Hardware Design Requirements

Distributed Fence Vibration Monitor System

Version 1.1

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# Introduction: High-Level Architecture

## Purpose, Intended Audience and Reading Suggestions.

## This document will serve as a reference to how the hardware is connected and configured along with requirements that drive those parameters. The intended audience are those continuing the development of this system and those who are maintaining this system. This document is intended to be read as a set of requirements and primary reference to other documentation, the goal is to describe how the system was designed.

## Operating Environment

The end product is being designed for use in South African game reserves. But these requirements are set for a proof of concept system that will be used in the area of Prescott Arizona, primarily during the ERAU fall and spring semesters by students and faculty for research purposes.

## Assumptions and Dependencies

This document largely assumes that the platform in use has already been determined and is the MKR1310. These requirements assume that this is a research project that will be used by ERAU students and faculty. Because this system will be deployed for relatively small scale research, it is assumed that all components in the system will be easily accessible for maintenance and repairs.

## Product Scope & Constraints

Diagram

Description automatically generated

Figure - Implementation Specific High-Level Hardware Diagram

# Hardware Features

## Individual Nodes Hardware

|  |  |  |
| --- | --- | --- |
| MKR1310 Device | Minimum Value | Preferred Value |
| Power Connectors | On-board battery connector (mini-JST) | USB, JST, terminal or barrel |
| Accelerometer Compatibility | ADXL345 | ADXL345, ADXL355 |
| Wireless Capability | LoRa | LoRa |
| Headers | Optional | 10 for test, 30 I/O |
| Mode Switches | Mode switch | Yes (DIP switch, various) |
| Programmability | Micro-USB | Micro-USB |
| Debug Interfaces | Optional | Serial/UART or JTAG |
| Mounting Options | PCB mounting holes | PCB mounting holes, protective case |

## Central Server Hardware

The central receiver is physically similar to one of the nodes, but does not need the sensor capabilities, as the central receiver is loaded with a unique program to differentiate it from the nodes.

|  |  |  |
| --- | --- | --- |
| MKR1310 Device | Minimum Value | Preferred Value |
| Wireless Capability | LoRa | LoRa |
| Mode Switches | None | Mode Switch |
| Programmability & Interfacing | Micro-USB | Micro-USB |

# Physical & Mechanical Requirement Specifications

1. The device shall be inexpensive
   1. Developmental units cost $135 each
   2. First SMD prototype expected to cost ~$40
2. The device shall be self-contained
   1. Any computer, sensors, antenna, battery, and solar are all to be affixed in or on the unit
   2. There is no wired tethering to another device when operating
   3. Should electrical grounding be necessary, the device may simply contact the fence
3. The device shall be weatherproof
   1. The housing of the unit shall be water and dust resistant to IP66 standards
   2. Temperature resistance
   3. UV resistance (don’t melt or discolor)
4. The device shall be easy to install
   1. One person can handle multiple (5-10) units at a time
      1. The casing of the units must be stackable
   2. The units must be easy to transport
      1. **[NTH]** Fit snugly in a rectangular crate
   3. Each unit shall weigh less than 400g
   4. Installation must be repeatable
      1. Attachment to the fence is facilitated by a reusable clip

# Electrical Requirement Specifications

1. The device must accept energy from multiple power sources
   1. Battery management system (BMS): capable of battery, solar, and charging
   2. Solar panel in the range 5-7 V, capable of 512mA
      1. The MKR1310 BMS requires 512mA to charge a battery [1]
      2. 2-4A is recommended for greater efficiency [1]
   3. A Lithium-Polymer (LiPo) battery [2]
      1. Nominal voltage 3.7V-3.8V
      2. At least 1024mAh capacity [2]
      3. The battery must supply at least 150mA when loaded down to 3.3V
      4. The LoRa module may consume 128mA [1], and we need some overhead
      5. Absolute minimum viability: 48 hours
   4. **[NTH]** USB charger capable of 5V ±5% and at least 1000mA DC
2. The device shall decouple from its power supply
   1. A 200uF decoupling cap on 5V rail has been recommended by many to avoid tripping OCP at high transmission strengths
3. The device shall be capable of multiple power modes
   1. Power consumption is measured WRT the 3.3V rail
   2. ULP sleep mode
      1. ~100 µA [2]
   3. Processing mode
      1. 6-30 mA [3]
   4. High power transmitting mode
      1. Up to 128 mA [1] with Power Amplifier Boost

