Boost-Buck Voltage Converter

ECE 499 Group 1

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Introduction

The goal is to design a boost-buck voltage converter with a wide input voltage range for phone charging capabilities during emergency power outage situations. This project compares two different designs of switch-mode voltage regulators: the first uses uses two interconnected NE555 timers as the feedback mechanism, and the second uses a microcontroller as the feedback mechanism.
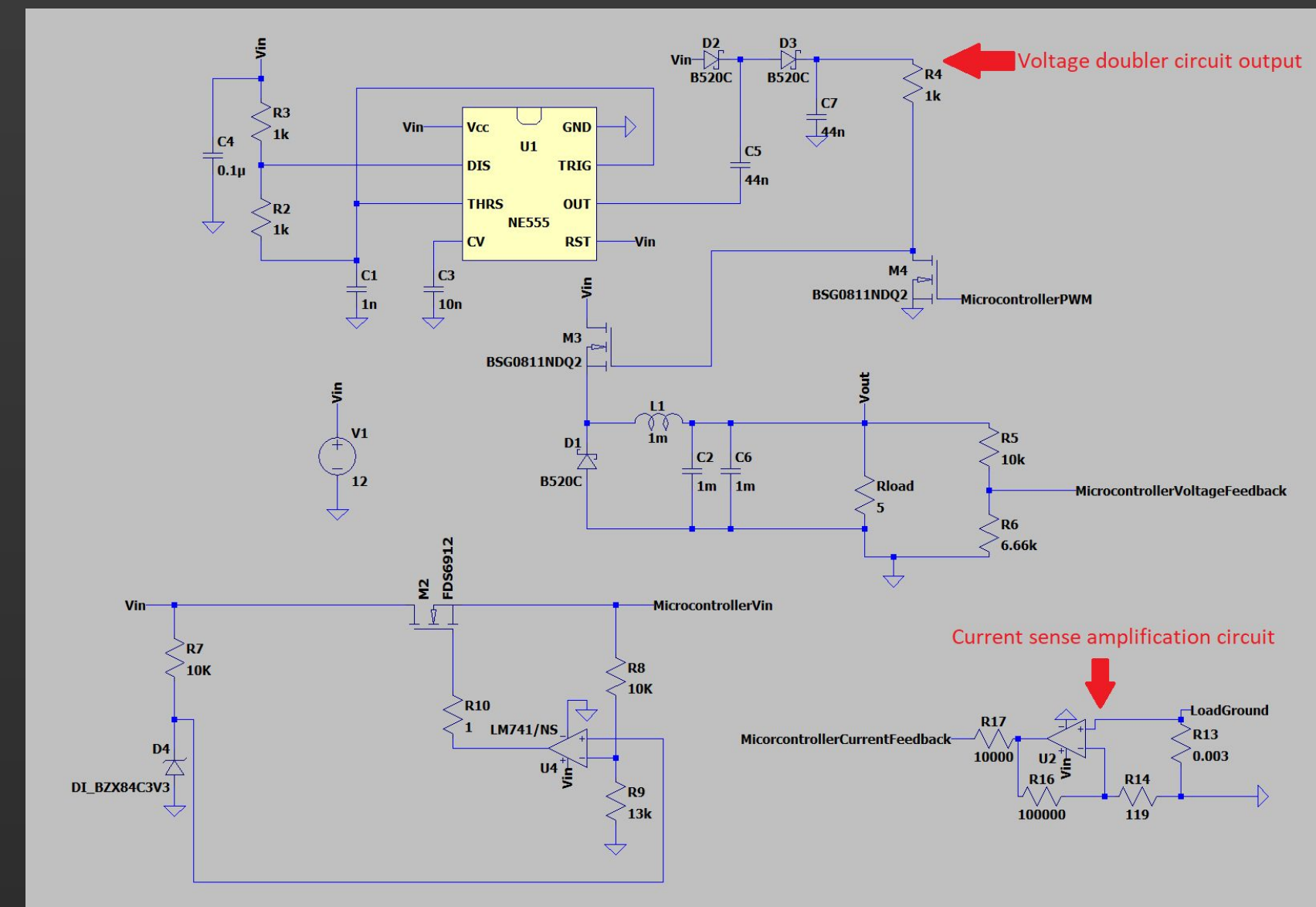
Design Objectives

- Regulate 9 to 16 volts input to constant 5V output
- Supply current up to 500mA
- Maintain high efficiency to minimize energy loss
- Charge USB A devices

Switching Regulator [1]

NE555 Timer Switching Regulator

The dual NE555 Timer voltage regulator circuit uses two NE555 timers for its feedback network. The first timer generates the pulse while the second modulates the pulse width. The following figures shows the LTSpice circuit, electronic circuit.

