

Climber Communication System



Caroline Dworken and Elaina Huber

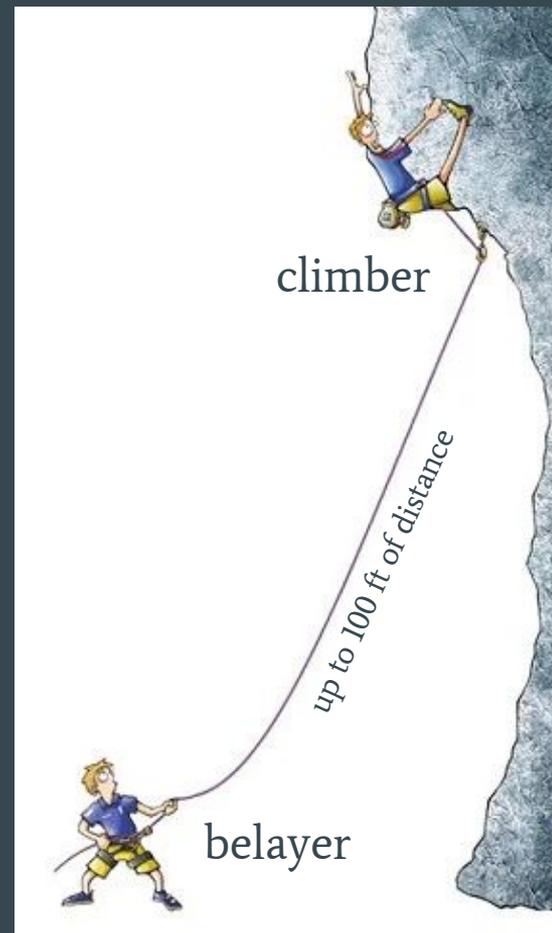
Overview

Communication between climber and belayer can be difficult due to environmental factors, and miscommunication can lead to injury or even death.

Our solutions: A wearable, wireless communication system that enhances safety through real-time monitoring and alerts.

Key Features:

- Wireless communication
- Automatic fall detection and alerts
- Real-time monitoring
- Hands-free and quick operation



Description

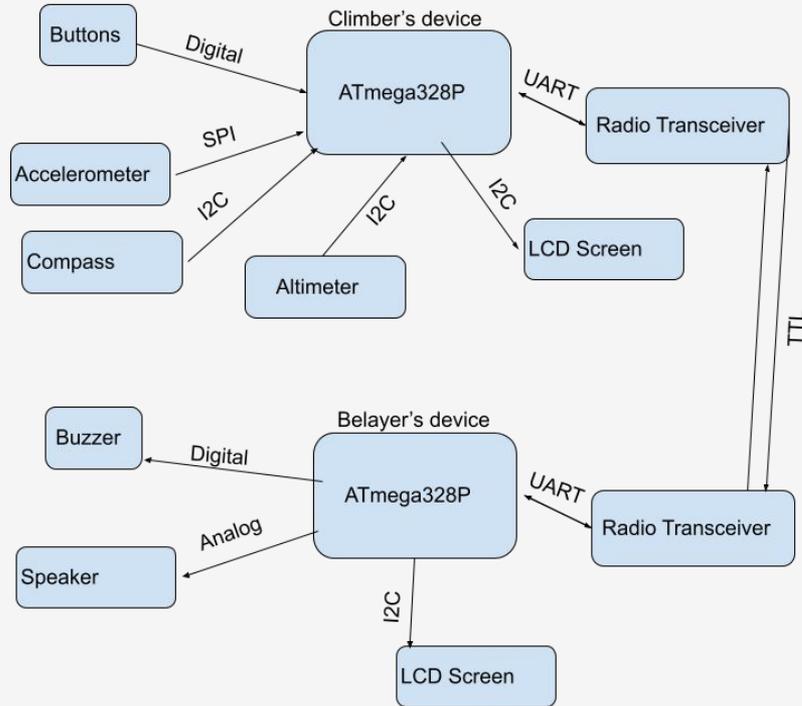
The Climber Communication System consists of two complementary devices meant to be worn on a standard climbing harness.

The climber's device will collect data and allow the climber to quickly communicate standard messages with the press of a button.

The belayer's device will present information about the climber's progress and any messages received.

