

Low Power Event Detection on Microcontrollers

1. Background and Motivation

- Remote embedded sensing systems traditionally consume too much energy for continuous, long-term deployment.
- Energy harvesting provides power in the micro- to milliwatts.
- Battery-less solution requires low-power event detection.
- We must navigate trade-off between power consumption and quality

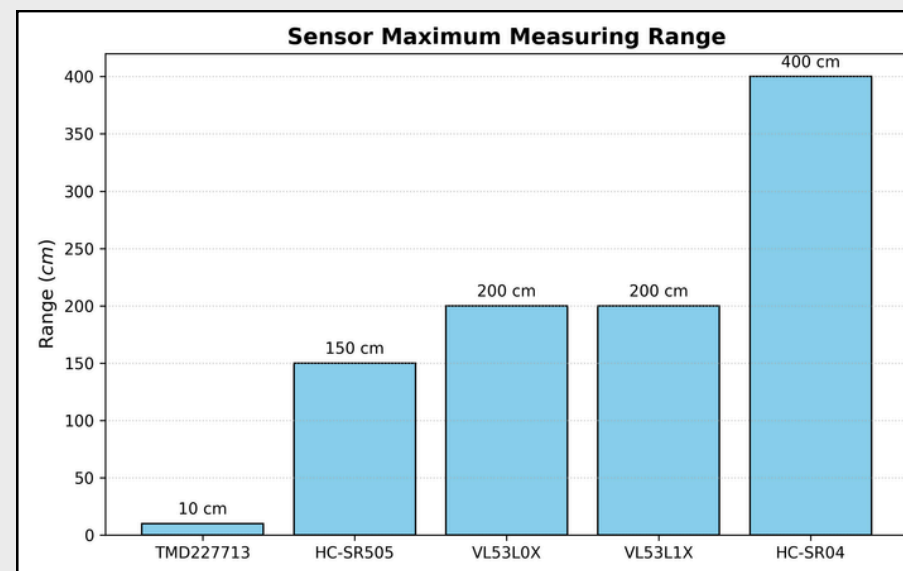
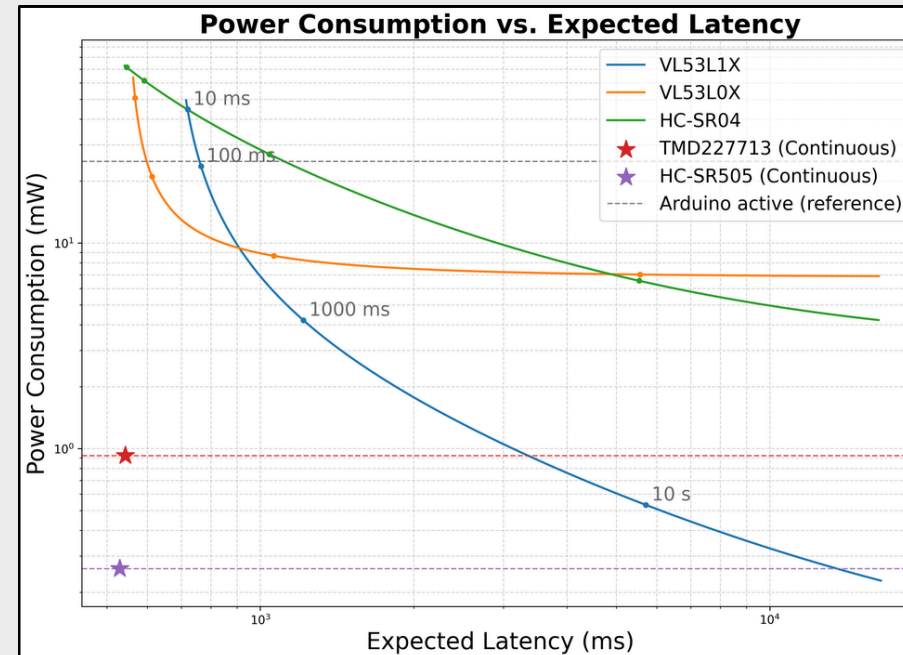
2. Research goals

- Evaluate five sensors with various modalities on power consumption, range, and latency:
 - PIR motion sensor (HC-SR505)
 - ToF distance sensors (VL53LxX)
 - Ultrasonic sensor (HC-SR04)
 - Proximity sensor (TMD227713)
- Design and evaluate multi-stage hierarchical event detection pipeline consisting of two sensors.
- Demonstrate reduced overhead for battery-free system

3. Methodology

- Configure sensor to minimize power
- Program microcontroller to sleep and wake up by sensor interrupt
- Power profiler measures power consumption and timing information.
- Digital signal lines show points of interest:
 - Wake-up trigger by sensor
 - Host ready signal
- Measure max distance range in identical conditions

