FAMU/FSU College of Engineering

Department of Electrical and Computer Engineering

Preliminary Detailed Design

Team # 302 – Design/Prototype a Multi-Platform Broadband Communication Payload for a Search and Rescue Operation

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1. Introduction

As we have stated several times before, our design consists of a payload that will attach to a provided drone. This payload will consist of several parts working in conjunction.

2. Selected Concept

The selected design concept consists of a total of 5 separate concepts that will connect to one another. The final concept selection was decided by analyzing each multiple options (parts) for each concept. The general concept for the design consists of an antenna that connects to a transceiver that will connect to the FPGA. The results will need to be stored on some sort of storage device. There will also be a power source that will need to last past an hour of use. The selected parts for these concepts are listed below.

Antenna – VHF stout and long antenna SMA connector 147-160MHz

Transceiver – AD-FMCOMMS4-EBZ Wideband Software Defined Radio Board

FPGA – Xilinx Zynq UltraScale+ MPSoC ZCU102

Storage – SanDisk 32GB Ultra SDHC UHS-I Memory Card

Power - BatteryGuy 12V 220 mAh Alkaline Door Lock Battery

3. Preliminary Design

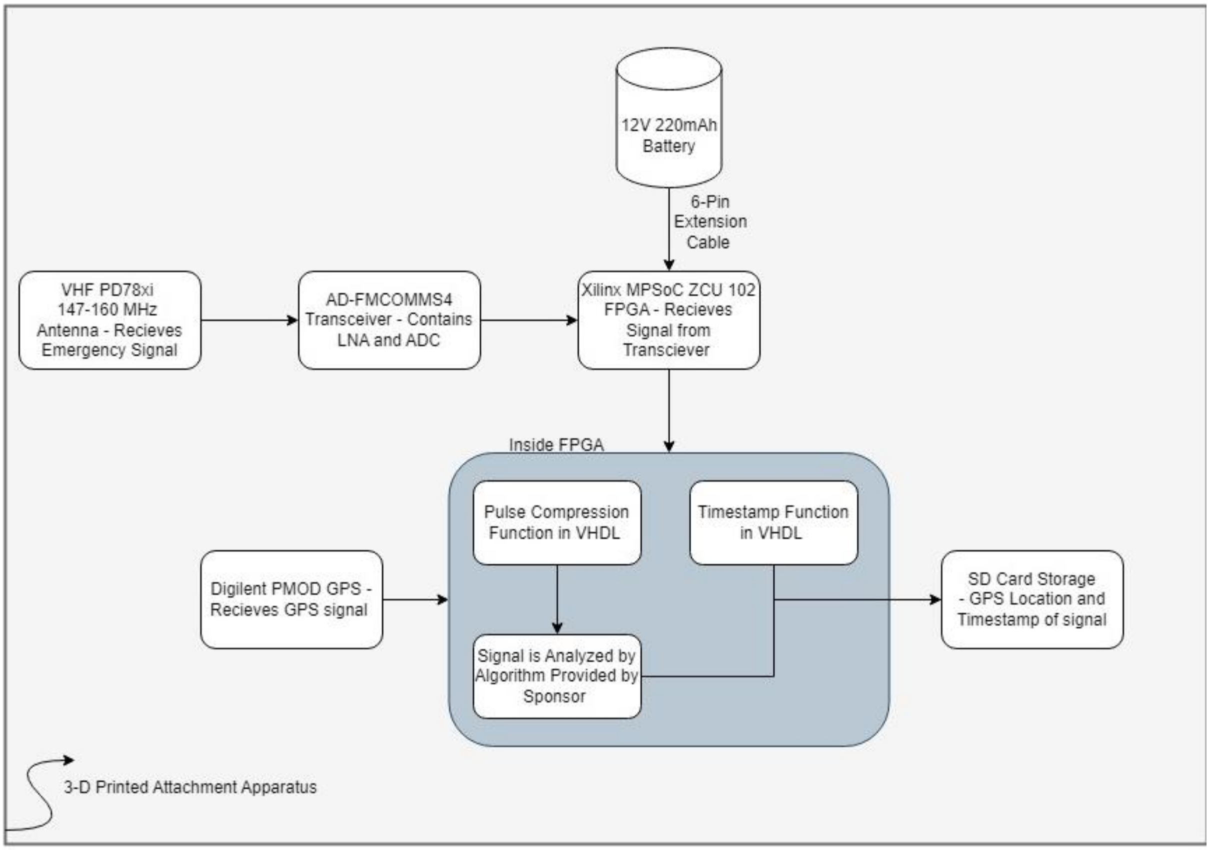

Figure 1 - Preliminary Design Diagram

