Junior Design Final Project

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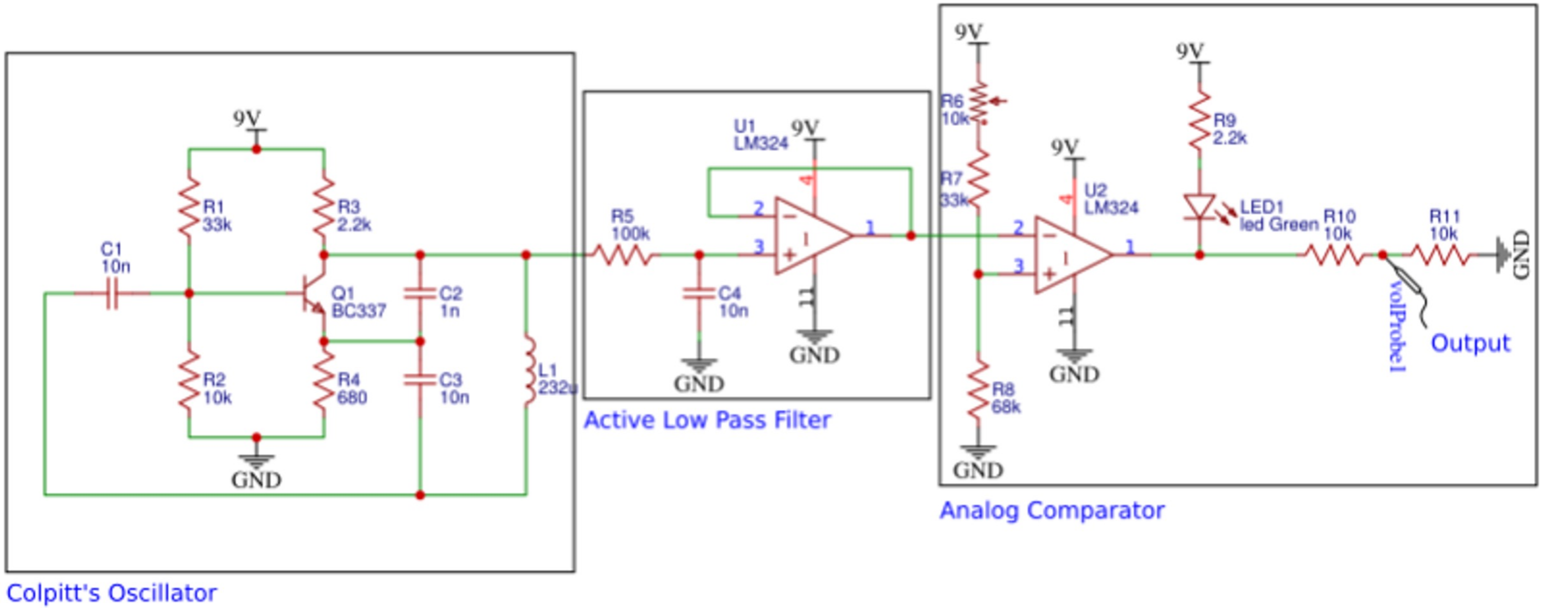
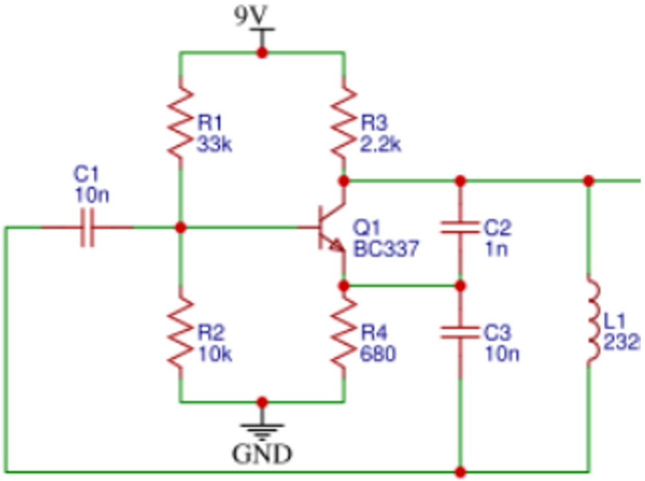
Circuit Design



