Abstract

The purpose of this project is to design, build, and test an autonomous mobile robot, which travels on railroad tracks, and will identify bolt loosening or separation at a joint plate which connects two rail segment components of a railroad track. Early identification of rail separation can prevent a number of dangerous and potentially catastrophic events including train derailment. Until now, that process required significant man power and time as well as high costs.

Plexiglas (acrylic) was used to construct the robot base which supports instruments and circuits to detect bolt loosening circuits. IR technology and computer programming in PBASIC were used to localize and record the location of the defects, using a specially built rail system, the autonomous robot is able to accurately identify bolt loosening.

Bench-tests have shown that the robot has a very high accuracy rate. Several measurements were taken including train vibrations and velocity. The data obtained can be transmitted to a central station. Further testing will be necessary to determine the capability of transmission in enclosed spaces and under different environmental conditions.

Introduction

Since the railway was invented, rail maintenance had always been a problem. Cracked or damaged rails could lead to derailments. Visual inspections miss many of the stress defects that occur within the steel matrix.

In the late 1920s, Dr. Elmer Sperry designed a rail inspection car that used magnetic flux leakage detectors and an applied current to find imperfections with in the track. Where the rail could not hold the magnetic flux created by the current, a defect existed. The flux leakage method was later complimented with the ultrasonic method that helps detect flaws deeper into the rail where the former method proved ineffective.

These methods went only as far as checking the rail itself, but in railways all over the world, joint plates are still needed to connect long segments of track. Continuously welded rail has eliminated some of these joint plates, but they are still needed to connect the welded pieces together. The joint plates are vulnerable to being loosened by wear, vibration and even by people with malcontent. A solution to solve this would be to use safety wire around the bolts to tie them in place. When safety wiring is done properly, loosening one bolt would tighten another and the only way to entirely loosen the bolt is to remove the wire. If a circuit where the safety wire carries a small current is built, where cutting the wire would mean an infrared transmitter would go off, then a robot containing the detector could search for it and leave a marker, so track crews could check it.

Method

Raw acrylic sheet 1/8” thick was cut into a 10” square, to be used as a top for the rail cart with a bandsaw. Two rectangular strips, 10” long and 3” wide were cut out of the same stock to be used as the sides. A rectangular hole the same size a servo motor was cut into a strip using a 3 axis milling machine. The hole was cut on the extreme end of a strip with respect to the long side and centered with respect to the narrow side. Holes were drilled on the drill press to mount the servo motor. The layout was mirrored on the

second strip. A third strip the same size was made and trimmed to fill up the back of the cart and to prove support. A pair of holes were drilled in the corner of the 10” square to secure the Board of Education. Another hole ¼” in diameter was drilled into the same square to allow wires to pass from the Board of Education to the limit switch and the servo motors. Another pair of holes was drilled for the front wheels. The acrylic parts were then melted together using methylene chloride. Four, 3” wheels were cut from plastic stock, 3/16” thick. Two were mounted on the servos and the remaining two were screwed on the reserved holes.

. The Board of Education was then bolted in and breadboard was double sided taped in. Circuits for the limit switches, servo motors and infrared receivers were built using pre-drawn schematics from Parallax’s user guides. Two 2xAA battery packs were modified and wired in series to give 6V. This was then attached to the 10” square of acrylic using Velcro. The infrared receivers were then taped on the top plate over the sides of the cart in front of the servo motors. The limit switch was then taped to the side plates in front of the servo.

The rails were constructed from 4’ x2” long sections of wooden stock ¼” thick. These was then laminated to 4’ x 1.75” x 1/4” pieces of wood. One foot of rail from each was cut off. Joint plates, 1’x 2” x1/4” were again cut from plywood. The rails and the joint plates were then drilled for 3/8” bolts. The bolts were then drilled across the head for safety wire. Using washers as spacers, the track was bolted together. The two joined rails were tied using a dozen 1.75’ x 2” x .25” pieces of wood that were notched ¼” deep, 2” from the sides that were 2” wide. Electrical wire acted as safety wire.

Infrared transmitter schematics were researched online. They were replicated onto breadboard and tested, at first using a digital camera, which the CCD sensor inside can pick up infrared, and later with the actual infrared sensors. The circuit was then wired to the safety wire as a joint between the battery pack of the transmitter and the actual circuit.

Code was then written in the Parallax Basic Stamp compiler, so that when the cart is rolling on the track and the limit switch is activated by the joint plate, the receivers will search for any signal and register the position if a signal is not found.