Circuit Schematic
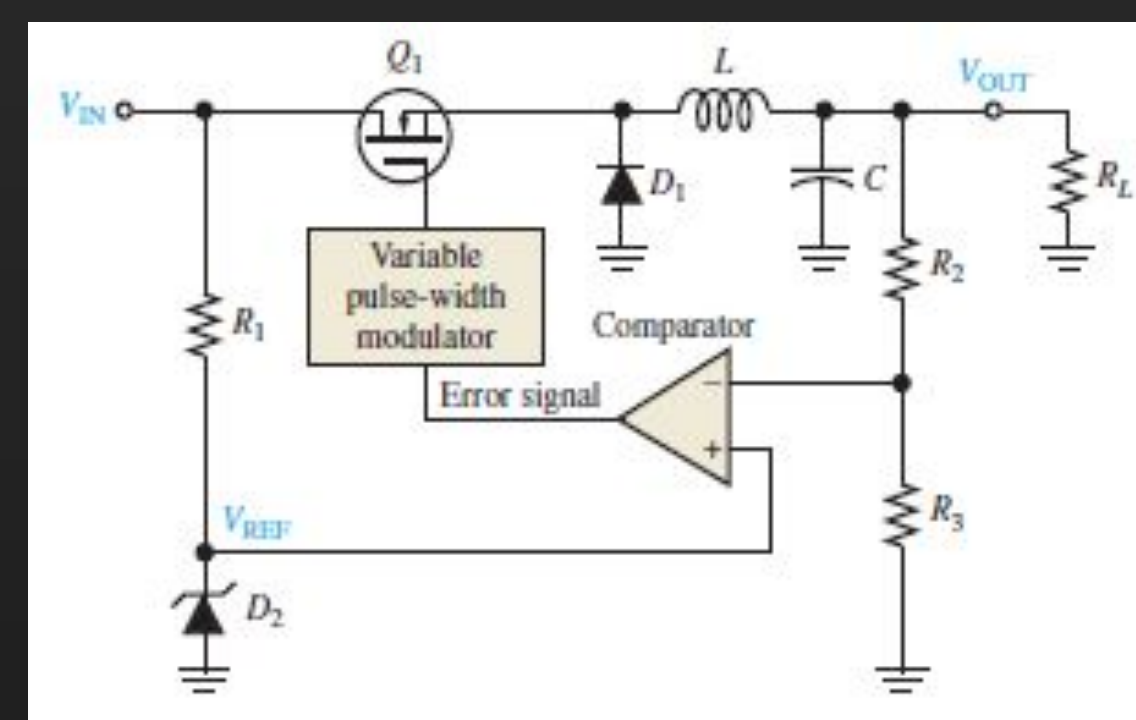
NE555 Timer Switching Regulator

Microcontroller Design

The final design features a microcontroller used in the regulator's feedback network. This design was chosen over the NE555 Timer Switching Regulator as it operates more efficiently and is capable of regulating a greater range of voltages.

Microcontroller Based Switching Regulator

Testing Results

Simulated Performance at 9V - 16V Input Voltage

Both designs were tested to see if they met the design objectives. The NE555 timer design's n-channel MOSFET was inadvertently designed such that it was operating in the lossy linear region of operation which caused severe overheating and erratic output voltages. This result was unexpected as the circuit worked in simulation.

Conversely, the microcontroller based design was able to achieve a steady 5V output and a maximum output current of 1.1A was observed when the system was connected to a 4.7 Ohm load. The output ripple voltage was measured at 0.3Vpp. The maximum efficiency of the system was 80% and the optimal observed pulse-width modulation frequency was 47kHz.

