MECHATRONICS DESIGN PROJECT

ETHAN SALAZAR, JACOB OGANDA, & KAYLON GILBERT

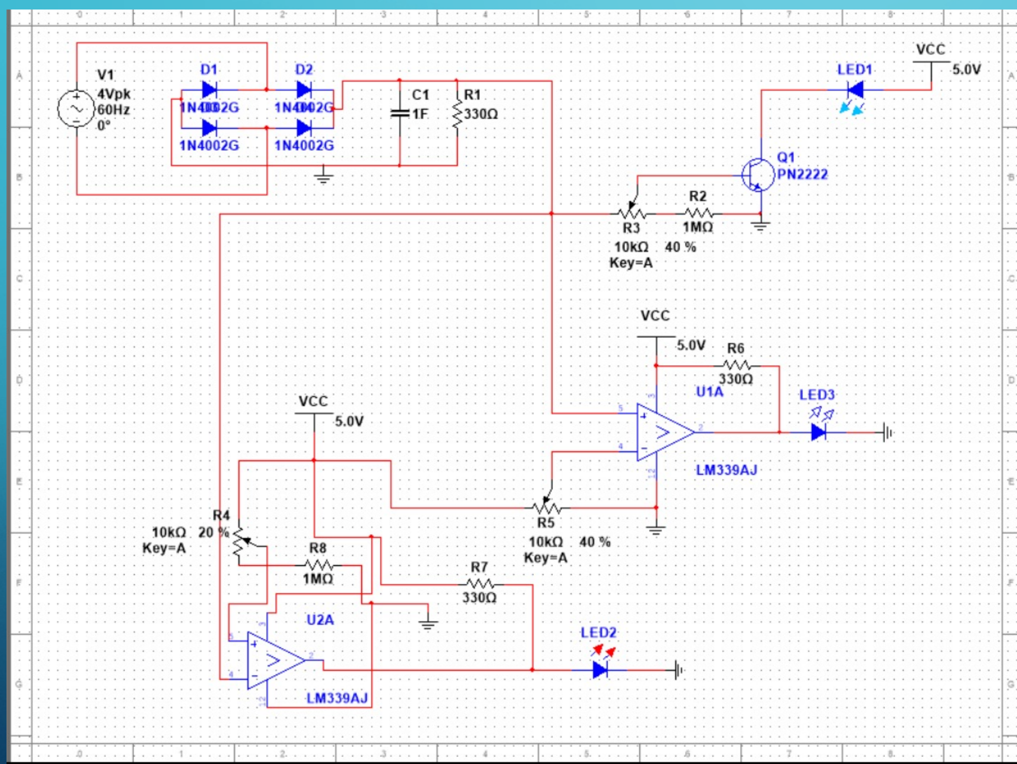
TABLE OF CONTENTS

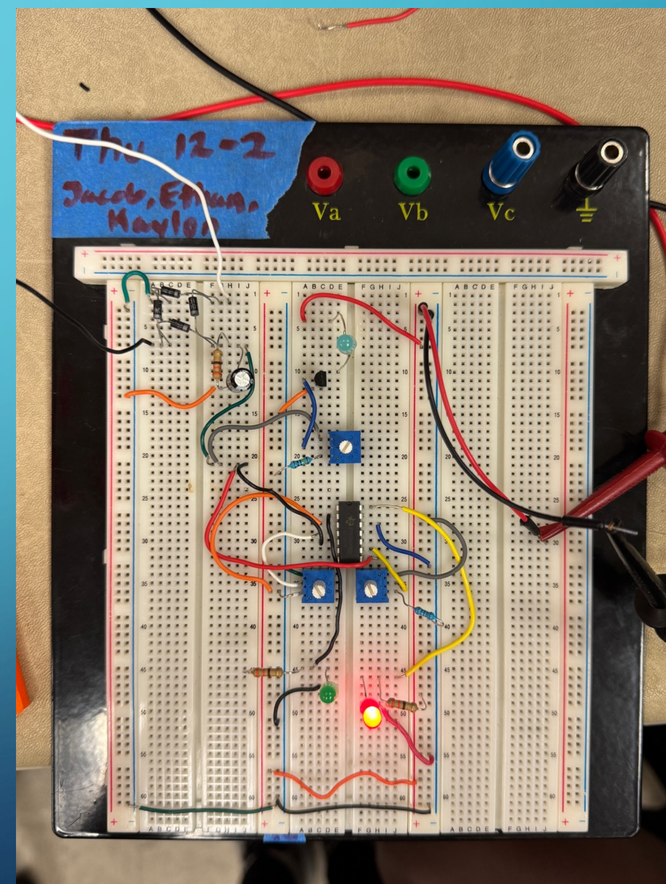
INTRODUCTION

The proposed circuit is engineered to transform the AC voltage generated by the windmill into a stable DC voltage using a full bridge rectifier. It features two comparators that manage indicator lights reflecting the windmill's operational speed—one light indicates speed that is too low, while the other warns of excessively high speed. These comparators are set with a 5V supply voltage and an adjustable potentiometer for precise control.