Data

Key	
Signal	1
No Signal	0

	Wire Intact (robot moving at steady pace)									
	1	2	3	4	5	6	7	8	9	10
Signal	1	1	1	1	1	1	1	1	1	1

	Wire Cut (Robot moving at a steady pace)									
	1	2	3	4	5	6	7	8	9	10
Signal	0	0	0	0	0	0	0	0	0	0

	Wire Intact (Robot moving at a pulsout of (500,1000) while rail is vibrating)									
	1	2	3	4	5	6	7	8	9	10
Signal	1	1	1	1	1	1	1	0	1	0

	Wire Intact (Robot moving at a pulsout of (740, 780) while rail is vibrating)									
	1	2	3	4	5	6	7	8	9	10
Signal	1	1	1	1	1	1	0	1	1	1

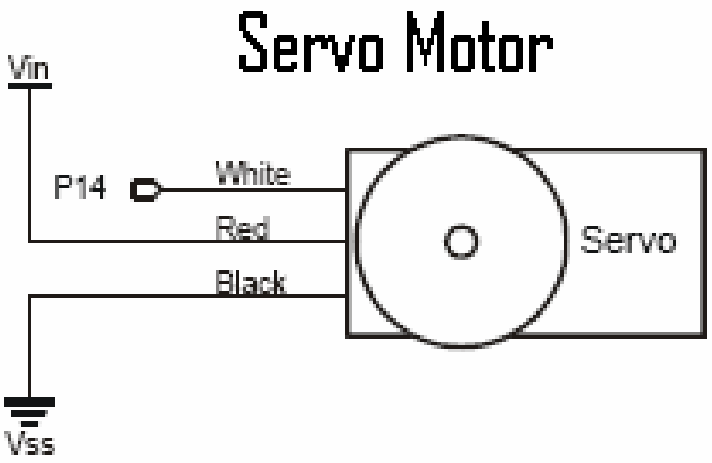
	Wire Intact (Rail and transmitter vibrating)-Robot moving at a pulsout of (500, 1000)									
	1	2	3	4	5	6	7	8	9	10
Signal	1	1	1	1	1	1	1	1	1	1

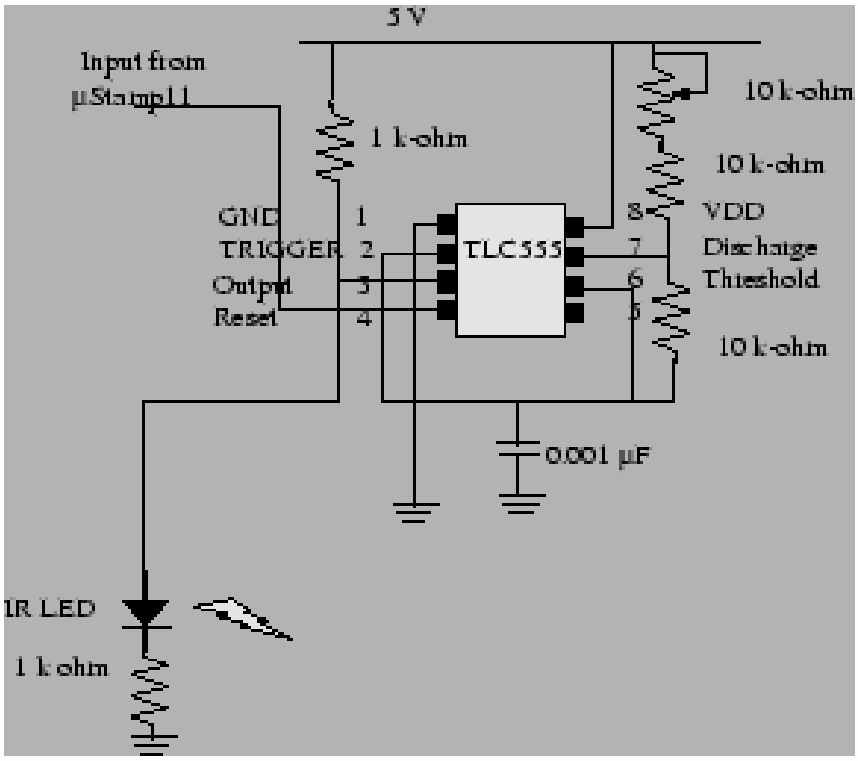
	Wire Intact (Rail and transmitter vibrating)-Robot moving at a pulsout of (740, 780)									
	1	2	3	4	5	6	7	8	9	10
Signal	1	1	1	1	1	1	1	1	1	1