3.1 Antenna Block Description - VHF PD78xi 147-160 MHz

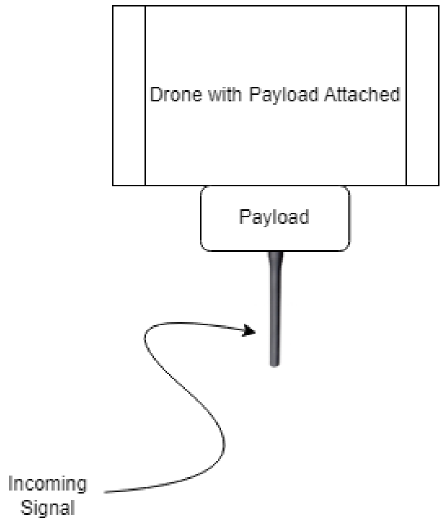

Figure 2 - Antenna Block Diagram

Technical Description of Selected Antenna

- Desired Emergency Signal frequency range to Detect: 156.8 MHz
- Antenna Resonance Frequency: 136 – 174 MHz
- Gain of Antenna: -0.5 dB
- Polarization Mode: Vertical
- Connecter: SMA

Input – Ideally 156.8 MHz signal, but can detect any signal

Output – Received signal will be sent to transceiver via a SMA connection

The preliminary design for the antenna is for it to face vertically downwards sticking towards the ocean. A SMA cable will be needed to connect the antenna to the transceiver inside the payload. The desired distress signal to detect is 156.8 MHz because it is the maritime international distress frequency. The chosen antenna has resonance frequency corresponding to this input. The polarization of the antenna is vertical which aligns with the idea of positioning the antenna vertically straight down.

3.2 Transceiver Block Description - AD-FMCOMMS4-EBZ Wideband Software Defined Radio Board

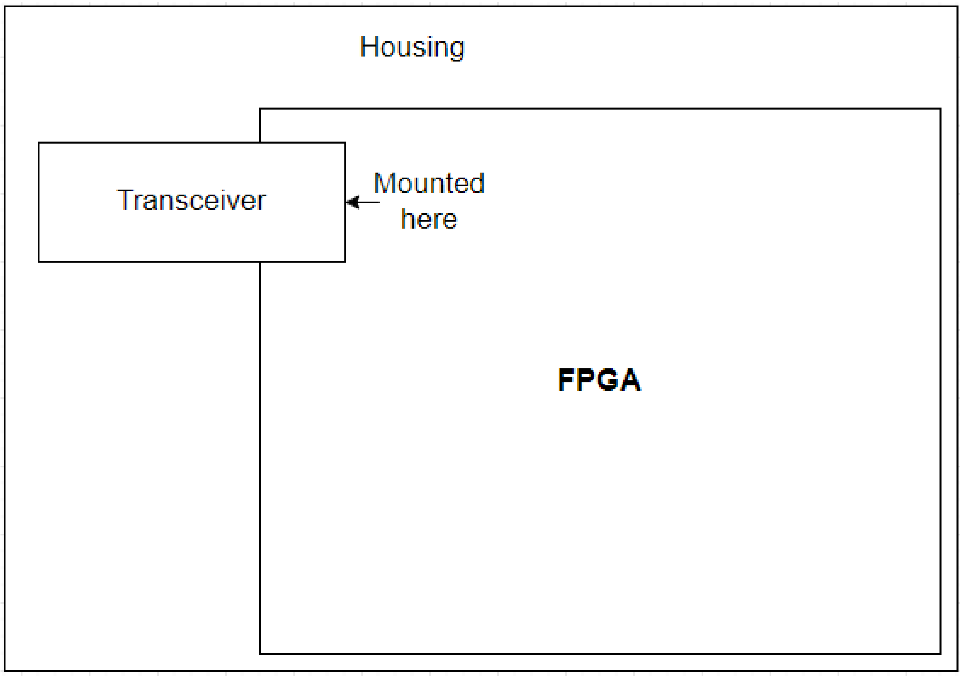

Figure 3 - Transceiver Block Diagram

Technical Description of Selected Transceiver:

- Software tunable across wide frequency range (70 MHz to 6.0 GHz)
- Channel bandwidth of <200 kHz to 56 MHz
- Phase and frequency synchronization on both transmit and receive paths
- Powered from single FMC connector
- Contains ADC

