Application of Electroactive Polymers to Improve Cooling Systems in Motorsport

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INTRODUCTION

This project is focused on showing how the use of Electroactive polymers can potentially be used to improve the current cooling systems in place within the motorsport industry. The device will be integrated into the respected vehicle and then controlled by the newly designed control system. The control system will allow the user to activate the device when it suits them best with the race conditions. When activated the device will create a wider opening allow for more air to come inside the car structure in order to cool. Places that would benefit from having a wider opening include: the front air ducts, the side pods and the most beneficial would be the engine air intake.

BACKGROUND

For the project it was decided that the focus would be on how the use of Electroactive Polymers could be used in different industries. It was decided to implement the Polymers into Motorsports as it is not currently implemented in this industry. Since it is not currently used, research was needing to be done on the different disciplines to find out what the rules and regulations say in regards of the allowance of performance enhancement due to moving parts and additional materials. And more specifically whether moving parts were allowed for the improvement of cooling the car. The disciplines researched were: Formula 1, Formula E, World Touring Car, Grand Touring Endurance, Le Mans Prototype 1 & Indy Car.

REGULATION RESEARCH

Formula 1

Allowed under 'Article 11.14.1 – Front Air Ducts' [1]

Formula E

Not allowed under 'Article 4.16 – Turning vanes, barge boards and cooling ducts' [2]

World Touring Car

Allowed under 'Article 6.5 – Intake System' [3]

Grand Touring Endurance

Allowed under 'Article 334 – Supercharging System' [4]

Le Mans Prototype 1

Allowed under 'Article 3.4.4 b – Air Intakes' [5]

Indy Car

Not allowed under 'Article 14.15.4' [6]

NITINOL

The Electroactive polymer that was decided on was Nickel Titanium Oxide (Nitinol) due to main its characteristics, the polymer can memorise the shape that it changes to and its original state. Therefore after a source of either current or heat is introduced to the wire it will move into the user's desired shape and once the source is removed from the wire, it will return to its original shape/state. Whilst researching into values that the wire needs and requires to function, it was found that the wire withstand a high current/voltage, but the downfall is how hot the wire does get as it can withstand nearly 500°C. When looking into a circuit that would be able to incorporate the wire and also keep the current high, it was decided that a power transistor would be required in order to make sure that the current provided is sufficient without damaging the circuit.

METHODOLOGY

EXPERIMENT

Before the device was able to be built, reaction timings for the Nitinol wire were needed. To get these values the wire was connected directly to the power supply with a limit of 6V. Initial testing was done with increments of 0.5V. But from those the wire would not straighten until 2.5V/0.5A was introduced, therefore the increments where changed from 0.5V to 0.1V, then from there the noticeable movements was between 2.7V up to 4.5V. What we were looking for was that the wire would straighten out when current was applied, and would then time with a stopwatch to see how long it would take for the wire to fully straighten out. When looking for suitable values for the wire to straighten, it was important to concentrate on the amount of current as it is when the wire is introduced to either a heat/current source it begins the process of shaping/moving. After recording the values, and taking into consideration human error whilst pressing the stopwatch it was decided that the best values found were 1.09A and 4.3V. These values were chosen because it only took 2.42s for the wire to straighten out fully.

CIRCUIT DEVELOPMENT

The circuit was initially supposed to include a bipolar junction transistor, but after discussion it was found that a bipolar junction would just not work in the circuit's design. After a later discussion it was decided that a to implement a power transistor. This decision was due to it's ability to maintain a stable output of current so that the wire could change to the desired shape. Then in the final circuit a relay was incorporated within it which allows for a higher current output to the circuit without causing transistors and resistors to overheat or break.

The device itself has 4 main components: The microprocessor, the relay, a light system and the Nitinol wire. The microprocessor used is the Arduino Uno and is the core of the device since it has the code of the system and controls the activation of the Nitinol wire. The relay is used to ensure that the device has a stable current input into the Nitinol wire so that it can stay in shape for the duration of activation. The light system indicates when and in what state the device is currently active in, and the colours of the device are as follows:

Red - 'Ready to use'

Green - 'Active'

Blue - 'Failed system'

And the final piece is the nitinol wire itself which can be changed for any device depending on the car needed.

