output requirement, ETSI EN 300 718-1 V2.2.1 (2021-06) Technical Standard

12. Transmission shall be detectable by commercial transceivers at up to 30 meters but not more than 70 meters
13. The frequency error shall not exceed ±80 Hz at 457 kHz.
14. The minimum transmitted field strength at 457 kHz shall not be lower than -6 dBµA/m (0.5 µA/m) at a distance of 10 m.
15. The maximum transmitted field strength at 457 kHz shall not exceed 7 dBµA/m (2.23 µA/m) at a distance of 10 m.
16. Radiated emissions below 30 MHz shall not exceed the generated H-field of 27 dBµA/m descending 3 dB/oct at 10 m.
17. The power of any radiated emission shall not exceed 250 nW.
18. The accumulated measurement uncertainties of the test system in use for the parameters to be measured should not exceed those given in table below.

Parameter	Uncertainty
RF frequency	±1 x 10^{-6}
Radiated emission of transmitter, valid up to 1 GHz (Substitution method)	±2 dB
Radiated emission of transmitter, valid up to 1 GHz (direct measurement, using calibrated antennas)	±6 dB
Temperature	±1°C
Humidity	±5 %
Transmitted H field at a distance of 10 m	±0,1 µA/m
Carrier keying times	±3 ms
NOTE: For the test methods according to the present document the uncertainty figures are valid to a confidence level of 95 % calculated according to the methods described in the ETR 028 [2].	

Allowed uncertainties per the ETSI EN 300 718-1 V2.2.1 (2021-06) Technical Standard

19. Must be enclosed in an IP65 rated enclosure.
20. Operating instructions must be delivered with every equipment. They must cover the following subjects:
    1) a statement on avalanche danger;
    2) instruction for checking the battery, transmitter performance and range;
    3) instructions for turning on the transmitter and strapping the beacon to the body;
    4) a statement on the temperature sensitivity of essential parts;
    5) a statement on the battery lifetime;
    6) device-specific measures on a tour.

w) The equipment may include a carrying system that gives the possibility for easy operation and safe placing. The carrying system can be a part of the equipment or an accessory device. The carrying system must have a joint tensile strength of at least 50 N.

5.5 Deliverables

- Project Proposal - this document.
- Documentation that describes the transmitter function, a user guide, user warnings/safety from outside elements and interference.
- Digital Design logs weighing the pros and cons of each iteration that lead to our final prototype.
- Weekly check-ins with weekly progress reports.
- Various simulations of device operation using LTSpice and Multisim with imported part characteristics. These documented electrical and CAD files will be supplied as gerber files and STL files respectively with proper version revisions and notes about design updates.
- Bill-of-Materials (BOM) with sourcing and pricing of various components and functionality behind each part for easy future reference and redesigns. Throughout this project we will make notes of the updates, upgrades, and manufacturing services needed to make the product in the event that any manufacturing services used today are unavailable in the future.
- A public Git repository containing all aforementioned documentation.
- At least one working prototype avalanche transmitter, to be given to the industry sponsor.
- Extra working or non-working prototypes to be kept by team members.
- A final report on our capstone project.
- Capstone presentation at Portland State University with a poster for presenting the prototype

5.6 Initial product design

Our initial approach to designing this avalanche transmitter will consist of:

- A PCB with the following components:

    - A programmable frequency generator IC, likely the Si5351 or similar. With I2C pinouts for programming via external MCU. An external crystal oscillator used as reference either (25 or 27 MHz)
    - An amplifying stage likely using either an RF op-amp or a discrete transistor design
    - A filter stage of either active or passive bandpass or low pass filters
    - Power supply circuitry including: Linear regulator and supporting passive components
    - Battery indicator circuit including: A display IC such as LM3914 Dot/Bar Display Driver, or LP5012 RGB LED driver, a series of LEDs or a multi-LED bar graph display
    - All required passive components
- An antenna most likely being a tank circuit with a ferrite rod and with wrapped Litz wire. Utilizing off the shelf ferrite rods and a designed and constructed coils by Team Avalanche.
- User inputs consisting of: ON/OFF switch, button for a battery check feature (Req
- Outputs consisting of: ON/OFF status leds, perhaps a transmission status LED, a battery charge status indicator.
- Battery based power supply using common alkaline AA/AAA batteries.
- A durable IP65 enclosure either off the shelf or designed and made by Team Avalanche made of plastic with easy access to replace batteries.