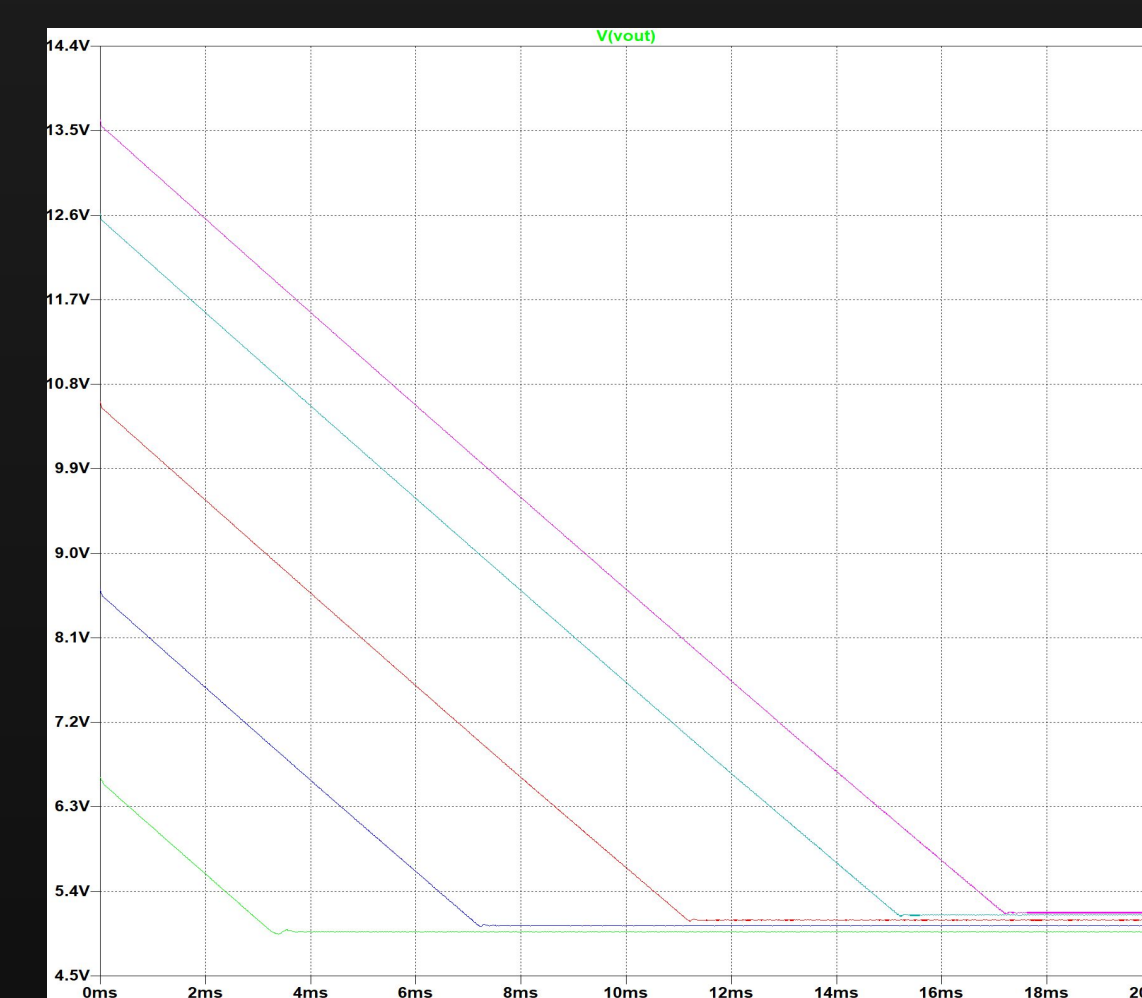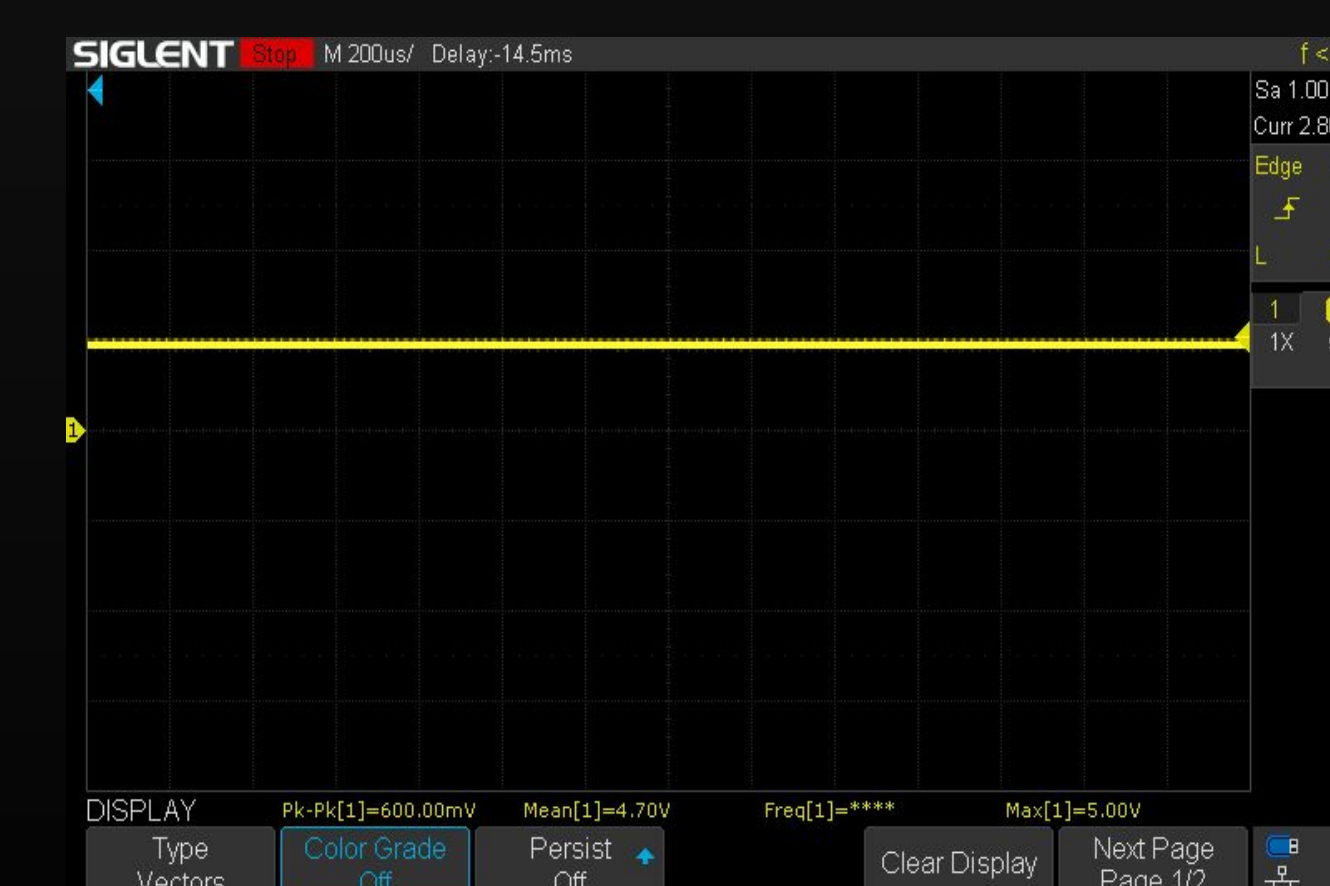Output of Microcontroller Based Switching Regulator

