Longboard Light Painting Speedometer

Concept -

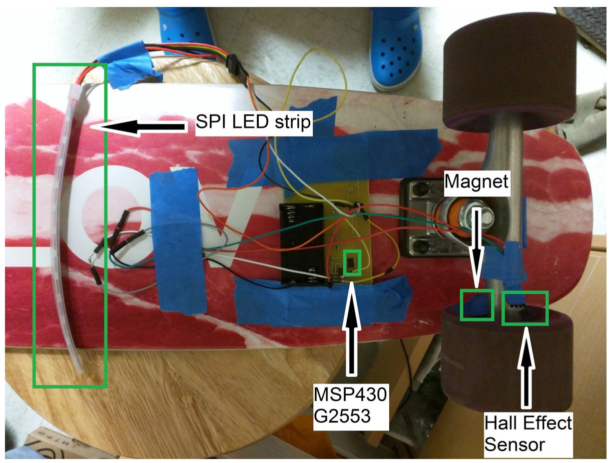
Given the high popularity of skateboards amongst college students, we came up with the idea of creating a speed measuring device for skateboard which also displays the speed in a created way - light painting. An LED strip will be taped to the back of the skateboard, leaving a light painting display of speed behind the board. Since light painting requires periodically changing pattern of the LED strip which frequency is dependent on the speed of the skateboard, the two parts of this design project come together to form a final product.

Design -

The project comprises of 2 parts: speed measurement and light painting. The parts required are as shown below:

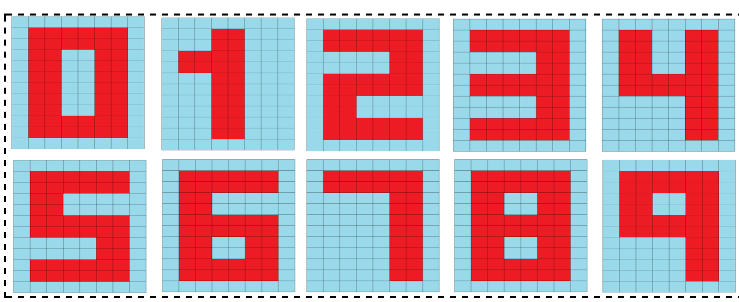
1. Speed Measurement : Hall effect sensor and a strong magnet
2. Light Painting: SPI controlled LED strip.

The actual setup of the system is shown below:



Both the Hall Effect Sensor output and the input for SPI LED strip are fed through Port 1 of MSP430G2553 microcontroller chip. This frees up Port 2 of the chip which can be used for other purposes like more complicated SPI LED light painting applications where more LED strips can be used.

The LED displays speed as pixelated numbers of 12x8 arrays, which means that each number is displayed as 8 columns, requiring LED strip to be programmed 8 times to display each number. The shapes of the pixel numbers are illustrated as below:



Speed measurements -

Speed measurement is done by detecting proximity of magnet, which is taped to the side of a wheel, to a hall effect sensor. The hall effect sensor has an analog output which varies with proximity to an external magnet. When magnet is far away from the sensor, the analog output reads high(around 1000 on the MSP430 ADC reading with default settings), but when the magnet gets close to the sensor(less than 0.5 centimeter), the output drastically drops to around 0.

There are two methods of detecting speed using this output:

1. *ADC10 reading:*

The analog output is converted to a digital value. The value is polled at a regular interval and a high to low transition is looked for. If a high/low transition is detected, this signifies a wheel turn and relevant counter is incremented.

2. Hardware Interrupt:

The sharp decrease in output as magnet moves close to the sensor can be used to trigger a Hardware interrupt. MSP430 GPIO pins can be used to detect high/low or low/high transitions. Either configuration will produce an interrupt and we can simply increment the wheel_turn counter inside the interrupt routine.

Comparison between the two methods:

Clearly, the hardware interrupt implementation requires much less power as the device stays in Low Power Mode unless waken up by the hardware interrupt.