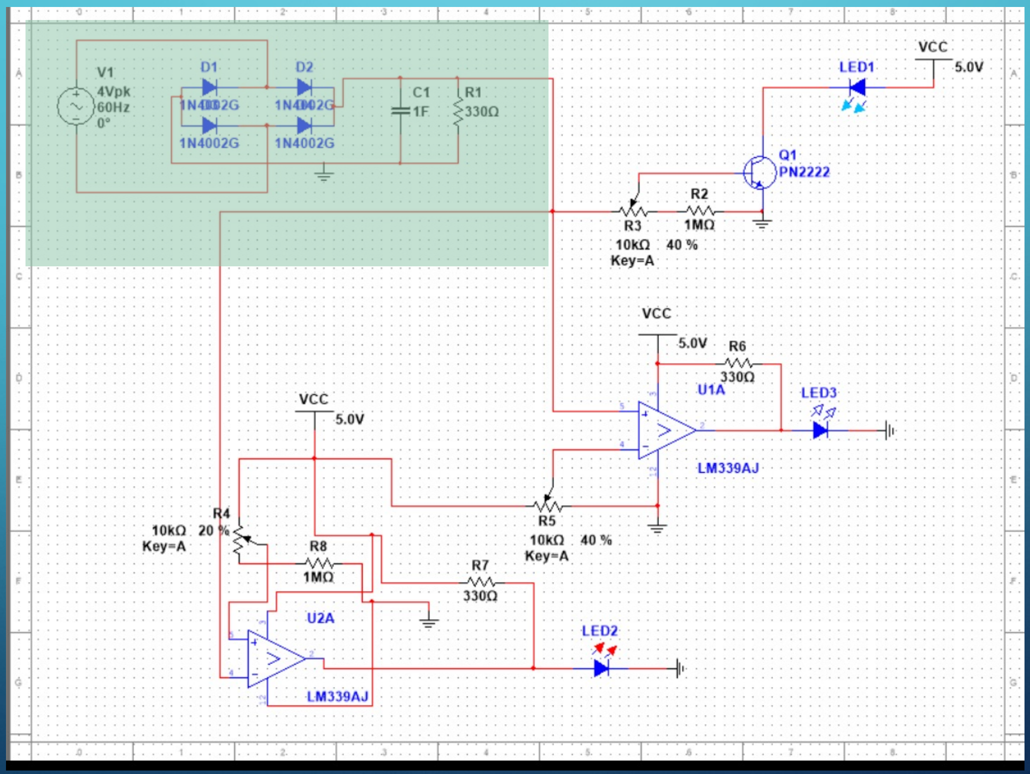
Additionally, the circuit uses an NPN transistor to vary the brightness of an indicator light, providing a visual cue of the windmill's speed fluctuations. This design efficiently converts the voltage for practical applications. It also incorporates a sophisticated monitoring system that uses indicator lights to display speed conditions and an adjustable light intensity for detailed speed analysis.