Conclusion

In conclusion, the switching regulator incorporating a microcontroller as its feedback system was chosen as the prototype yielded more consistent operating characteristics including output voltage, current, component temperature, and operating efficiency than the switching regulator that incorporated NE555 timers for the feedback network. This design meets the design objectives as it is capable of supplying a steady 5V output for mobile device charging across a wide range of input voltages with a stable output current at twice the desired value.

Future Work

Future work of the project includes the addition of current limiting circuitry to ensure that the system does not exceed the systems current limit. This added feature would ensure that complements are not damaged if a significant amount of current is drawn. Additional work includes the addition of a full bridge rectifier that would allow the system to receive AC power, furthering the system's use case.
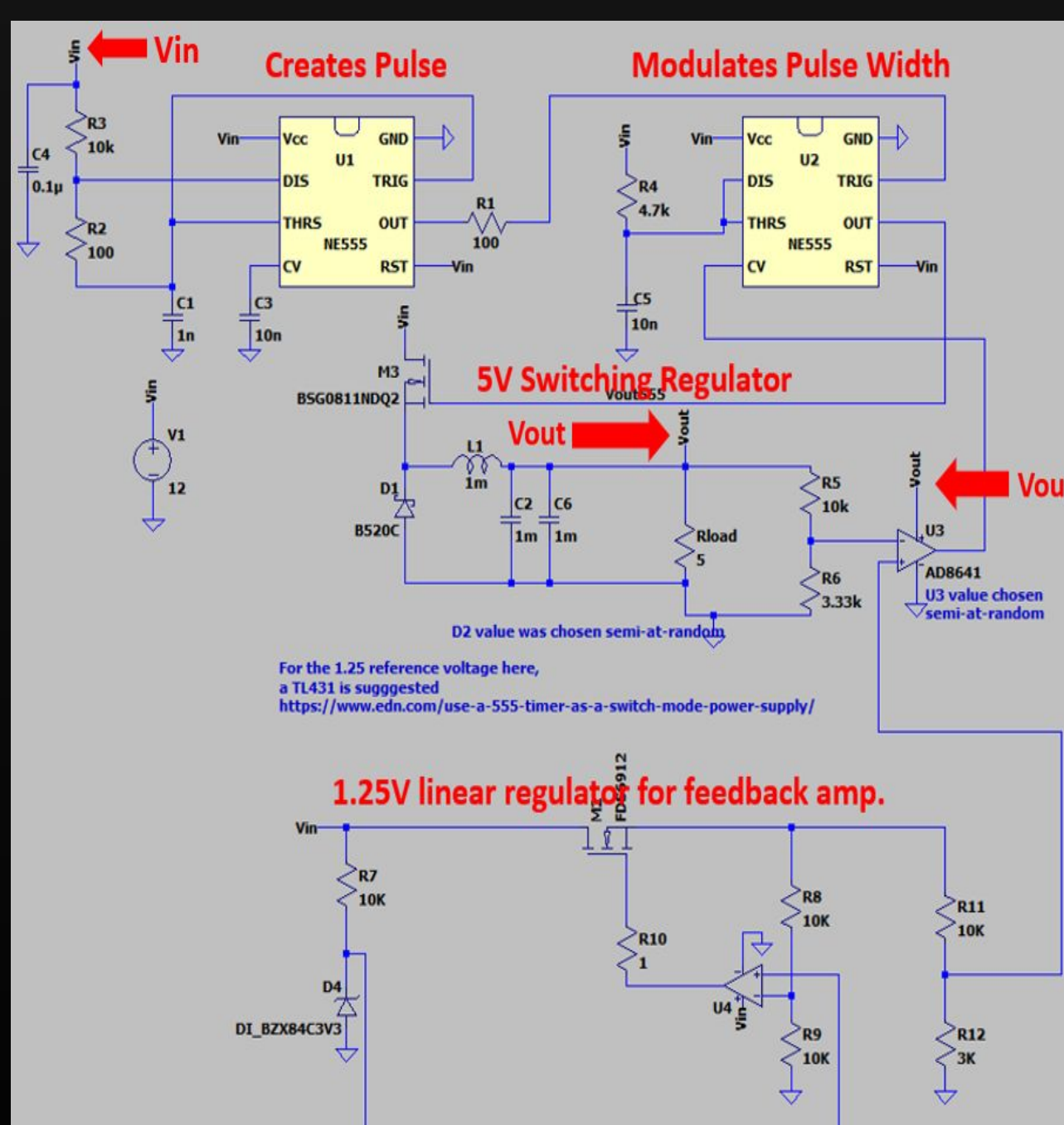
References

[1] Thomas L. Floyd "Voltage Regulators," in *Electronic Devices Electron Flow Version*, 9th ed. Upper Saddle River, New Jersey, USA: Prentice Hall 2012 [Accessed: Feb-26-2020]

Acknowledgements