Input – Analog signal from antenna

Output - Digital signal to FPGA

The selected transceiver will be used as a component to perform preliminary processing of the received analog radio signal. The onboard ADC will convert the analog signal to a digital signal so it can be processed by the FPGA. The transceiver also has a LNA (Low Noise Amplifier) which will most likely be used. It will be situated onto the side of the FPGA, as it fits directly onto the righthand portion of the board**.**

3.3 FPGA – Xilinx Zynq UltraScale+ MPSoC ZCU 102

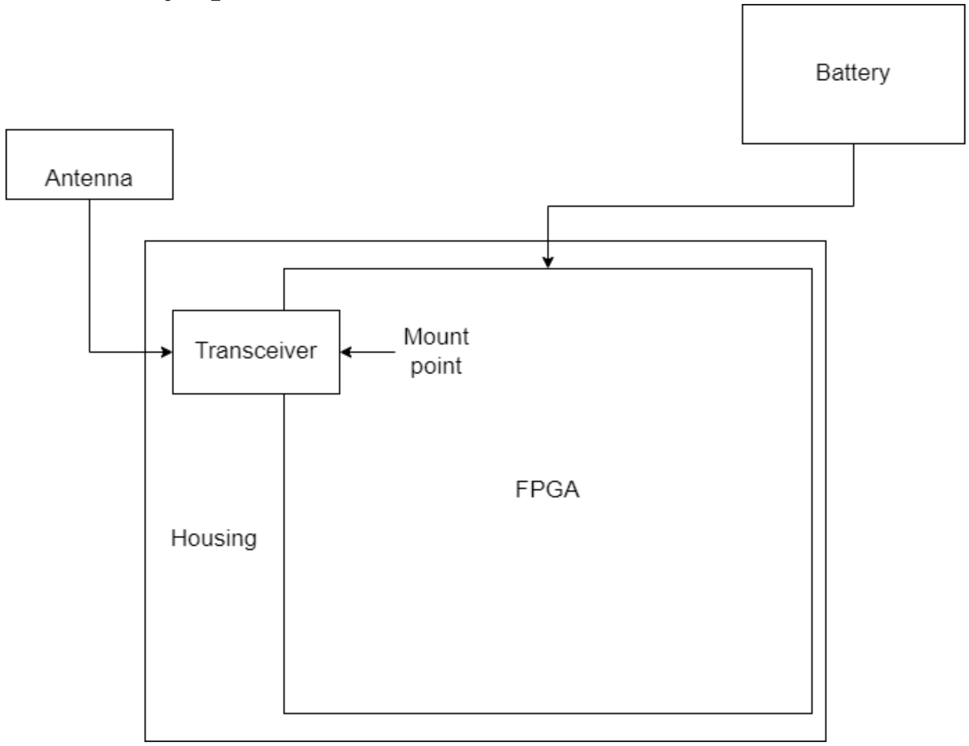

Figure 4 - FPGA Block Diagram

Technical Description of FPGA:

- DDR4 SODIMM Memory – 4GB 64-bit w/ ECC attached to processing system
- PCIe® Root Port Gen2 x4, USB3, Display Port, and SATA
- 2x FPGA Mezzanine Card (FMC) interfaces for I/O expansion.
- Quad-core Arm® Cortex®-A53, dual-core Cortex-R5F real-time processors, and a Mali™-400 MP2 graphics processing unit

Input – Digitized emergency radio signal

Output – Compressed and timestamped signal and GPS location of signal origin processed by algorithm written by NGC.

The Xilinx Zynq UltraScale+ MPSoC ZCU 102 will be the brains of the entire payload. It will perform pulse compression and timestamp the time the was received. The timestamp and the compressed signal data will be stored in the SD card. The FPGA