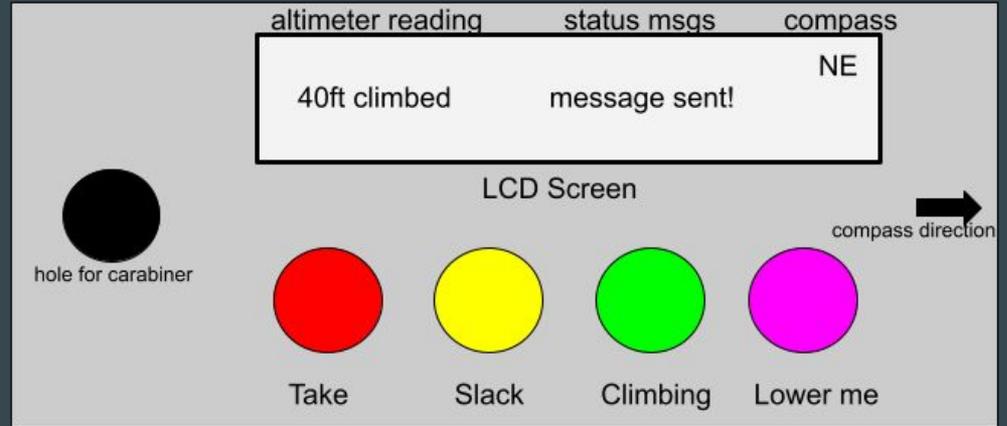


System Block Diagram

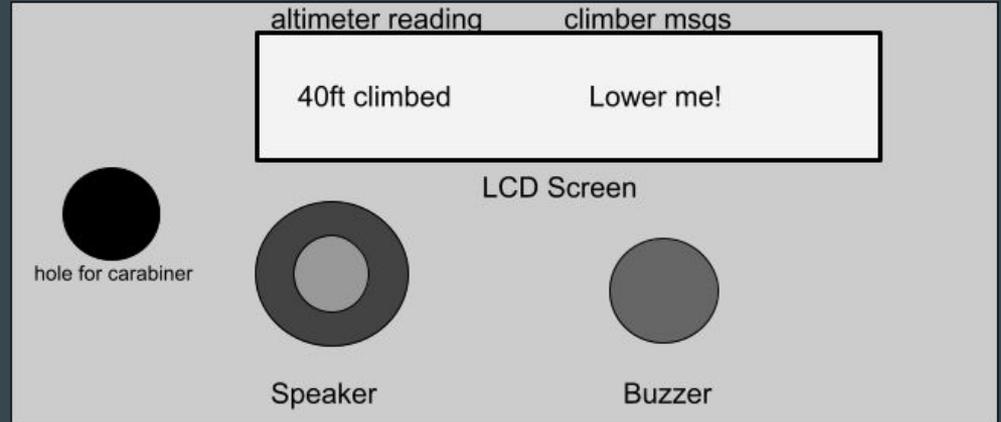


Device Mockups

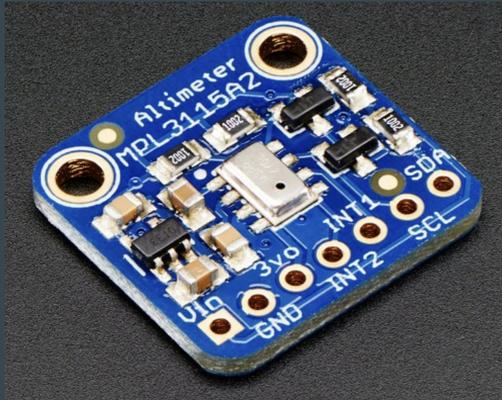
Climber's device



Belayer's device

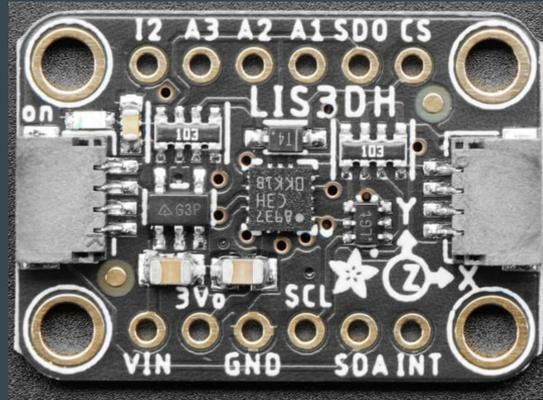


Sensors - Climber's Device



Altimeter (MPL3115A2): Measures climber's vertical ascent, to be displayed on LCD screens.

Uses I2C to communicate with microcontroller, has low-power interrupt mode, and precision to 1 ft.



Accelerometer (LIS3DH): Tracks movement and fall detection of climber, to be communicated to belayer.

