Analog Lab

Experiment 9: Buck Converter

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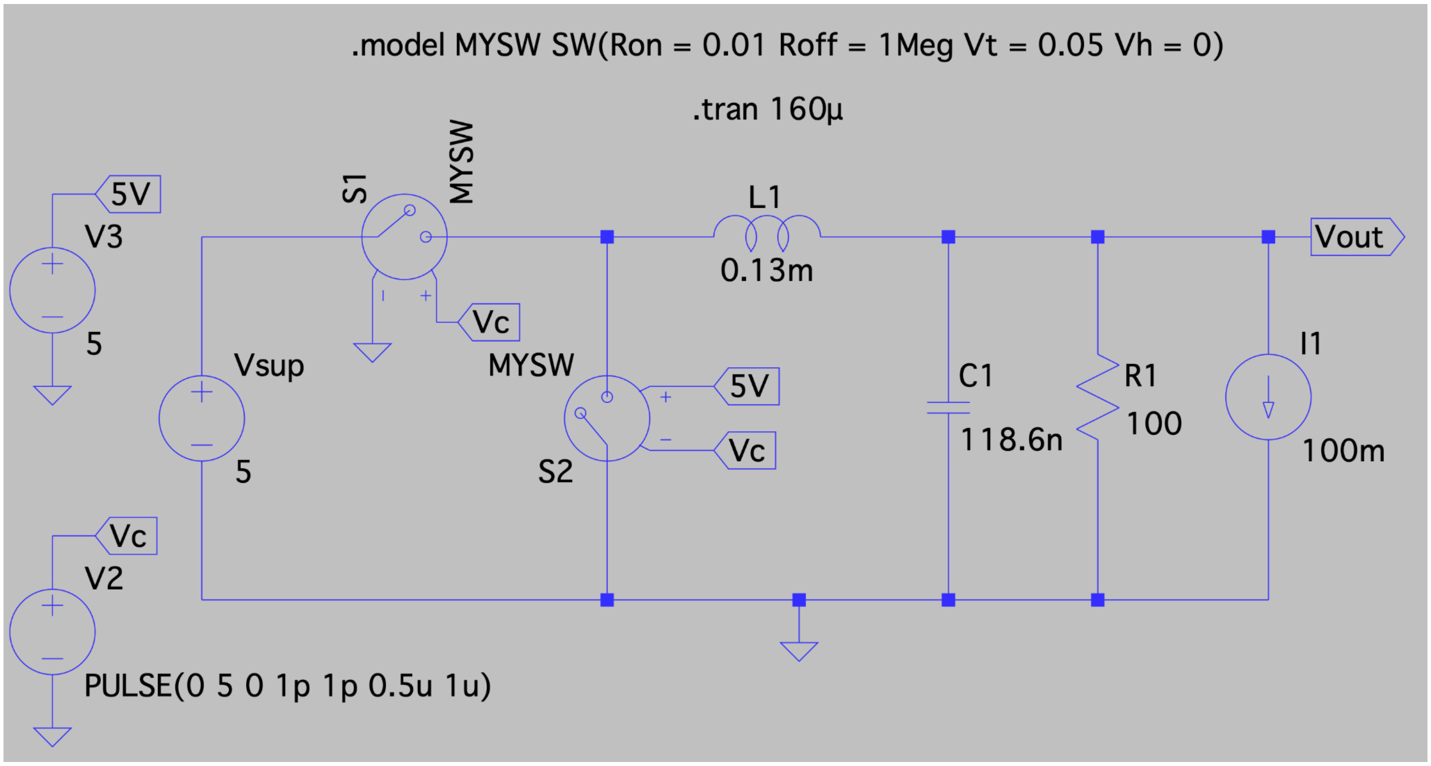
1. To replace the switches from experiment 7 with MOSFET and Diode