3.4 SD Card – SanDisk 32GB Ultra SDHC UHS-I Memory Card

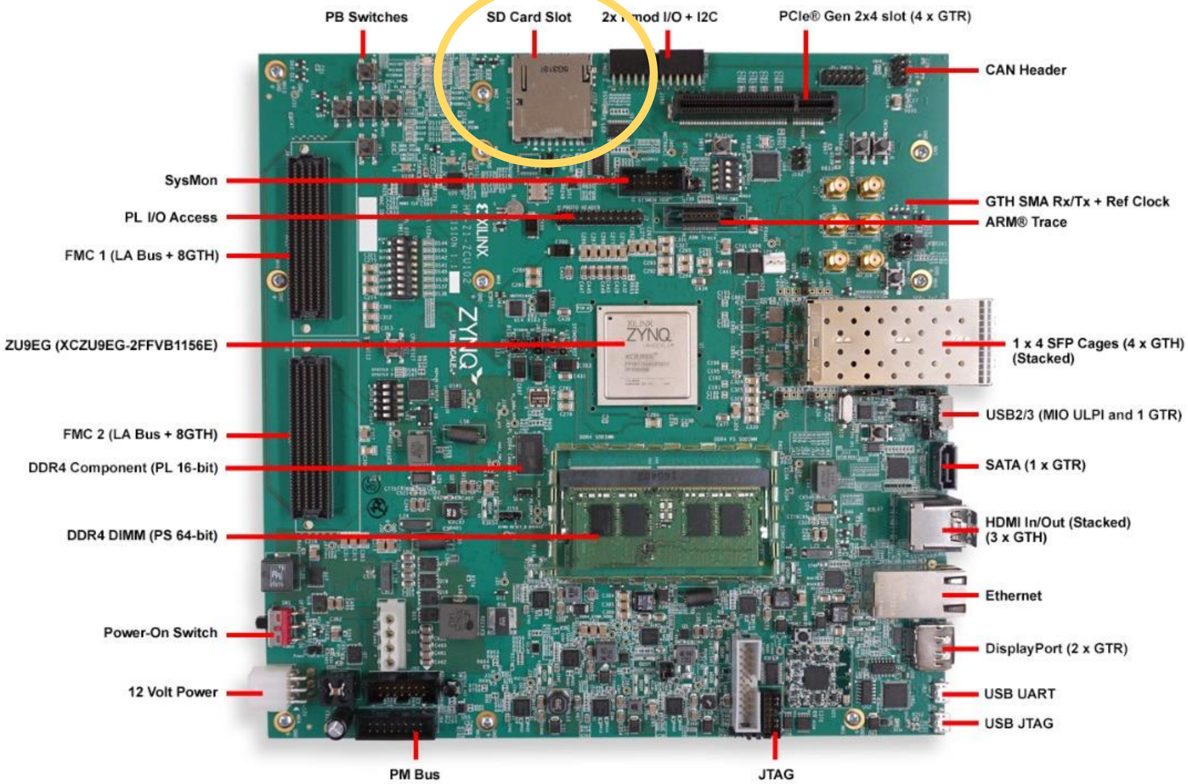

Figure 5 - SD Card Slot on FPGA

Technical Description of Selected SD Card:

- 32GB of storage space
- Transfer speed of 120MB/s
- Compatible with selected FPGA

Input – Timestamp of received signal and GPS location of where signal came from. (From FPGA)

Output – No technical output just stores output/results from FPGA.

The SanDisk 32GB Ultra SDHC UHS-I Memory Card will be used to record the time stamp of received emergency signal and the location of where it was sent from. When the drone has landed the SD card can be taken out of the FPGA and put into a laptop/computer to read data.

Yellow Circle – Position of SD card slot on FPGA

3.5 Power Source – BatteryGuy 12V 220mAh

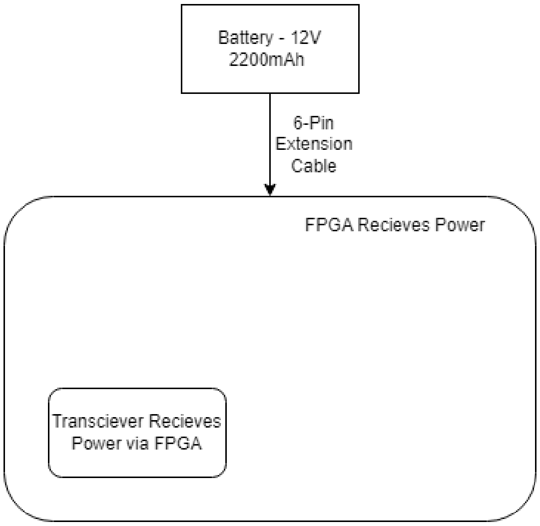

Figure 6 - Power Flow Diagram

Technical Description of Selected Battery:

- 12V Output
- 2200 mAh Output
- Weight - 0.44 lbs

Output – 12V, 2200 mAh

The selected battery should last multiple 1hr flights and can be easily replaced if were to die. Only downside is not knowing the life of the battery before flight. The battery will be connected to the FPGA by a 6-pin extension cable. The transceiver will receive power through the connector on the FPGA. The only connection for power is from the battery to the FPGA. The FPGA has on board power management.