FULL CIRCUIT



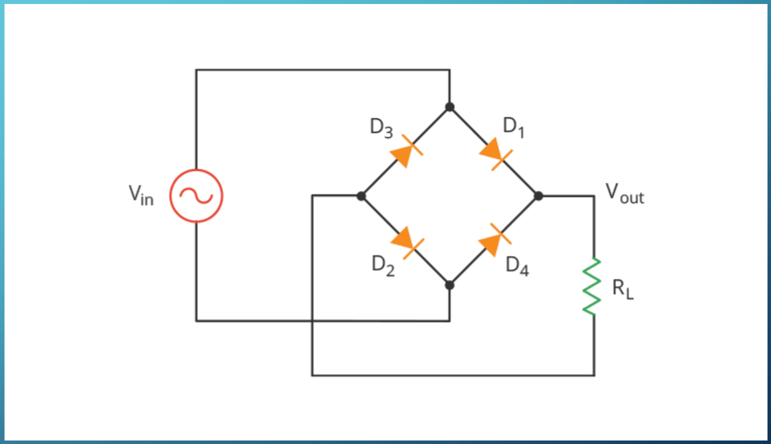


AC-TO-DC POWER CONVERSION: FULL BRIDGE RECTIFIER

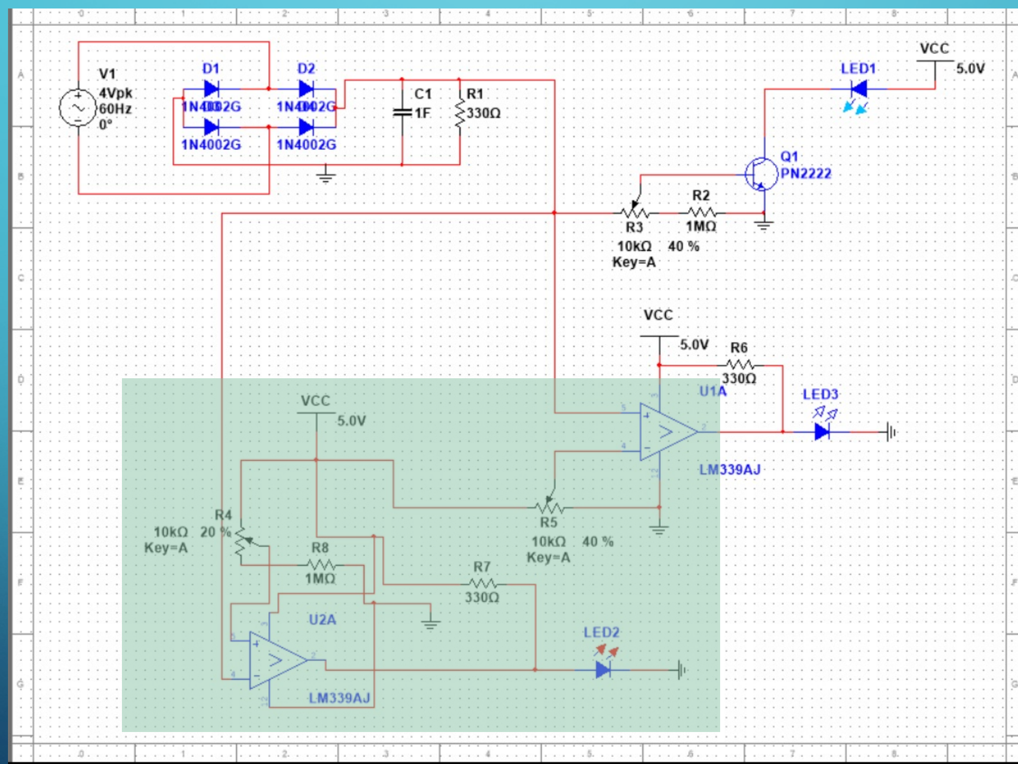


AC-TO-DC POWER CONVERSION: FULL BRIDGE RECTIFIER

A full bridge rectifier consists of four diodes arranged to convert alternating current into direct current. It operates by directing current to flow only in one direction across each half-cycle of the AC waveform. During the positive half-cycle of AC, two diodes become active, allowing current to pass in one direction; similarly, the other two diodes conduct during the negative half-cycle, facilitating current flow in the reverse direction. This arrangement transforms the AC into pulsating DC. To achieve a more stable DC output, a filter capacitor is typically added following the rectifier to reduce fluctuations and smooth out the voltage.



LOGIC CONTROLLER



LOGIC CONTROLLER

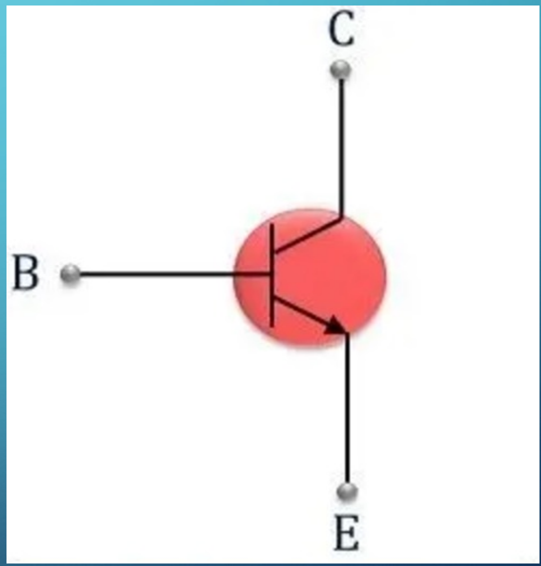
Two comparator-driven logic controllers:

Two comparator-driven logic controllers are employed to monitor the DC output voltage from the rectifier. The comparators assess whether the voltage crosses predetermined thresholds and activate the appropriate indicator lights to signal whether the windmill is operating too slowly or too quickly. In comparator operation, the output turns high if the non-inverting (+) input exceeds the inverting (-) input. Conversely, the output goes low if the inverting input surpasses the non-inverting input. For monitoring purposes, the DC voltage is designated as the inverting input for one comparator and as the non-inverting input for the other, allowing each to compare the voltage against set thresholds to signal either excessive or insufficient power.