The circuit and the PCB will be designed and simulated by Team Avalanche in KiCAD. The PCB will be manufactured by OshPark. Team Avalanche will solder the PCB together using components purchased online from DigiKey or Mouser. The enclosure, if not off the shelf, will be designed in Fusion360 or Solidworks.

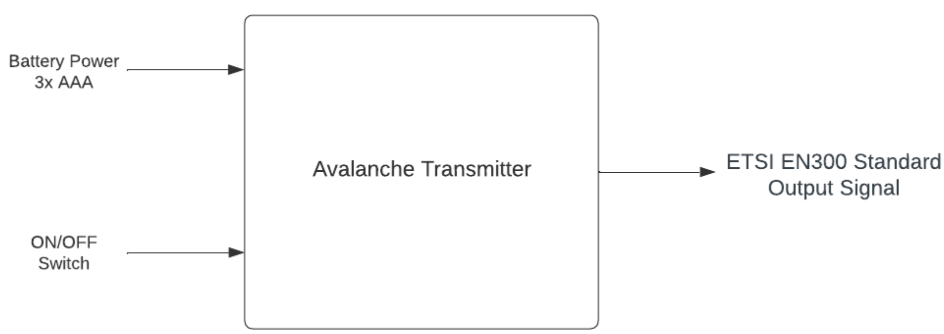
The main risk of this project is deviation from the ETSI EN 300 718 standard, especially if the team identifies any of the deviations during the final testing stages. The goal is to examine what factors may cause deviations during the design stage, and build prototypes of regulated systems as soon as possible in order to have time for multiple rounds of testing and fixing as needed.

The team is currently in the research stage, putting together a more detailed concept of the final device. We are scheduled to interview a member of Portland Mountain Rescue to better understand the expectations SAR teams might have for the design of the avalanche beacon.

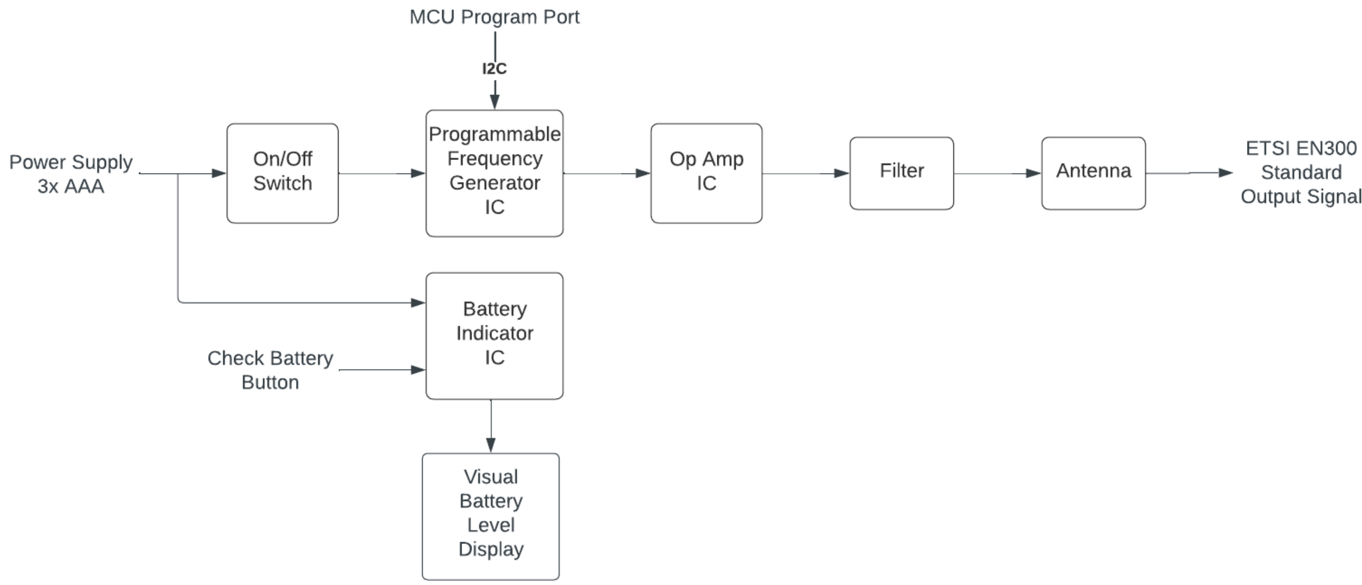
We are also actively discussing the potential circuit designs with our academic advisor to identify possible approaches and their trade-offs and present our findings to Galois and determine the final design.

