Methods

Sawaiz Syed

March 13, 2014

1 Methods

The construction of this sensor will follow a hardware driven methodology as cost is the major factor in determination of components and functionality. Everything will be built in a modular fashion to make expansions and future development simple. The components will be designed in sections talking in power and signals, or outputting data.

1.1 Hardware

The general build of the hardware will consist of a microcontroller, the acting processor, executing code based on inputs and outputs attached. There will be sensor attached to multiple pins including temperature, humidity, light, and location sensors. The high voltage power supply tuned to hold the a Geiger tube at its operating voltage. A sector for collecting and storing power, and finally a wireless transmitter.

Microcontroller The selection of the microcontroller is the factor the rest of the project will be constructed around. The prototypes were initially made from the ATtiny13A made by Atmel. It is a eight pin device in package sizes down to $3mm \times 3mm$. It was chosen for its low cost, and personal experience with the Atmel's offerings. As pins ran out and additional functionality was needed, an upgrade to ATtiny24 was in order, it provided six additional sensor and communication pins. The programming is done though C and/or Avr assembly, a lower level interface for faster operations.

The receiver is mainly being designed for testing, and will be made in the Arduino (a popular prototyping platform based on Atmel microcontrolers) and programmed in C++ for quicker prototyping.

Wireless The wireless system will consist of a transmitter on the sensing device communicating at either 433 MHz or 915 MHz as those are the legal ISM (Industrial, Scientific, Manufacturing) frequencies in most of the world. Another option would be the 2.4GHz band, but with a lower penetration and a more congested frequency it is a worse option, the lower frequencies have enough bandwidth. These bands are FCC compliant to keep certification simple, and the transmitter will be using a trace antenna, one that resides only on the circuit board, to keep costs low.

Sensors The main requirement of the device is to sense radioactive particles, so a Geiger Müller tube will be used, the SBM-20 shown in Figure 1, a Russian tube designed for detecting Hard Beta, and Gama rays. With a manageable recommended voltage of 400 V, pulse life of 2×10^{10}, and ease of availability, makes it a great choice [1]. Other sensors such as a temperature, humidity, and light will be added to provide ambient information. GPS sensors will be designed as an expansion module for devices that are expected to have changed position after installation, such as those on rail.

Figure 1: SBM-20 Geiger Muller Tubes [1]

Power Power to the unit will be provided through a lithium ion 3.7V (nominal) battery such as those common in consumer electronics. Its safety will be manged by a charging and protection chip which will be able to monitor current draw, and provide recharging power through a solar panel attached outside the enclosure. The high voltage supply will be a simple boost converter (a circuit that uses the voltage rise in inductors to generate higher voltages) tuned to the 400V required for the Geiger tube.

Casing Enclosure design will be based around PVC pipe for lower volume and injection molded ABS for higher volumes. The pipe is conducive to the long components that take the majority of the volume of the design. The Tube, and the battery will stack vertically with PCB (printed circuit board layers) in the middle very similar to Cordwood construction ,exampled in Figure 2, previously used in missile and telemetry systems where space was at a premium. These layers will be connected with long strips of PCB material connecting them top provide rigidity and structure and act as power lines. The ABS design will be based on ease of mounting and identification of the modules.

Figure 2: A circuit built with stacked PCB [2]

1.2 Software

Software will be programed in AVR C for the transmitter and C++ and Java for the receiver for quicker prototyping. Code flow with be dependent on incoming pulses form the radiation detector. Upon receiving the microcontroller will cycle through it's duties shown in Figure 3 before returning to sleep(the low power mode).

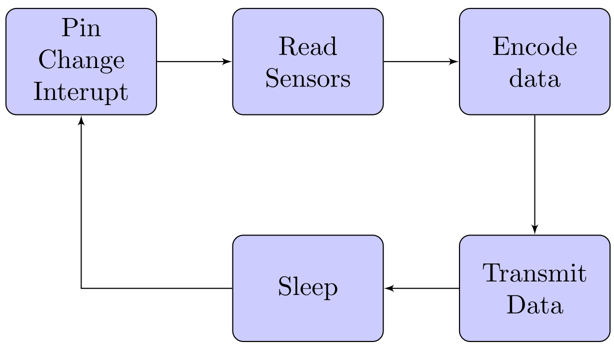

Figure 3: Software Structure

Encoding The receivers auto gain control adjusts to ambient noise level. This means the gain must be reduced before the first byte can be transmitted. There is a pulse train of square waves one unit width in timing that are transmitted before any messages to reduce gain and therefore interference. Then a synchronization pulse is sent so the receiver knows where to begin timing. The data is sent in a Manchester encoding style as recommended in RF Monolithic guide [3]. This forces the output pin to not remain in one state for too long causing the gain to not fluctuate as much as it might otherwise by sending the inverse of the previous bit for one unit, see Figure 4 as reference. The encoded data to send will include ID of the unit (set at install), the readings from the sensors, and calculated parity bits to verify data on the receiving end.

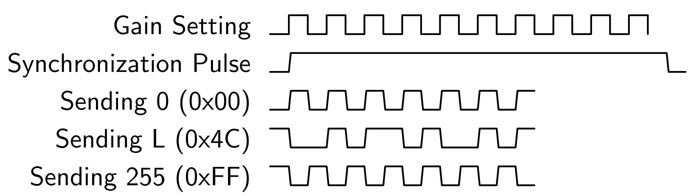

Figure 4: Timing Tables of transmitting pulses

1.3 Testing

The devices will be range tested at distances of up to 100m for both data integrity, and verification that the majority of pulses that occur are received. With the solar panel, discharge rate and recharging time will be addressed to verify that device will remain operable over its lifespan.

1.4 Production

Designing for production requires more forethought than when building a one off system.

Scaling The quantity is the major determinate in at what cost you can build your devices. Component selection is important as slight cost increases trickle to larger costs. The cost assembly and shipping become major expenditures as with smaller runs, the designer does assembly and shipping is consider to be nominal as it only occurs once. Another important aspect during scaling is to consider time required between each step, different fabrication facilities have varying fulfillment times.

Documentation Documenting work for future development will be done though a document that explains the use and modifications required for it to fit the purpose. The hardware will have 3D models created for it during development and those will provide diagrams and animations for documentation.

References

[1] Anton Bodunova-Skvortsova. Parameters and characteristics SBM-20.

[2] Arnold Reinhold. Cordwood Circuit, 2006.

[3] RFMonolithics. ASH Transceiver Software Designers Guide. 2002.