4. Code and Standards Code and Standards

4.1 IEEE Code of Ethics

This code outlines the ethical responsibilities of IEEE members, including the obligation to prioritize the health and safety of the public. If the search and rescue drone is operated in a way that endangers human life or health, it could be seen as a violation of this code.

4.2 IEEE Standard for Unmanned Aircraft Systems (UAS) (IEEE 2911.1)

This standard provides guidelines for the design, testing, and operation of unmanned aircraft systems. If the search and rescue drone does not comply with the requirements outlined in this standard, it could be considered a violation.

4.3 IEEE Standard for Safety Considerations in the Development of Autonomous Systems (IEEE 2855)

This standard provides guidance on ensuring the safety of autonomous systems, including drones. If the search and rescue drone operate in a way that does not prioritize safety; it could be seen as a violation of this standard. Our design is not autonomous, but the team should be aware of these regulations.

4.4 NEC Requirements for Electrical Installations (Article 110)

This code outlines the general requirements for electrical installations, including the design and construction of electrical systems, grounding and bonding, and electrical protection. The payload must follow these standards to ensure proper electrical safety.

4.5 NEC Requirements for Grounding and Bonding (Article 250)

This article covers requirements for grounding and bonding of electrical systems, including grounding electrode systems, grounding conductors, and bonding of equipment and structures. This will dictate how the grounding on the drown is implemented.

4.6 NEC Requirements for Wiring (Article 300)

This article covers the wiring methods for electrical systems, including conduit, cable, and raceway installations. The team is using a male to male SMA cable and will ensure the use of this cable will follow NEC regulations.

4.7 NEC Conductors for General Wiring (Article 310)

This article covers the types and sizes of conductors used in electrical systems, including the installation and termination of conductors.

4.8 FAA Regulations

The Federal Aviation Administration aims at keeping a safe and efficient aerospace system. The FAA has numerous codes and standards including aircraft standards, air traffic, space, and drones. Our group will ensure to follow to the best of our ability standards for drones and aircraft set by the FAA. This would include registering the drone, flying it in proper airspace and additional standards.

Public Safety and Other Factors

The primary concern of the design is, inherently, the safety of the public. Being that this is a search and rescue drone, its entire function is to provide rescuers with information needed to help save lives in times of crisis. The fact that something like this would be used in a time of crisis removes a lot of the potential violations of privacy that would normally be hazardous due to drone usage.

The design utilizes an alkaline battery, which, above all else, prioritizes battery life above potential fire hazards and other pitfalls that stem directly from the usage of said batteries. The event that something this catastrophic, purely in terms of the scope of the design, occurs is unlikely, and if it did occur, it would be mitigated by the housing. This is all to say that the latent risk of using an alkaline battery is low at worst and non-existent at best.

Another environmental/public safety concern would be the payload falling off the drone. If the payload with a max weight of 5kg were to detach from the drone and fall two instances could occur. The likely instance would be the payload falling into the ocean. There is no danger to human life in this scenario but would cause debris in the ocean and could harm ocean life. The second scenario would be the payload falling on a human, which could be life threatening. The team is making the payload as light as possible and is considering multiple attachment designs to ensure the payload will not fall off the drone

There are no other compromises to be made in any aspect of the design that would lessen the environmental impact of the drone catastrophically failing and falling into the ocean. The hard weight limit prevents any form of secondary buoyancy being applied to the payload to prevent the entire drone from going under.

Overall the scenario for this design is in a very remote area (pacific ocean) so threat to public safety is very minimal. Environmental risks consist of losing the payload in the ocean and hurting ocean life. There is not much minimization the team can do on the design level to prevent damage to aquatic life. However the team will consistently think of public safety and environmental concerns when developing and implementing this design, to ensure it is as safe as possible.

Summary

In summary, our design's purpose is to locate downed vessels transmitting distress signals. It will do this by attaching the designed payload to a pre-provided drone. Our payload will consist of several pre-made parts working in tandem. The initial signal detection will be done by an antenna attached to the exterior of the payload; once this signal has been received by the antenna it is passed to the transceiver to be parsed and clarified, then pulse modulated by our FPGA. From there the data will be in a legible state, and thus can be stored on our SD card for retrieval. We believe this design should adequately accomplish all the provided goals of the design and should do so while being underbudget.