The team is optimistic about completing the project in alignment with the requirements defined in this proposal within the four month period.

5.6.1 Hardware architecture



L0 Block Diagram



L1 Block Diagram

5.6.2 Software architecture

The team is in the process of assessing whether and what microcontroller would be needed to program the transmitter and what programming language would be used for that. The majority of the work for this project lies in hardware and circuit design, so the team is confident we will be able to program any selected software solution, especially given the strong programming background of all team members.

5.7 Verification plans

We plan to follow the testing requirements within the ETSI EN 300 718-1 V2.2.1 (2021-06) Technical Standard for Avalanche Beacons. We are designing a transmitter for training purposes only, therefore we will disregard any receiver specific requirements, as well as standards pertaining to commercial products. Formal test plans and documentation will be generated from the following document. The key aspects are listed below as defined in the standard.

5.8 Testing defined by ETSI EN 300 718

The content, headers, and section numbers below are taken from ETSI EN 300 718-1 V2.2.1 (2021-06) Section 5. Section numbers are denoted by the letter "E".

E5 Testing for compliance with technical requirements

E5.1 Environmental conditions for testing

E5.1.1 General

Tests defined in the present document shall be carried out at representative points within the boundary limits of the operational environmental profile defined by its intended use, which, as a minimum, shall be that specified in the test conditions contained in the present document (see below). Where technical performance varies subject to environmental conditions, tests shall be carried out under a sufficient variety of environmental conditions as specified in the present document to give confidence of compliance for the affected technical requirements.

Testing shall be made under normal test conditions, and also, where stated, under extreme test conditions. The test conditions and procedures shall be as specified in clauses 5.1.2 to 5.1.4.

E5.1.2 External test power source

During the tests, the power source of the equipment shall be replaced by an external test power source capable of producing normal and extreme test voltages as specified in clauses 5.1.3.2 and 5.1.4.2. The internal impedance of the external test power source shall be low enough for its effect on the test results to be negligible. For the purpose of the tests, the voltage of the external test power source shall be measured at the input terminals of the equipment. The non-grounded terminal of the batteries shall be disconnected, but batteries shall be left in place. The external test power source shall be suitably de-coupled and applied as close to the equipment battery terminals as practicable. The power leads shall be as short as practicable and properly dressed. For radiated measurements fully charged internal batteries should be used. The batteries used should be as supplied or recommended by the manufacturer. During tests the external test power source voltages shall be within a tolerance ±1 % relative to the voltage at the beginning of each test.

E5.1.3 Normal test conditions

E5.1.3.1 Normal temperature and humidity

The normal temperature and humidity conditions for tests shall be any convenient combination of temperature and
humidity within the following ranges:

• temperature: +15 °C to +35 °C;
• relative humidity: 20 % to 75 %.

When it is impracticable to carry out tests under these conditions, a note to this effect, stating the ambient temperature
and relative humidity during the tests, shall be added to the test report.

E5.1.3.2 Normal test voltage

The normal test voltage shall be the nominal voltage of the device. The value shall be stated in the test report.
NOTE: The nominal voltage of the device depends on type and number of batteries, as specified in the user manual.

E5.1.3.3 Normal test modulation

The normal test modulation shall be carrier-keying with 100 ms on-time and 900 ms off-time.

E5.1.4 Extreme test conditions

E5.1.4.1 Extreme temperatures

The equipment shall be able to operate correctly in the temperature range from -20 °C to +45 °C and shall be stored without damage in the temperature range from -25 °C to +70 °C.
Before measurements are made the equipment shall have reached thermal balance in the test chamber. The equipment shall be switched off during the temperature stabilizing period.
In the case of equipment containing temperature stabilization circuits designed to operate continuously, the temperature stabilization circuits shall be switched on for 15 minutes after thermal balance has been obtained, and the equipment shall then meet the specified requirements.
If the thermal balance is not checked by measurements, a temperature stabilizing period of at least one hour shall be allowed. The sequence of measurements shall be chosen, and the humidity content in the test chamber shall be controlled so that excessive condensation does not occur.