Circuit Design Constraints

- The circuit should output a DC voltage that represents a logical 0 or 1 on the Papilio board (less than 1.3 V = low, between 1.3 V and 5 V = high)
- The output should go high when metal is close, but should be low otherwise
- It should be consistent and should avoid false positives at all costs
- It should also be sensitive enough to detect metal anywhere underneath the inductor

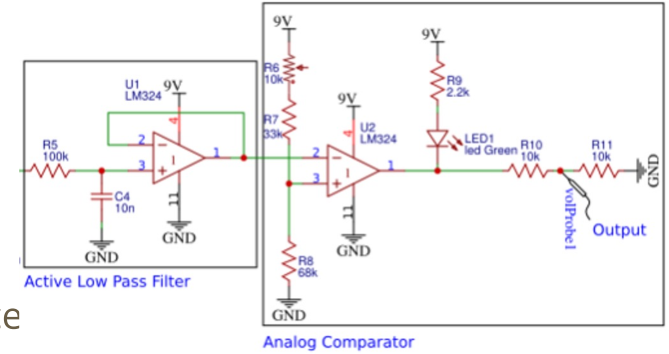
Metal Detection



- Colpitts Oscillator: A LC oscillator circuit that outputs a semi-sinusoidal signal
- If metal is **not** present: the oscillator outputs a sinusoidal voltage with **Amplitude**: 2.82 V | **Frequency** = 334 kHz | **DC RMS Voltage** = 5.4 V
- If metal is present: the oscillator outputs a sinusoidal voltage with **Amplitude**: 2.78 V | **Frequency** = 336 kHz | **DC RMS Voltage** = 5.37 V

Active LPF & Analog Comparator

- LPF used to filter out all frequencies
  - Circuit operating in kHz range so the filter has a frequency cap of about 1kHz
  - Eliminates all sinusoidal components
  - Active over passive so we keep the gain
- Analog Comparator
  - Papillio pin is active high
    - 3.7 V with metal, .3 V without
  - LED is on except when metal is near
  - Normally output of filter is higher than the reference
  - Metal decreases overall voltage at filter output
  - + end of op amp higher so the output voltage is high

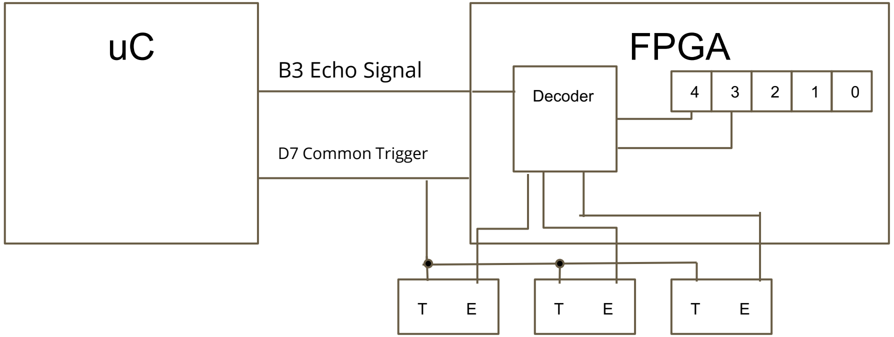


IR Remote and Receiver

- Infrared remote control used to start and stop the rover
  - Implemented using a combination of pin change interrupts and polling on the Atmega
  - The Interrupt Service Routine sets a global variable for button presses high and disables itself when IR pin is pulled low
  - An idle state function keeps the rover stationary while the button press variable is high and exits when the IR pin is pulled low from the receiver using polling
  - When a second button press occurs, the global variable for button press is set low, pin change interrupts are re-enabled on the IR pin so the ISR can be used again