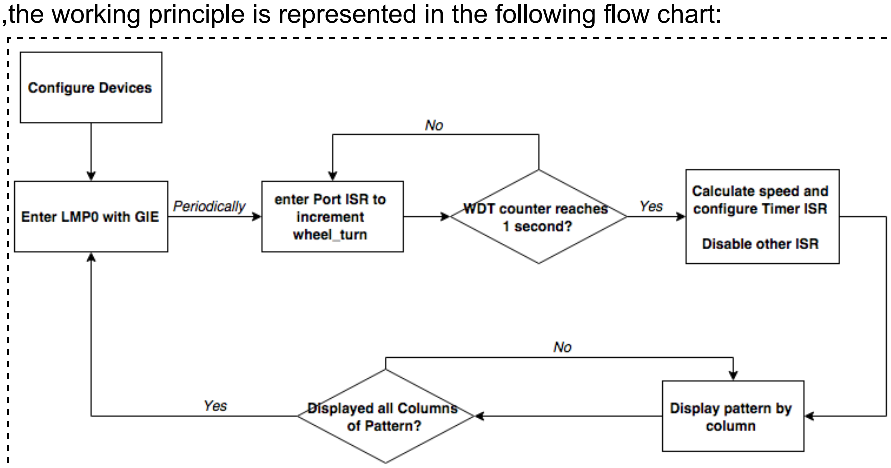
SPI LED display-

The SPI LED strip used contained 12 SPI LEDs connected in series. The light painting is achieved by periodically change the pattern shown in the LED strip as it sweeps horizontally. The period of sweep is dependent on the speed travelling as higher speed will require a shorter period to keep the displayed values to maintain a relatively constant width.

A base period is calculated for the width of the strip to be around 0.015s when moving at 1 meter/second. Based on that, the period for each different speed is simply (0.015/speed). This period is fed to CCR0 of timer A1 which is configured to up mode, meaning it will count up till it reaches CCR0 value which is when an interrupt is triggered. Each time an interrupt is triggered, which means a new pattern for the SPI LED is required, a new column is displayed if not all columns have been shown. If all patterns have been shown, a new speed reading is obtained outside of the Timer A1 ISR and the new pattern is displayed from the first column.

Architecture -

The architecture of the program has mostly been explained as above. To better illustrate the logic flow of the problem,the working principle is represented in the following flow chart:

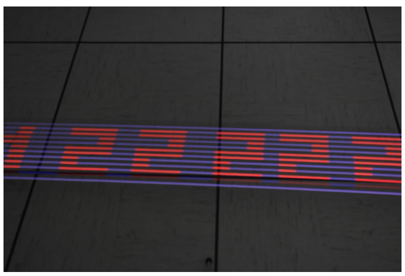


The system will be mainly be in low power mode ensuring minimum power usage. The only time that the system is awake is when it is required to calculate the speed of the skateboard and configure timer interrupt to display that speed value.

The system will first record number of wheel turns using Hardware Interrupt within a time window controlled by WDT interrupt. After WDT interrupt reaches a desirable amount of time, WDT and Hardware Interrupts are disabled, speed is calculated and Timer Interrupt is configured and enabled with the speed value. After all patterns have been displayed, the system disables Timer A1 to stop pattern display and re-enables WDT and Hardware interrupts to get new speed.

Functionality of device-

This device worked perfectly during all of our tests as shown below:



It is able to record the speed of the skateboard in real-time and display the speed (in meters/second) as a light painting pattern. It can also be programmed to display other patterns with the same LED strip.

Challenges-

The greatest challenge was to configure the Timer Interrupt correctly. Due to the inconsistency of DCO clock (even after calibration), to change the delay between columns of a pattern with respect to speed is very time consuming and relatively challenging.

We expected voltage supply to hall sensor to be a problem as the datasheet said it requires ~25V supply, but 3V supply to the whole system turned out to be functional.

Future Work-

The current product is just a prototype. Better packaging will be made in the future and damage-proof casing for hall sensor will be made to protect the sensor from uneven surfaces.

Light Painting pattern could be varied to increase the entertainment value of the product.

An additional speedometer could be made to display the speed to the skater. Though we weren't able to implement this due to time limitation, it could be easily achieved by simply adding another ring of LED connected to the same MSP430.