E5.1.4.2 Extreme test voltages

The extreme test voltages shall be as defined by the intended use of the EUT. The values shall be stated in

the test report.
NOTE: The extreme test voltages of the device depend on type and number of batteries (as specified in the user manual) and the degree of battery discharge, which is allowed to maintain proper function of the device.

E5.2 Interpretation of test results

Guidance on the interpretation of test results is given in annex F.

E5.3 Compliance test procedures

E5.3.1 Modulation and carrier keying

The carrier keying shall be measured by means of an oscilloscope connected to an H-field test antenna, or alternatively by means of a spectrum analyser, set to 457 kHz in zero span mode with resolution bandwidth ≥ 1 kHz.

NOTE: The attenuation of the magnetic field at 457 kHz of a temperature test chamber is considered to be low, therefore the magnetic field emitted by an avalanche beacon inside the test chamber can be measured outside the test chamber by an H-field test antenna.

The H-field test antenna shall be placed in the best coupling position to the EUT in a distance smaller than 1 m.

E5.3.2 Frequency error

The carrier frequency shall be measured by means of a frequency counter, connected to an H-field test antenna.

The frequency counter shall be capable of measuring the transmit frequency of the EUT within the on-time of the on/off-keyed carrier, that is within ≥ 70 ms.

E5.3.3 Output field strength (H-field)

Step 1: Absolute measurement at normal test conditions
The H-field produced by the equipment shall be measured in best coupling position at distances of 10 m on an open area test site (see clause B.1.3). The test antenna shall be a calibrated shielded magnetic field antenna. The measurement shall be done by means of a measuring receiver, tuned to 457 kHz, with resolution bandwidth ≥ 1 kHz. The maximum signal level detected by the measuring receiver shall be noted.
Step 2: Relative measurement at extreme test conditions
The equipment shall be placed in a temperature test chamber. The H-field test antenna shall be placed in the best coupling position to the EUT in a distance smaller than 1 m. A first measurement shall be made at the same temperature as in step 1. Subsequent measurements shall be made at extreme temperatures. The difference of the H-field level relative to the first measurement shall be noted and added to the value from step 1.
NOTE: The attenuation of the magnetic field at 457 kHz of a temperature test chamber is considered to be low, therefore the magnetic field emitted by an avalanche beacon inside the test chamber can be measured outside the test chamber by an H-field test antenna.

E5.3.4 Transmitter spurious emissions

E5.3.4.1 Method of measurement Radiated H-field (< 30 MHz)

The field strength shall be measured for frequencies below 30 MHz. The equipment under test shall be measured at a distance of 10 m on an open area test site. The test antenna shall be a calibrated shielded magnetic field antenna. The equipment under test and test antenna shall be arranged as stated in annex B, clause B.1.3. The equipment under test shall be switched on in transmit mode. The measuring receiver shall be tuned over the frequency range 9 kHz to 30 MHz, except for the frequency band ±100 Hz from the frequency on which the transmitter is intended to operate. At each frequency at which a spurious signal is detected the equipment under test and the test antenna shall be rotated until maximum field strength is indicated on the measuring receiver. This level shall be noted. The limits are quoted in dBμA/m, so it is necessary to reduce the reading as explained in annex D for measuring equipment calibrated in dBμV/m.