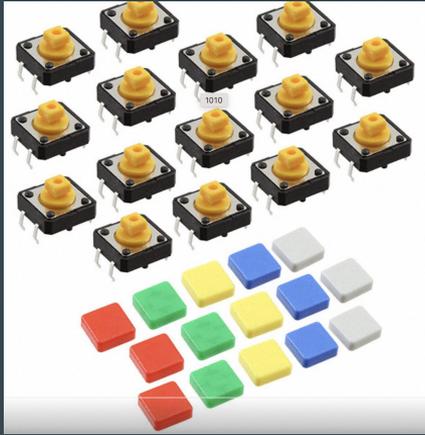
Uses I2C or SPI, has movement and freefall interrupts, and configurable precision.



Compass (HMC5883L): Aids navigation and displays on climber's LCD screen.

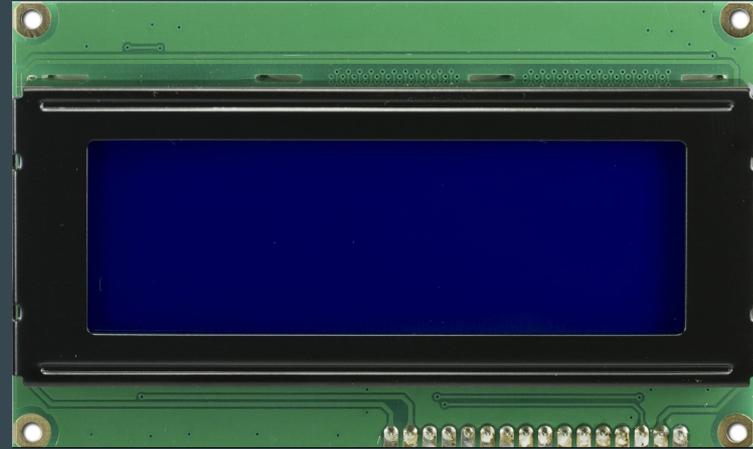
Uses I2C, will be positioned away from other metal elements to avoid interference.

Control - Climber's Device



Buttons (1010): Enables selection of pre-set messages to transmit to belayer.

Different colors allow for easy selection, where the climber need only quickly remove a hand from the wall to send a message.



LCD Screen
(CFAH2004AC-TMI-EW): Displays altitude, compass direction, and status messages.

Uses I2C, will keep climber updated on sensor outputs.

Alert System - Belayer's Device



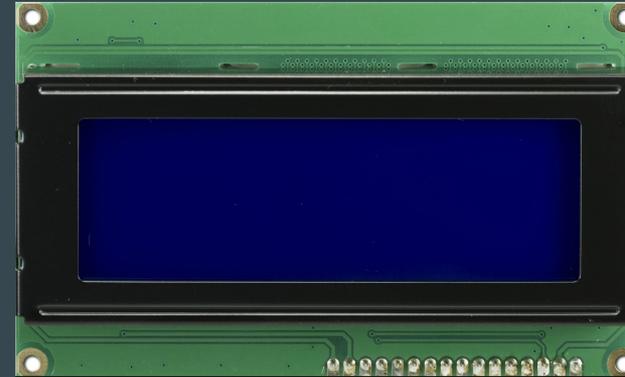
Buzzer (CX-0905C): Alerts the belayer of an incoming message or emergency.

Buzzer will go off once to alert belayer of an incoming message prior to speaker, or go off three times for a fall detected.



Speaker (3968): Provides audio with pre-set messages from climber for distraction-free communication.

Speaker will be sent one of four pre-set messages when the belayer's device receives notification that the climber has pressed one of the buttons.



LCD Screen (CFAH2004AC-TMI-EW): Displays climber altitude and notifications.

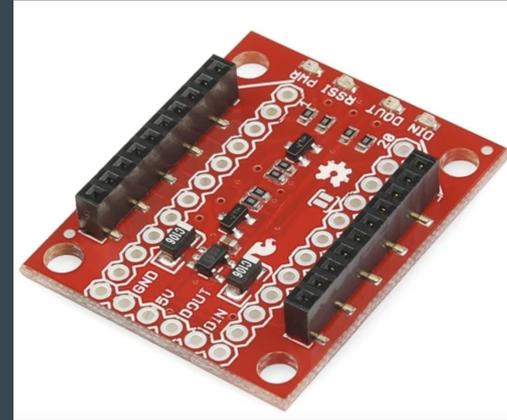
Uses I2C, will keep belayer updated on climber's progress and any messages.

Radio - Both Devices



Radio Transceiver (XBee Pro S1, XBP24-AWI-001): Ensures real-time data exchange between climber and belayer devices.

