

The Smart Road

**A Mechatronics
Demonstration
Project**

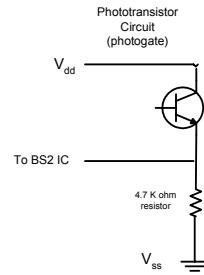
By Clay Davis

and

Richard Balsamel

This work was supported by the National Science Foundation under an RET Site Grant 0227479

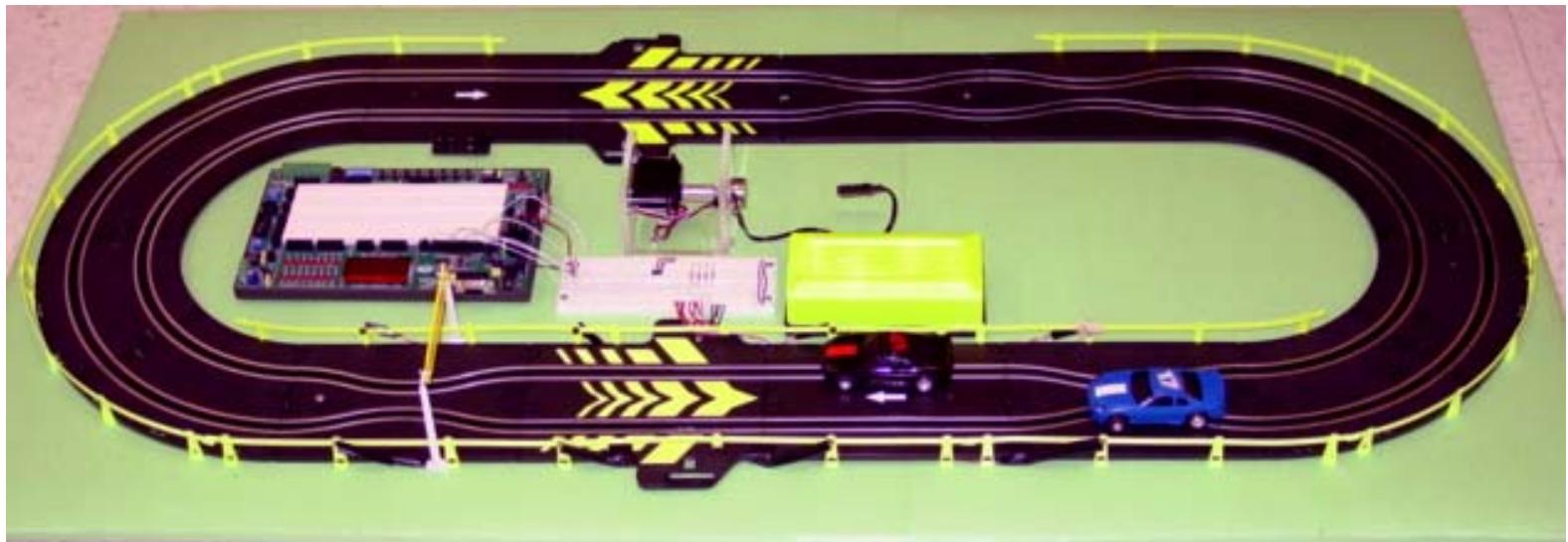
Mechatronics is an integration of mechanical engineering, electrical engineering, control theory, and computer engineering.



This Project shows an application of mechatronic principles to analysis and control of cars on roadway

Design

This project is designed to demonstrate some of the principles of mechatronics by of modifying slot car track to allow the Basic Stamp 2 IC to measure and control the speed of the car.



**Motion
INVOLVES:**

Displacement

Time

Velocity

Acceleration

Average speed = displacement /time or $v = d / t$

Acceleration = Δ velocity/ Δ time or $a = \Delta v / \Delta t$

$$D = v_o t + 1/2 a t^2$$

Components

The parts used include IR LEDs, phototransistors, a rotary potentiometer, a servo motor, and resistors and the Board of Education.



IR LED



Phototransistor



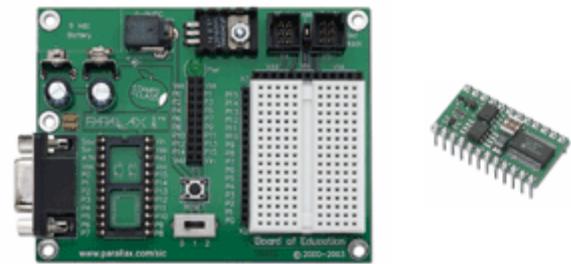
Rotary Potentiometer



Servo Motor



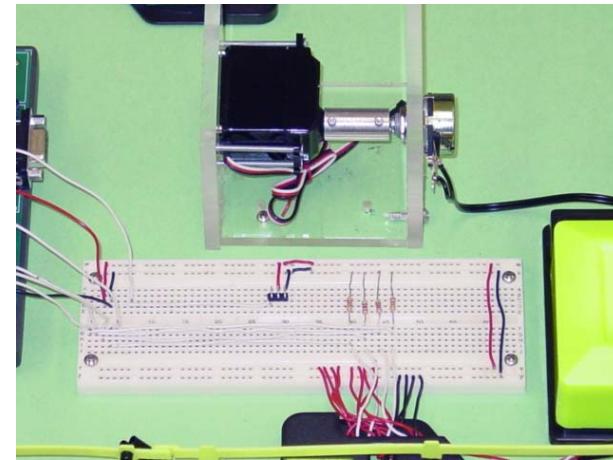
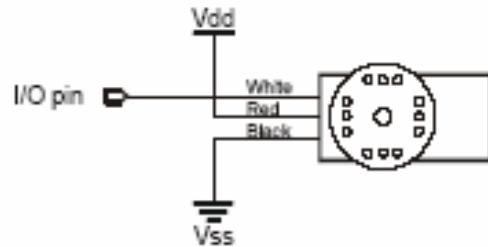
Resistor