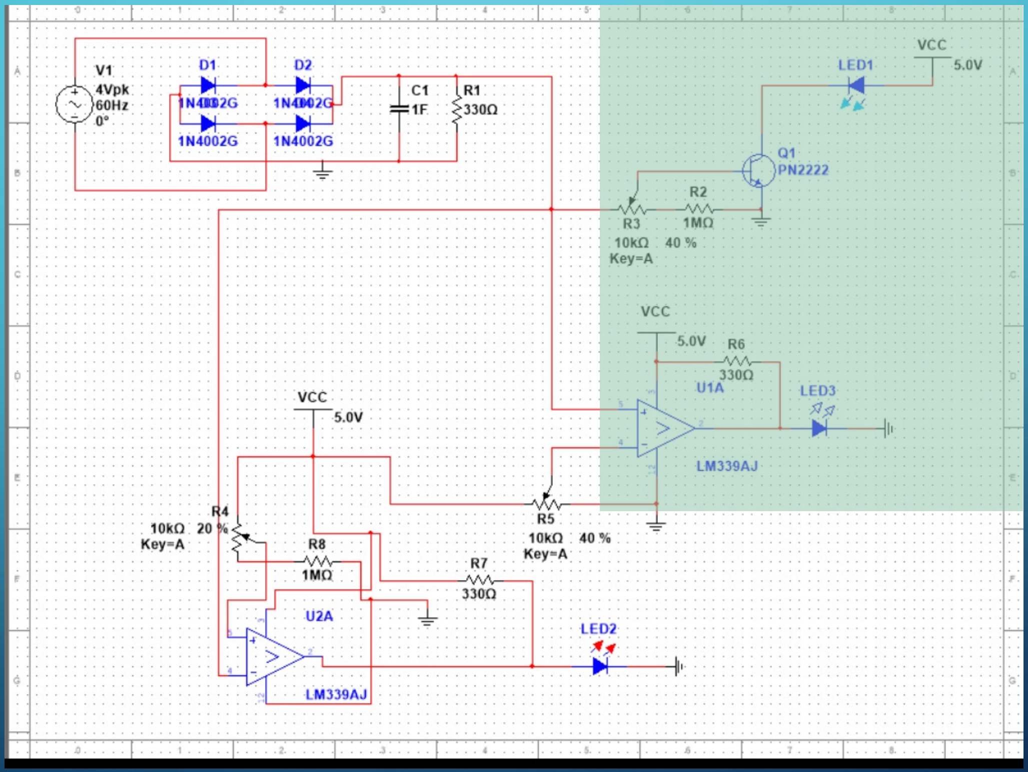
LOGIC CONTROLLER

One transistor-driven logic controller:

In this setup, a bipolar transistor leverages a small base current to manage a larger current. This larger current then flows from the collector to the emitter, thus amplifying signals. Within the circuit, this characteristic allows the bipolar transistor to enhance the fluctuations in the rectified DC current. Consequently, it controls the power intensity delivered to a load, facilitating the modulation or adjustment of the power according to the requirements.



INDICATOR


V1
4Vpk
60Hz
0°
D1
D2
1N4002G
1N4002G
1N4002G
1N4002G
C1
1F
R1
330Ω
VCC
5.0V
LED1
Q1
PN2222
R2
1MΩ
R3
10kΩ 40 %
Key=A
VCC
5.0V
R6
330Ω
U1A
LED3
LM339AJ
VCC
5.0V
R4
10kΩ 20 %
Key=A
R8
1MΩ
R5
10kΩ 40 %
Key=A
R7
330Ω
U2A
LED2
LM339AJ

INDICATOR

A diode permits current to flow only in one direction, so to decide whether the LED lights up, we need to establish a differential voltage across it. With a 5V power supply on one side, if the other side also has a high voltage (dictated by the logic controllers) there will be no voltage difference, and the LED will remain off. However, if the voltage on the other side is lower, the resulting voltage differential will allow current to flow through the LED, turning the light on.

REFLECTIONS AND CONCLUSIONS

- What difficulties were encountered, and how did you solve them?
  - Incorporating a sensor to measure windmill speed precisely involved significant calibration to set the appropriate thresholds for the indicator lights. Similarly, adjusting the variable intensity of an indicator light based on windmill speed required meticulous fine-tuning and numerous adjustments of resistor values to effectively control the light intensity.
- With further time, what could you improve?
  - Further refining the calibration of the windmill speed sensor could enhance the accuracy of the indicator lights, ensuring they more accurately reflect variations in windmill speeds. Enhancing the user interface with features such as a digital display could offer real-time feedback on the windmill's operational speed. Additionally, integrating an energy storage system could capture and store excess power during periods of high wind speed, providing a reserve during times of lower wind activity.
- Any lesson learned from this project?
  - The project underscored the importance of an iterative testing and refinement process through experimentation to optimize the system.