# Hardware Requirement Specifications

1. The device must contain a microcomputer
   1. A flash memory capable of holding the compiled software as described in the SRS document
   2. Processing ability to perform the functions as described in the SRS
      1. With interrupt abilities
      2. With RTC abilities
2. The device must implement an accelerometer or IMU
   1. The maximum sampling rate must be at least 80 Hz
3. The device must implement an RF transceiver
   1. Radio communications shall adhere to local regulations
   2. The radio must implement American (915MHz) and African (868MHz) LoRa frequencies
4. The prototype shall be built upon a useful PCB platform
   1. The PCB must have power and status indicator LEDs
   2. There must be a physical switch to facilitate any changes in modes or configuration
   3. Diagram

      Description automatically generatedThe board must extend and support the MCU SWD interface [4]

Figure - MKR1310 JTAG Interface Pinout

# Acronyms and Abbreviations

The below table contains acronyms and abbreviations used in this document.

|  |  |  |
| --- | --- | --- |
|  | Abbreviation | Description |
| **A** | ADC | Analog to Digital Converter |
|  | ADXL | Analog Devices accelerometer |
|  | AGC | Automatic Gain Control |
| **B** | BER | Bit Error Rate |
|  | BLE | Bluetooth Low Energy |
|  | BMS | Battery Management System |
|  | BW | Bandwidth |
| **C** | CLK | Clock |
|  | CPU | Central Processing Unit |
|  | CRC | Cyclic Redundancy Check |
| **D** | dBm | Decibel Milliwatts |
|  | DAC | Digital to Analog Converter |
|  | DC | Direct Current |
|  | DFM | Distributed Fence Monitor |
|  | DIP | Dual In-line Package |
| **E** | EEPROM | Electrically Erasable Programmable Read-Only Memory |
|  | *EasyEDA* | Schematic capture and circuit board design software |
| **F** | FCC | Federal Communications Commission |
|  | FIFO | First In, First Out |
|  | FSK | Frequency-shift Keying |
|  | *FXOSC* | Frequency of Crystal Oscillator |
| **G** | g | grams |
|  | GPIO | General Purpose Input/Output |
| **H** | HDR | Hardware Design Requirements |
| **I** | I2C, IIC | Inter-Integrated Circuit |
|  | IC | Integrated Circuit |
|  | IO, I/O | Input/Output |
|  | IP | Ingress Protection rating |
|  | IRQ | Interrupt Request |
| **J** | JST | Japan Solderless Terminal |
|  | JTAG | Joint Test Action Group |
| **K** | kHz | Kilohertz |
| **L** | LED | Light Emitting Diode |
|  | LiPo | Lithium Polymer battery |
|  | LNA | Low Noise Amplifier |
|  | LoRa | Long Range low-power wide-area network |
| **M** | mA | milliamperes |
|  | mAh | milliamp Hour |
|  | MCU | Micro Controller |
|  | MHz | Megahertz |
|  | MISO | Main In, Serial Out |
|  | *MKR1310* | An Arduino development platform with LoRa |
|  | MOSI | Main Out, Serial In |
|  | MPU | Motion Processing Unit |
| **N** | NTH | Nice To Have |
| **O** | OCP | Overcurrent Protection |
|  | OOK | On-off keying |
|  | OTA | Over the Air |
| **P** | PA | Power Amplifier |
|  | PCB | Printed Circuit Board |
|  | PLL | Phase-Locked Loop |
|  | PMIC | Power Management Integrated Circuit |
|  | PSU | Power Supply |
| **R** | RAM, SRAM | Random Access Memory |
|  | RF | Radio Frequency |
|  | RSSI | Received Signal Strength Indicator |
|  | RTC | Real Time Clock |
|  | RX | Receive |
| **S** | SF | Spread Factor |
|  | SMD | Surface Mount Device |
|  | SNR | Signal to Noise Ratio |
|  | SPI | Serial Peripheral Interface |
|  | SRS | Software Requirements Specifications |
|  | SW | Synchronization Word |
|  | SWD | Serial Wire Debug |
| **T** | TOA | Time on Air |
|  | TRNG | True Random Number Generator |
|  | TX | Transmit |
| **U** | uA, µA | microamperes |
|  | UART | Universal Asynchronous Receiver-Transmitter |
|  | uF, µF | microfarads |
|  | ULP | Ultra Low Power |
|  | USB | Universal Serial Bus |
|  | UV | Ultraviolet Light |
|  | uW, µW | microwatts |
| **V** | V | Volts |
| **W** | WAN | Wide Area Network |
|  | WDT | Watchdog Timer |
|  | WRT | With Respect To |
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# Revision History

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| --- | --- | --- |
| Date | Revision | Changes |
| 1/26/2023 | 1.0 | First Release |
| 2/9/2023 | 1.1 | Draft |
|  |  |  |

# References

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| --- | --- |
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