Ultrasonic Sensors and PWM

- Shift register to serially transmit values from uC to FPGA
  - Select signals for ultrasonic sensor echo decoder
  - Select signals for motor outputs decoder
- Use of matches OC0A OC0B for individual motor PWM
- Simple functions to set appropriate movement
  - moveForward() //sets select signals for forward movement and shifts to FPGA
- Simple functions to set and read ultrasonic sensors
  - uint_8t left_US() //returns 0-256 representation of distance detected



Encoders and Metal-Detector Count

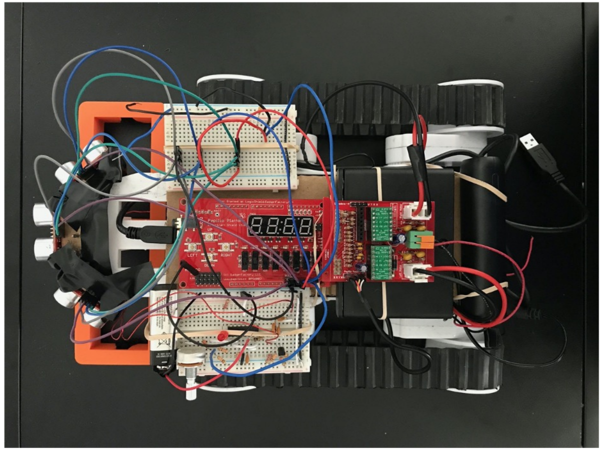
- Seven Segment Display shows status of rover
    - Leftmost byte displays distance travelled in feet
    - Third anode displays number of mines found
- FPGA Implementation
    - Use up-counters to keep track of increasing values
    - Use a pair of XORed encoders
    - Divider process on encoder signal to count every foot

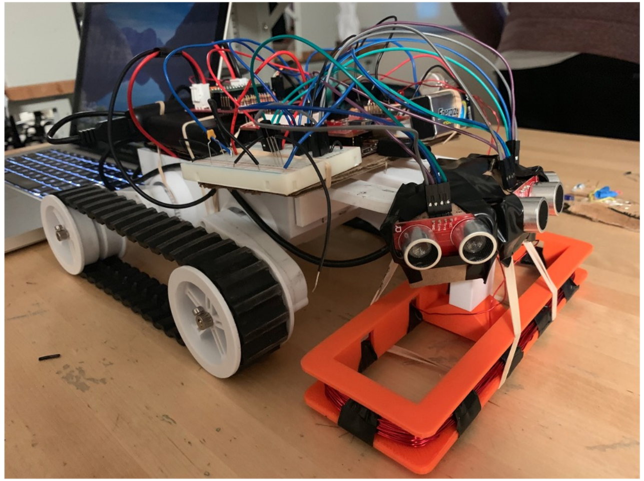
Driving Algorithm

- Our algorithm consisted of a two stage process
- Stages are changed based on the number of encoder ticks counted
- First stage: line following
  - Our first stage was a line following algorithm that would alternate between right and left bias approximately every 16 feet.
  - Our idea was to try to cover as much perimeter area as possible and reach all four corners.
- Second stage: randomized turns (“Panic Mode”)
  - At approximately 90 feet, our algorithm begins to cover the center part of the course
  - “Randomized” turns were implemented and the rover would turn randomly when any of the three sensors detected an obstacle or wall
  - This allows the rover to take random paths across the middle of the course to detect mines

Implementation

- Rover Layout





Design Results

- Our team successfully detected 4 mines and traveled a distance greater than the required 6 feet
- IR capability was successfully implemented
- Our two stage algorithm helped us detect mines close to the perimeter as well as in the center
- The detection of two mines near the center of the course was accomplished because of the second stage of our algorithm we call “panic mode”