Figure 1 - Williams F1 with highlighted sidepods [7]

Figure 2 - Hyundai WTC car with highlighted areas for application [8]

```
void setup()
{
  Serial.begin(9600);
  pinMode(ledRED, OUTPUT);
  pinMode(ledGREEN, OUTPUT);
  pinMode(ledBLUE, OUTPUT);
  pinMode(buttonPin, INPUT);
  randomSeed(analogRead(0));
}

void loop()
{
  buttonState = digitalRead(buttonPin);
  if(buttonState == LOW)
  {
    v++;
    if(v = 5){
      digitalWrite(ledRED, HIGH);
    }
  }
  if(buttonState == HIGH)
  {
    digitalWrite(ledGREEN, HIGH);
    randNumber = random(0,10);
    delay(200);
    digitalWrite(ledRED, LOW);
    if(randNumber < 5)
    {
      digitalWrite(ledBLUE, HIGH);
      digitalWrite(ledGREEN, LOW);
      delay(5000);
      digitalWrite(ledBLUE, LOW);
    }
    delay(5000);
    digitalWrite(ledGREEN, LOW);
    digitalWrite(ledRED, LOW);
  }
}
```

Test Light system code

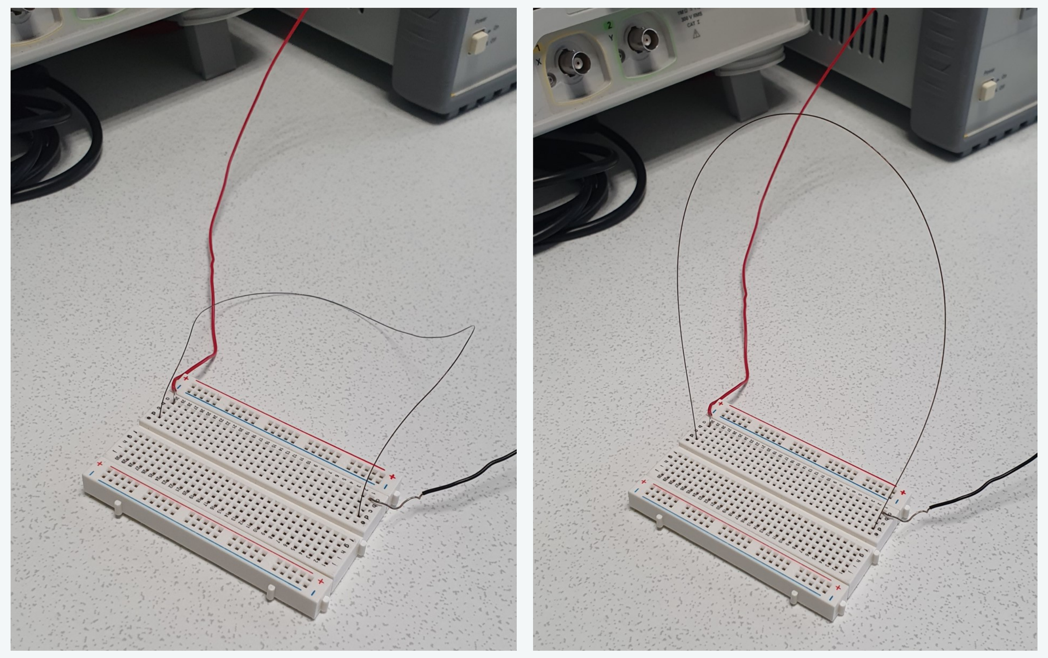


Figure 3 - Reaction Timing Experiment before and after introducing current

Voltage (V)	Current (A)	Time (s)
2.70	0.60	34.00
2.80	0.68	23.00
2.90	0.60	20.00
3.00	0.65	16.00
3.10	0.74	12.00
3.20	0.75	11.00
3.30	0.84	6.80
3.40	0.87	6.40
3.50	0.90	6.76
3.60	0.92	6.18
3.70	0.95	4.91
3.80	0.98	4.21
3.90	1.01	3.73
4.00	1.03	3.48
4.10	1.07	3.21
4.20	1.09	2.76
4.30	1.13	2.42
4.40	1.19	2.49
4.50	1.16	2.62