Conclusion

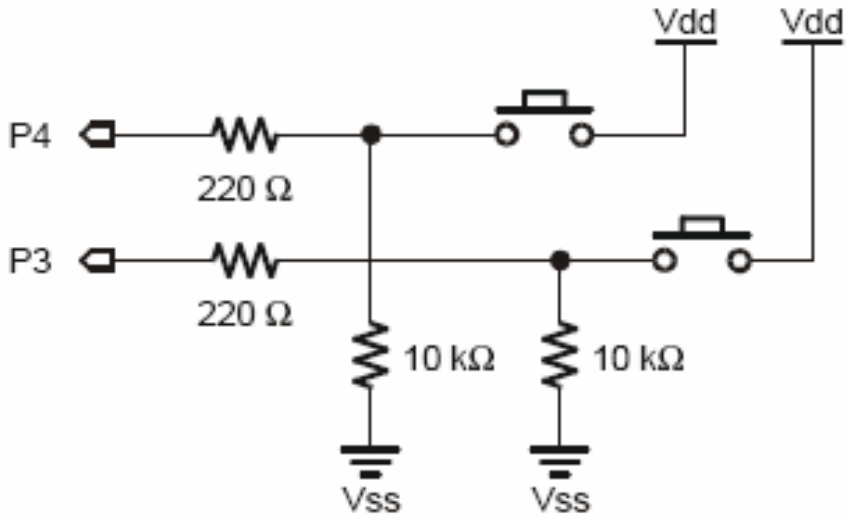
- The robot has a high accuracy rate, whether it was traveling rapidly or slowly.
- The IR transistor manual circuit successfully sent a signal to the passing robot.
- Limit switch proved to help us in recording the data accurately, and saved energy along away.
- 555 timers worked well, in the breadboard substitute that we used for the IR transmitter.
- Intact

Schematics

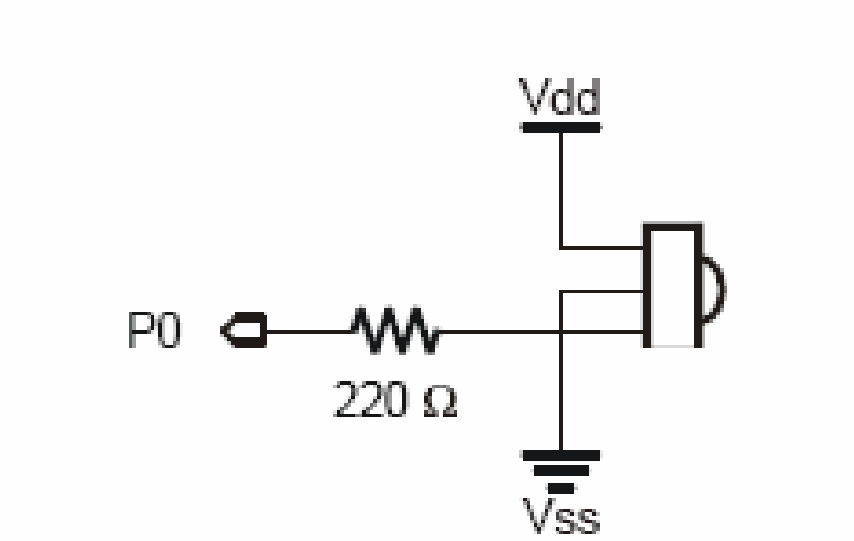




IR Transmitter



Double Pushbutton-Limit Switch



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Computer Programming

```
' {$STAMP BS2}
' {$PBASIC 2.5}

x VAR Word
decide VAR Bit


decide = 0

FOR x=1 TO 200
  PULSOUT 15,745
  PULSOUT 12,785
  PAUSE 20

  IF (IN9=1) THEN
    GOSUB check
  ENDIF

NEXT

GOSUB results

END



check:
  DO WHILE (IN9=1)
    PULSOUT 15, 745
    PULSOUT 12, 785
    PAUSE 20

    IF (IN11=0) THEN
      decide = 1
    ENDIF
  LOOP
RETURN
```

```
results:
  IF (decide=0) then
    DEBUG “The wire is cut.  BAD!”
  ELSE
    DEBUG “Rail GOOD!  Fire Ba-a-a-ad!!!”
  ENDIF
RETURN
```