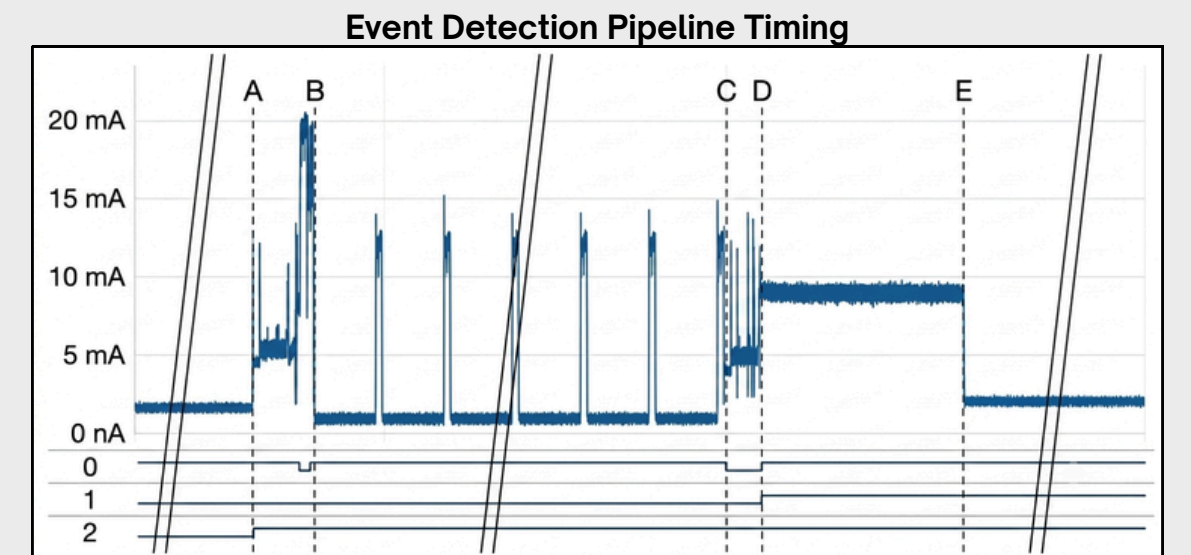
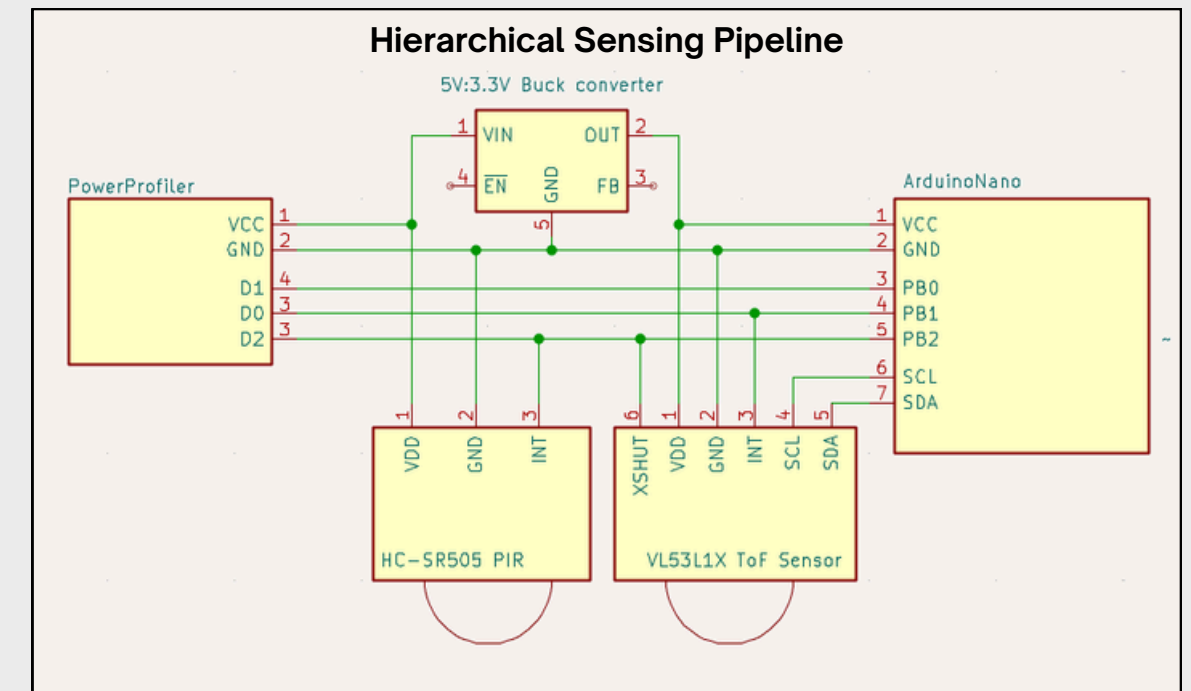
4. Results



Based on these results, a pipeline was created consisting of two stages.

- Stage A: The HC-SR505 PIR sensor continuously makes a coarse first measurement
- Stage B: VL53L1X makes precise measurements while motion is being detected by Stage A

When Stage B detects a valid event, the MCU is woken up to handle the event.



PIR motion sensing until event detected at A, A-B MCU configures ToF. ToF ranging between B-C. MCU woken up to handle event in D-E. Return to stage A after E.

5. Conclusion

The pipeline effectively saved power compared to an always on microcontroller, and the high power ToF sensor alone, only using it when an object is present, signified by the PIR motion sensor. The results could be greatly improved by higher quality sensor selection, and improving the hardware overhead imposed by the 5V to 3.3V power conversion required by the PIR motion sensor.