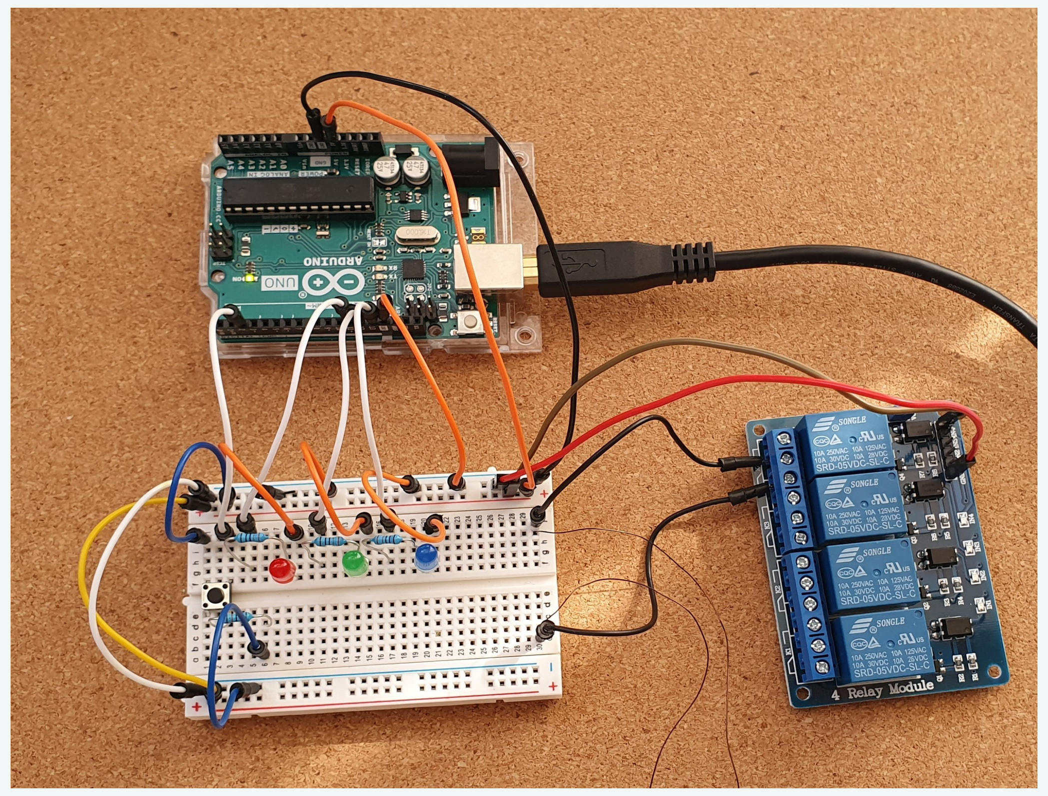
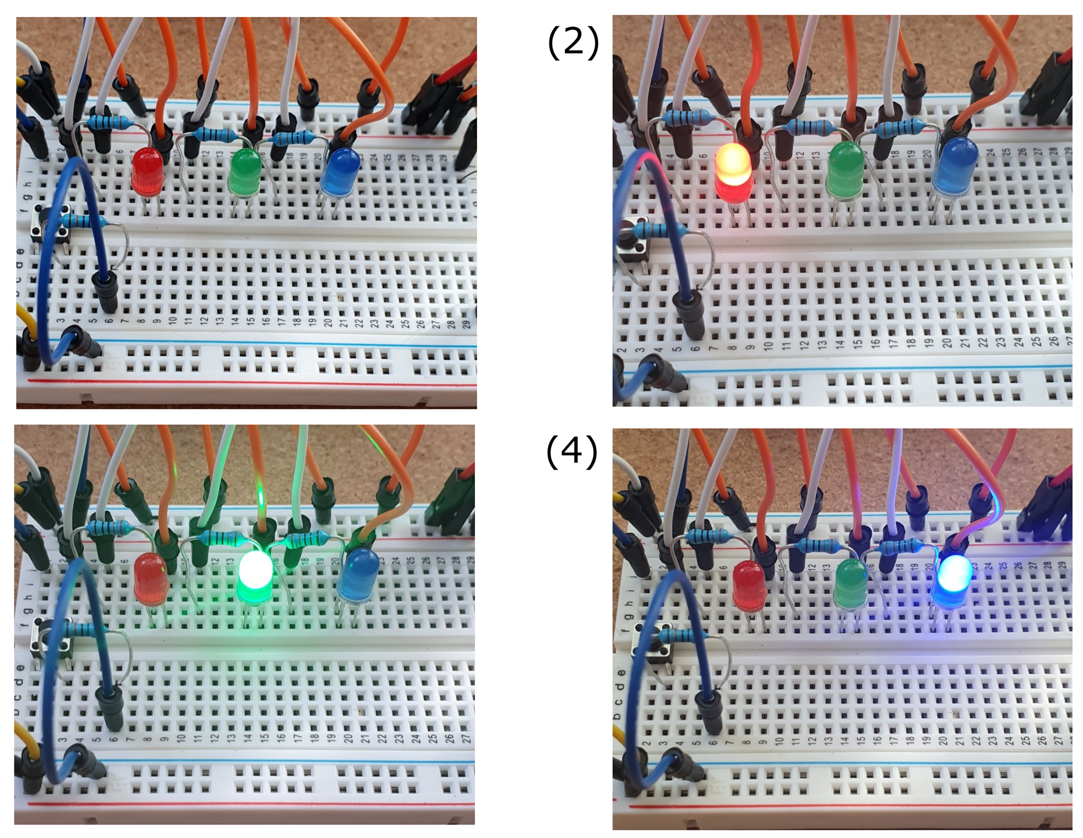