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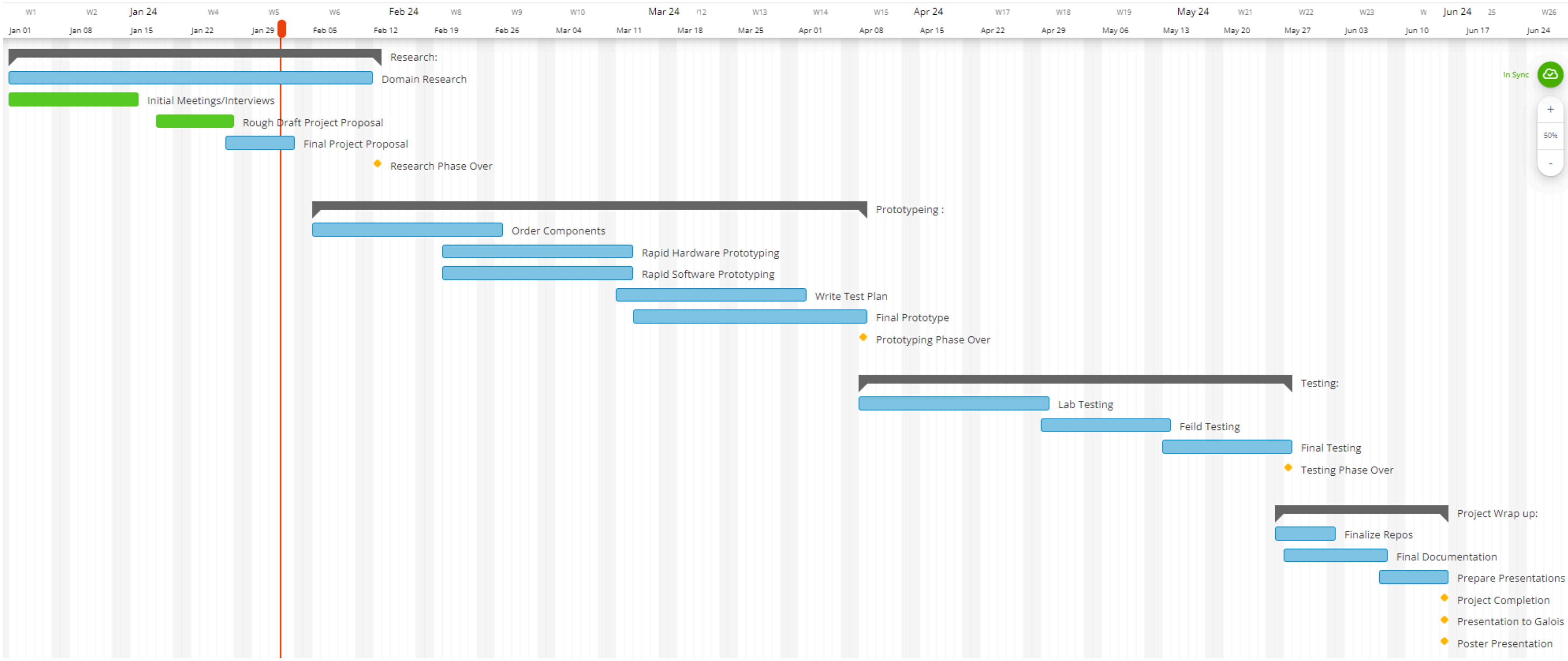
6. Project Management Plan

6.1 Timeline, with milestone



Project Timeline

We have chosen to use Instagantt to create and manage our team's schedule. Below is a preview of our Gantt chart. For the full and updated version please visit our gantt chart by using this link: Team Avalanche Gantt Chart[9]

6.2 Budget and Resources

Galois' budget for this project is approximately $500 to research, design, test, and produce a final device that can be used in avalanche testing. Throughout this project we will need to purchase components and parts as well as manufacture PCBs and enclosures to meet the design requirements of the project.

The purchasing process will involve team members sending a shopping list to Galois and upon approval, parts will be ordered by Galois either for a team member to pick up or delivered to a team member's address.

Galois will also provide a functioning avalanche transceiver for testing as well as access to a team of engineers with knowledge of system architecture and years of experience in project work.

The Team will provide approximately 8-10 hrs of time per week per member towards the development of this project.

As students we will utilize the Electronic Prototyping Lab (EPL) as a component store, as well as various CAD, simulation, and VCS's systems accessible under student licenses. We will also discuss design methodology, and FCC regulations and standards with faculty at Portland State University to ensure adherence to the standards. We may utilize the RF lab to perform product testing as well as a team locker to house parts as needed. The capstone lab, a lab containing measurement, testing, and prototyping equipment will be utilized to prototype and manufacture the transmitter.

Team members may also utilize their personal labs and workstations in the development of the transmitter. Some team members have standard electronic testing equipment, soldering stations, and 3d printers.