Board of Education and BS2 IC

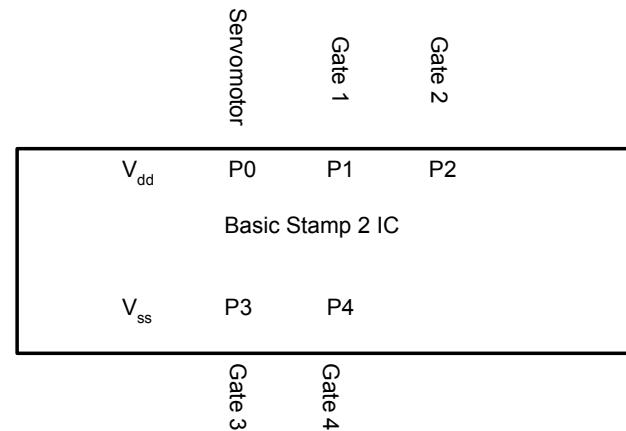
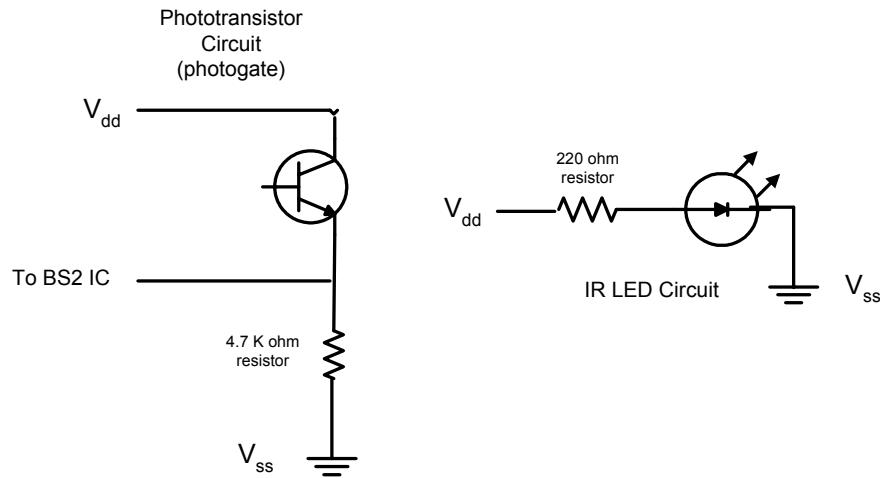
Servo Motor

A servo motor was connected to the shaft of a rotatory potentiometer and the BS2 IC. The **PULSOUT** command was then used to adjust the position of the potentiometer and the car's speed.



Electric Circuit Schematics

Four photogates were constructed using IR LED's and phototransistors. The photogates were then connected to the BS2 IC as inputs and the servo motor was controlled using a BS2 IC pin as an output.



Program Logic

Using PBasic commands and routines, the car's motion through the photogates was detected and timed. The velocity was then calculated and displayed. The data was also sent to a subroutine that compared the speed of the car to a selected speed limit. If the speed was above the limit the servo motor then changed the position of the potentiometer to lower the speed.

```
Start:          ' Check Gate 1 for car
LOOP :
Gate1:
Detect1 = IN5
IF Detect1 = 0 THEN Count1    'WAITS FOR CAR TO ENTER GATE 1
PAUSE 20
GOTO LOOP
Timing loop
COUNT1:          ' TIME BETWEEN GATES 1 AND 2
FOR y = 1 TO 65000           ' COUNTS TIME BETWEEN GATES
  Detect2 = IN8
  IF Detect2 = 0 THEN Count2
  PAUSE 10
  y=y+1
NEXT
```

```
CalcSpeed:      ' Calculates the speed using the "modulus" command to get three decimal places.
vel = 19*145/y
r4 = 19*145//y
v2 = 10*r3/y

vel2 = 19*145/b
r5 = 19*145//b
v22 = 10*r5/b

vel3 = 16*145/c
r6 = 16*145//c
v32 = 10*r6/c
```

Results

A slot car roadway was set up with four photo-gates and detectors aligned along the railings. These were able to detect the motion of the passing toy car. The time between detectors for the car's motion was then determined from the intervals between the gate blockings and then used to calculate the speed of the car between photo-gates. A program to control the speed of the car was made based on a set speed limit for the car's motion. This was able to reduce the speed of the car at a predetermine rate for a set duration of time. A program to calculate the velocity and acceleration of the car as is passed through the four photogates was. However, because the Basic Stamp 2 IC can only do integer math, the acceleration could not be accurately, and thus the acceleration portion has not be implemented at this time. The students must calculate the acceleration based on the computed velocities.

Conclusions

This racetrack apparatus can be used to demonstrate to student's changes in velocity and acceleration at various distances. Students can input various input speed and see how the system reacts based on these inputs. This demonstrates several aspects of mechatronics. A DC motor is modified to include a mechanical component (gears) and electronic components. Its speed is then controlled by a microcontroller connected to sensors that monitor the environment. A computer is interfaced with the mircocoontroller to both program the microcontroller and to display system outputs and monitor system performance.

The Final Product