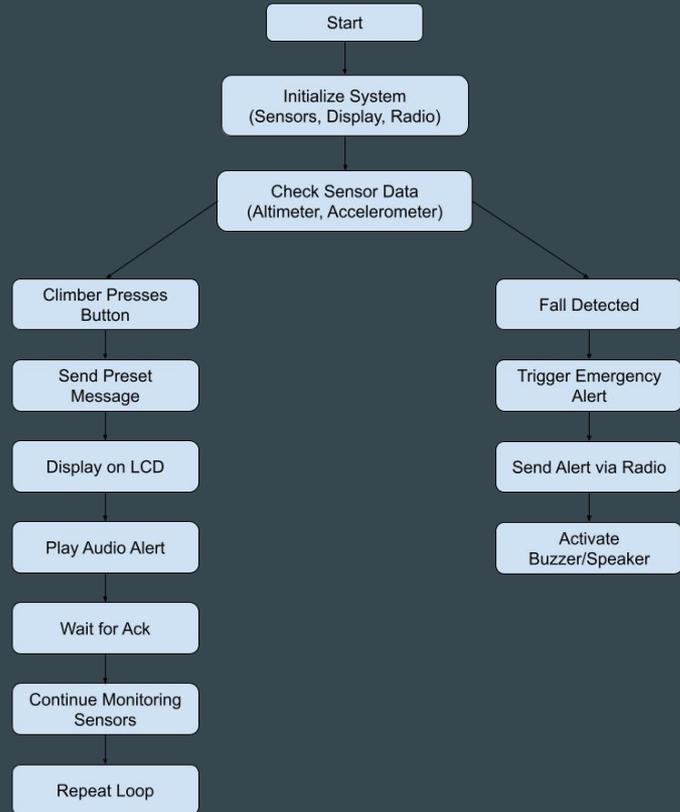
Wire antenna provides greater range.
Automatically connect with each other to send serial TTL data back and forth.



Breakout Board (WRL-11373):
Allows XBee to connect to board easily and breaks out pins.

Software Design - System Operation & Architecture

1. **Initialization** - The system powers on, initializes all sensors and communication modules.
2. **Continuous Monitoring** - Reads altitude and movement and detects falls.
3. **User Messaging** - If a button is pressed, sends a preset message.
4. **Automatic Fall Detection** - If sudden acceleration is detected, it sends an emergency alert to the belayer.
5. **Notifications & Acknowledgement** - Displays Messages on LCD, plays buzzer and audio alerts, and waits for belayer response.
6. **Looping System** - The system continuously runs until the climb is completed.



Software Design - Communication & Interrupt Handling

Interrupts & Event Handling:

- Accelerometer includes programmable interrupts for free-fall and movement detection, both of which will prompt a transmission to the belayer's device.
- Button de-bouncing will allow a seamless interrupt for climber messages.
- Altimeter has low-power mode with interrupts to indicate changes.
- Fall detection takes first priority when multiple interrupts are triggered. Pre-set messages and status updates will be processed after fall notification is complete.

Cost Estimate

Component	Estimated Cost Per unit (\$)	Quantity	Total Cost (\$)
Microcontroller	15	2	30
Altimeter	10	1	10
Accelerometer	8	1	8
Radio Transceiver	40	2	80
LCD Screen	10	2	20
Speaker	5	1	5
Buzzer	2	1	2
Compass	5	1	5
Power Supply (Battery)	10	2	20

Total Cost Estimate: \$180

Costs may vary based on supplier and bulk ordering.

Challenges

Technical Challenges:

- Ensuring reliable wireless communication in remote environments.
- Accurate and fast fall detection.
- Optimizing power consumption for long battery life.

Potential Risks & Mitigation:

- Signal Interference: Using robust communication protocols.
- False Alerts from Accelerometer: Implementing filtering algorithms.
- Battery Depletion: Power-saving strategies and backup alerts.

Future Improvements & Scalability

Possible Enhancements:

- Integration with smartphone apps for logging climb data.
- GPS tracking for remote climbing locations.
- Mesh network for group climbing scenarios.



Summary

The Climber Communication System is a wearable, wireless device designed to improve safety and communication between climbers and belayers.

It integrates sensor-based monitoring, real-time alerts, and quick messaging to overcome traditional communication challenges in climbing environments.

Works Cited

https://www.ukclimbing.com/articles/skills/dynamic_belaying_for_sport_climbs-1844

<https://nextadventure.net/blogs/blog/buying-climbing-harness-guide>

<https://www.istockphoto.com/photos/rock-climbing-group>

https://internal.rockymountainrescue.org/publications/2012_RMRC_Boulder_Eldo_Rock_Climb_Accidents.pdf