6.3 Intellectual Property

For the Avalanche transmitter project Galois will own the intellectual property. The project will be open source and use BSD-3 license. The use of the BSD-3 license was requested by Galois.
Reasons for choosing BSD-3 license:

- Requested by Galois
- It is easy to implement and has few requirements.
- It is a free license to use by any team.
- Limited restrictions placed on use modification, and redistribution.
- It does not impose any liability or warranty on the original authors of the software.
- Compatible with every major copyleft license

6.4 Team and Development Tools

The collaboration tools Team Avalanche will be using:

- Github
- Discord
- Zoom
- Google Drive
- Google Meet
- Google Calendar

[9] InstaGantt Team Avalanche (https://app.instagantt.com/shared/s/PfjcEdwF6cT5IL7uy7Jf/latest)

Technical tools and Languages to be used by Team Avalanche:
- KiCad
- Fusion 360
- Solidworks
- Multisim
- C language
- Assembly language

Team Avalanche will be following the Rigorous Digital Engineering (RDE) method as proposed by Galois. RDE will involve:
1. Rigorous tracking of requirements. Each design decision should be referencing a particular requirement that informs that decision. In SW, each line of code would be traceable back to a requirement. In HW design there is not a clear way to do it - in general, adding links/comments/references to requirements throughout your design is a suitable start. We can also add some light scripting at the end to see if all requirements were satisfied.
2. Feature modeling with Clafer - as shown in our meeting. There is more than one way to build the transmitter, a feature model helps you evaluate your option and establish a product line of possible transmitters.
3. Version control / git practices - happy to do a little presentation about this
4. (stretch goal) Automatic analysis of your design - can any of the KiCad and other tests and analysis run automatically in github every time you push a design change? Again, happy to dive deeper into this as time/interest permits.

6.4.1 Team Strengths and Roles
All team members will contribute to various overlapping aspects of the project, for now primary roles are as follows:
- Ken Sutter: Sudo Project Manager and FPOC for external communications with Galois and faculty advisor.
- Allen Bakira: Our only EE Major. RF technical lead, and technical research and development.
- Dmitrii Fotin: Technical Research and development
- Phil Nevins: Verification and testing. Git Repository administration. PCB design.
- Roberto Torres: SPOC for external communications, Documentation lead, Google Drive administration.

6.4.2 Skills section
Ken Sutter is good with circuit layout and design. Very good with soldering troubleshooting communication and planning coding in C, Python, Kotlin, SQL. Good at team management and project management. Lots of knowledge on CAN networking. Expert on vehicles. I have industry experience in automotive and using Linux and QNX machines. Also versed in AI learning and training AI algorithms. Ken will act as the main point of contact between the team and all of the stakeholders. Ken will also manage team documents, deadlines, and internal and external team communication.

Learning goals: How other companies conduct their engineering practice, how to build an antenna and send RF signals, how to build a project from the beginning to the end, learn more about SAR and PMR.

Allen Bakira has a background in RF concepts and fundamentals. Good with soldering and design decision making. Can code in C. Team player who gets their job done and pays attention to critical detail and pain points in project completion. Previous work experience at Qorvo, a semiconductor manufacturer.

Learning goals: Gain more experience in RF and antenna design. Project design and development.

Roberto Torres is good at troubleshooting and creative problem solving. Good at design, fabrication, assembly and soldering. Proficient in C, Python, Matlab and some Assembly. Decent at circuit layout and design. Decent at CAD and 3d Printing. Good at consuming data sheets until my head hurts. Decent at project management and team management. Very experienced in customer service. Working at Intel as an equipment technician. Some minimal SDR experience, and BLE experience. Some experience with onboard ATmega AVR MCU programming.

Learning Goals: Gaining experience with beginning to end modern engineering design , testing and validation for reliability, and project management/documentation. Gain experience qualitative design decisions.

Phil Nevins is good with PCB layout design. Good with programming C, Python, Assembly. Very good with communication and planning. Basic Verilog understanding. Some soldering experience. Basic understanding of Linux. Good with validation and verification

Phil will manage PCB design, validation and verification.

Learning goals: Validation and verification process. Start to finish product design and development using MCUs.

Dmitrii Fotin can program in C, C++, Python, Assembly, Java. Has experience in circuit/PCB design and 3D modeling. Has done projects involving wifi and bluetooth communication, displays, gyroscopes, accelerometers, light sensors, weight sensors, motors, band filters, LC circuits, OpAmps, transistors/mosfets.

Learning goals: Gain applicable experience in RF/analog signal transmission design and manufacture.

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