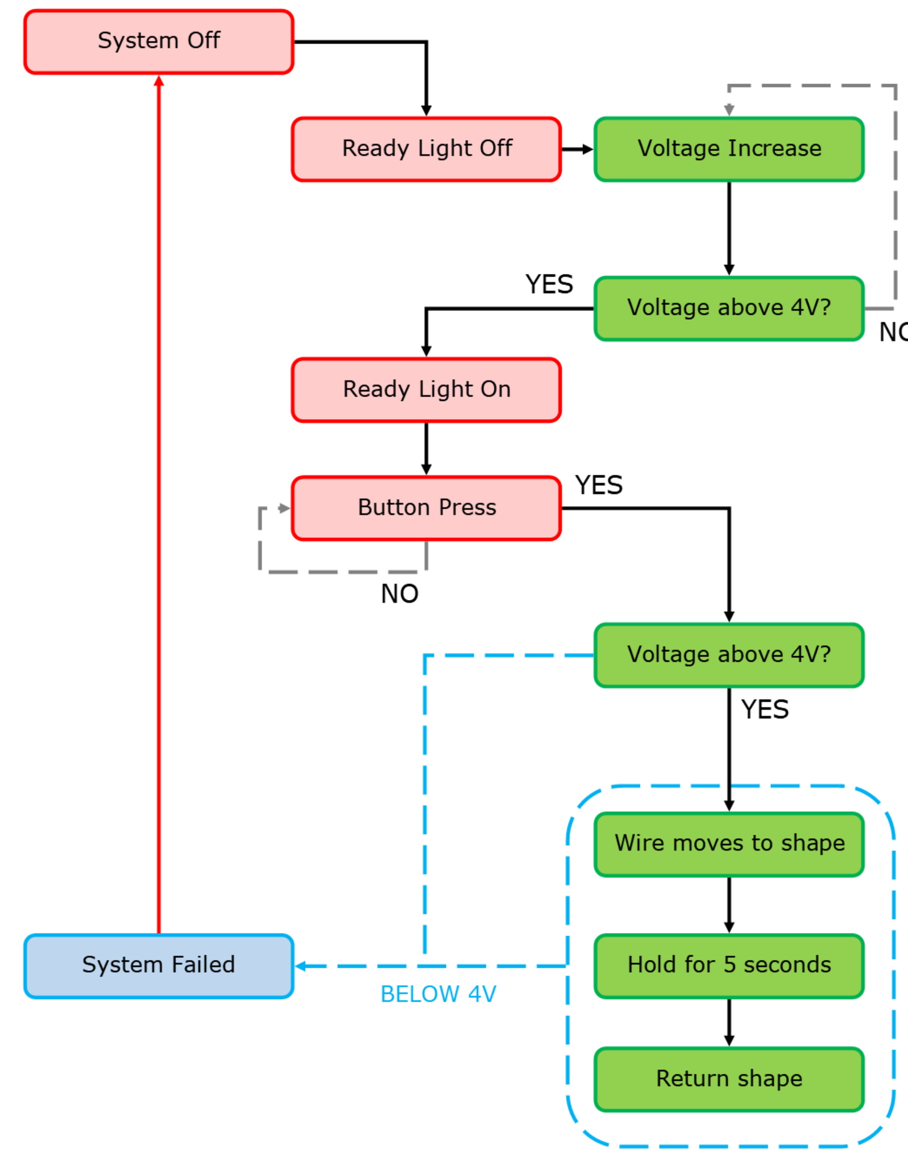
Figure 4 - Final Circuit

LIGHT SYSTEM AND STATES

1 = OFF - 2 = Ready - 3 = Active - 4 = Failed

(1) (2) (3) (4)





CONCLUSION

From the research on different disciplines it was found that four different disciplines were allowing the device to be added to the vehicle with different restrictions on dimension and location. But knowing this allows for the device to be more free to interpretation, as any team or company can change it specifically for their vehicle.

Also, from creating the device it was found that wire would only cooperate when there was more then half an ampere going through it, this in turn meant that we would need a stable output and to do this we concluded on adding a relay to the system in order to keep the wire stable and in shape for the whole duration of the process. The reaction timing experiment gave the values needed to get wire to activate properly and be effective to get into shape quickly, for this 4.5V and 1.09A was the optimal combination of values that allowed the wire to move into place within 2.42s.

So in conclusion this project has shown there is potential to use electroactive polymers to improve cooling, but the project would benefit from higher level equipment to get more in depth tests and better results.

REFERENCES

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