Distributed Fence Monitor

User & Developer Guide

In Association with ICARUS

ERP Capstone

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B. Braithwaite - M. Paff- L. Marin

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# Hardware

## Diagram Description automatically generatedHigh Level Architecture

# Printed Circuit Board

## PCB Description & Details

* The PCB is made of 100mm x 100mm x 1.6mm FR4. The solder mask and conformal coating are lead-free. Follow the schematic for resistor and capacitor values when soldering.
* Design rules dictate the track width for power signals. For 1 oz/ft2 copper, a tool was used to estimate that 0.6mm tracks are safe in warm environments even at the maximum current draw of 130mA.
* The PCB has separate inputs for power supplies (6V to 7V, uses VIN pin) and batteries (3.3V to 4.2V, must connect J1 Jumper to JST connector on MKR).
* On V1 of the PCB, certain aspects of the hardware can be toggled using a series of DIP switches. There are many options because the exact sensor and interface was unknown at the time of its design.

Diagram, schematic

Description automatically generated

## Configuration via DIP Switches

Please remove power before making configuration changes.

Block 1:

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| # | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** |
| On | Tie AREF pin to VCC (3.3V) | Connect MPU6050 over I2C. Ensure both 2 and 3 are enabled | | Connect ADXL345 over SPI. Ensure 4, 5, and 6 are all enabled | | | Connect ADXL345 over I2C. Ensure both 7 and 8 are enabled | | Tie MODE (pin 2) to GND. Can allow setting LoRa channel, for example. | Decouples RESET. The board is locked and may not be programmed |
| Off | Allows AREF pin to float | Disconnect MPU6050 I2C interface. Ensure both 2 and 3 are disabled | | Disconnect ADXL345 SPI interface. Ensure 4, 5, and 6 are all disabled | | | Disconnect ADXL345 I2C interface. Ensure both 7 and 8 are disabled | | MODE pin is pulled HIGH, if set in software | Unlock RESET capacitor. Allows board to be programmed |

Block 2:

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| # | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** |
| On | Connect ADXL345 INT1 to pin 7. Ensure pin 3 is off! | Connect ADXL345 INT2 to pin 6. Ensure pin 4 is off!  Note: this is also the LED\_BUILTIN pin | Connect ADXL355 INT1 to pin 7. Ensure pin 1 is off! | Connect ADXL355 INT2 to pin 6. Ensure pin 2 is off!  Note: this is also the LED\_BUILTIN pin | Connect ADXL355 over SPI. Ensure 5, 6, and 7 are all enabled. | | | Battery input connects to voltage divider | An ADC (pin A1) connects to voltage divider | No effect, due to an error |
| Off | ADXL345 INT1 is disconnected | ADXL345 INT2 is disconnected | ADXL355 INT1 is disconnected | ADXL355 INT2 is disconnected | Disconnect ADXL355 SPI interface. Ensure 5, 6, and 7 are all disabled. | | | No reason to have off; draw is minimal | Pin A1 is freed from voltage divider | No effect |

## Mistakes on PCB V1

* There are spots for 2 tactile momentary switches on the board. The switch labeled SW2 will never work because it has no grounding.
* The on-PCB status LED cannot turn on because it depends on switch 10 being on, which, due to a ground-island routing error, has no grounding. You can just use the built-in LED on the MKR board; they are the same pin.
* The top layer of the PCB has no solid copper zone. It looks bad, and this could’ve fixed the previous issue.

## Potential Improvements for V2

* Reduce side length from 100mm to 75mm
* Use SMD resistors, capacitors, momentary buttons, and LEDs
* Add a ground-plane strip for clipping oscilloscope probes
* Add a temperature sensor
* Add the proper type of JST battery connector
* Add a power supply capacitor
* Add a reset button (the little one on the board can be hard to see)
* The reset-decoupling capacitor is unnecessary. Unlike other Arduino boards, the MKR series has one built in
* Find a way to connect the battery more easily to both the board and the voltage divider to measure it
* Use different pins for interrupt to not conflict with the built-in LED

Diagram, engineering drawing

Description automatically generatedWe mostly finished designing this PCB, but there was no time to order before symposium. EasyEDA files including the BOM should be included in the deliverables package.

# Software

## How to set up Environment

* Install Arduino IDE 2.0
* Within Arduino IDE 2.0, get Arduino SAMD boards Core (required driver)

Text

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* Install git
* Install Visual Studio Code
* Within VS Code, get the PlatformIO extension
* Within VS Code, get the GitHub extension
* Clone the repo
* Open the project folder in VS Code and PIO will automatically get dependencies (give it a minute)
* Select the environment (node, central) on the lower ribbon



## Basic Node Configuration

We strive to keep every useful value you might want to configure visible and highly adjustable. Below is a copy of the configuration features from the repository README:

|  |  |
| --- | --- |
| System   * Node Identifier * Peripheral Connection Reattempts (default: 5) * Debug Interface on/off (default: on) * Debug Interface Speed (default: 115200) * Debug Interface Timeout (default: 10 sec) * ADC Bit Depth (default: 10, max: 12)   Motion Sensing   * Sample Rate (default: 100 Hz, max: 400 Hz) * Sensitivity (default: 2g) * Activity Threshold (default: 00007, min: 00002) * Inactive Timer (default: 0.8 sec, min: 0.8) * Severity Thresholds * Resolution (default: 10 bit @ 256 LSB/g)   Timing   * Reporting Interval (default: 15 sec, min: 5) * Maximum Readings to Take (default: 2x) * Sampling Duration (default: 500 samples, max: 2000) * Data Timeout (default: 50 ms)   Calibration   * Calibration Interval (default: 15 minutes, min: 1, max: 15) * Calibration Duration (default: 300 samples) * Calibration Time Slice (default: 0.5 sec, min: 0.5, max: 2.0) * Low-Pass Filter * Cutoff Frequency (default: 8 Hz) * Impulse Response Length (default: 16) | PCB Wiring Configuration   * Pinout * Mode pin (default: 2) * Status pin (default: 6) * Error pin (default: 3) * Battery pin (default: A1) * Switch pin (default: A5) * CS pin for ADXL1 (default: A3) * CS pin for ADXL2 (default: A4) * Interrupts pin (default: 7) * Temperature pin (default: 4) * Resistor Voltage Divider Values (default: 680k/330k)   LoRa Configuration   * Transmission Frequencies (default: 914.9 MHz) * Transmission Power (default: 4dB, min: 2, max: 17) * Acknowledgement Timeout (default: 1 sec) * Reject CRC Failures (default: false) * Bandwidth (default: 125kHz, max: 250kHz) * Spreadfactor (default: 7, min: 7, max: 12) * Syncword (default: 0012) |

## Severity Levels

Severity levels are spaced logarithmically between the minimum power to wake the node and the max power for the sensor, 0 being nothing and 15 being max severity. Each severity level requires around 50% more power than the previous level.

Chart, scatter chart

Description automatically generated

Figure 1: A test where an intruder climbed the fence in between the two nodes.

Chart, scatter chart

Description automatically generated

Figure 2: A test where an intruder climbed the fence directly on a node

# Appendix

Link to repository

Qr code

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