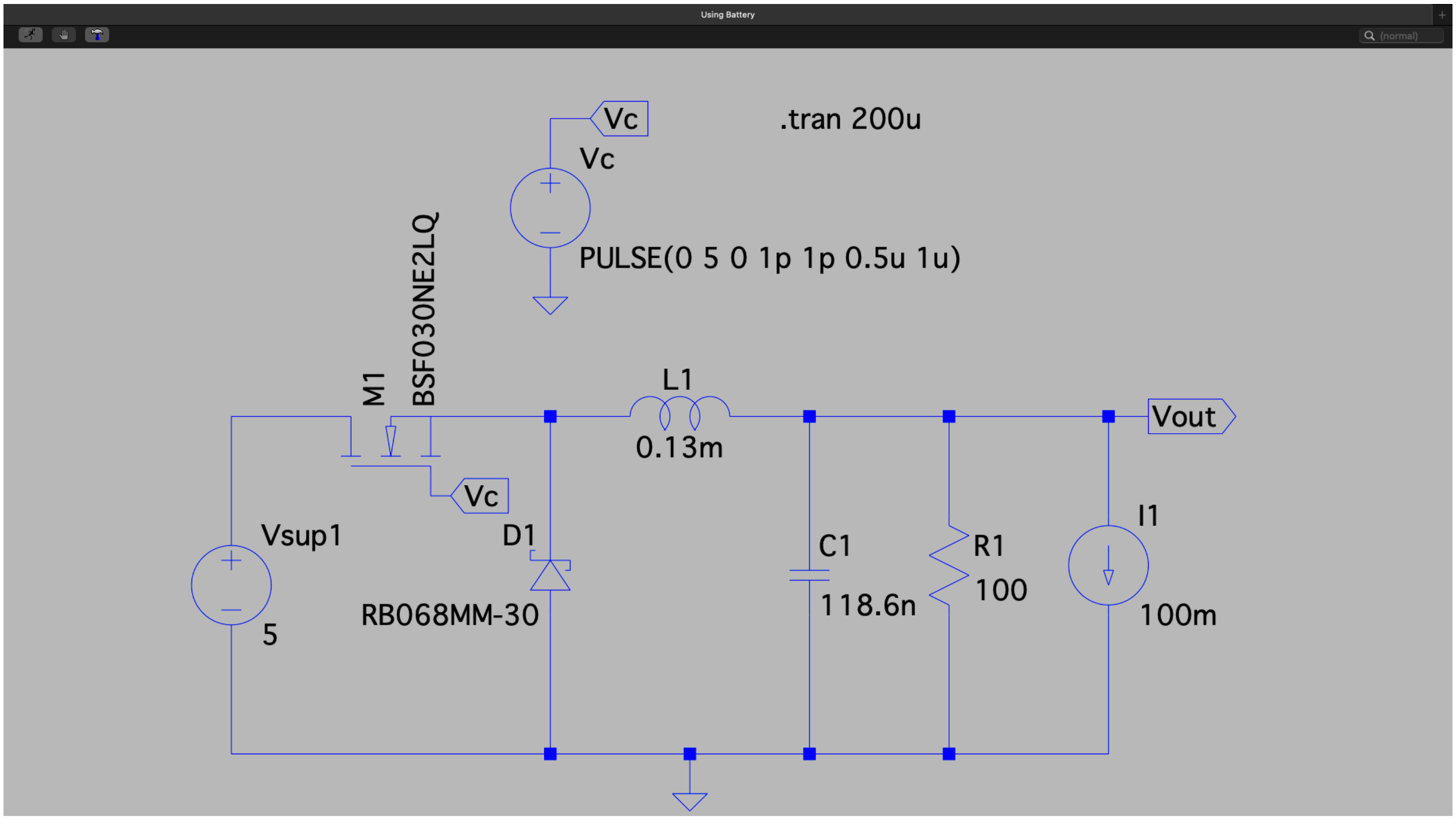


In experiment 7 we used voltage controlled switches to create a square waveform which was fed into the RLC filter. The on and off resistances of these switches were 0.01Ω and 1MΩ. The voltage difference across S1 when V_C is 5V is 1.7 mV and across S2 when V_C is 0V is again 1.72 mV and 5V when V_C is 5V.

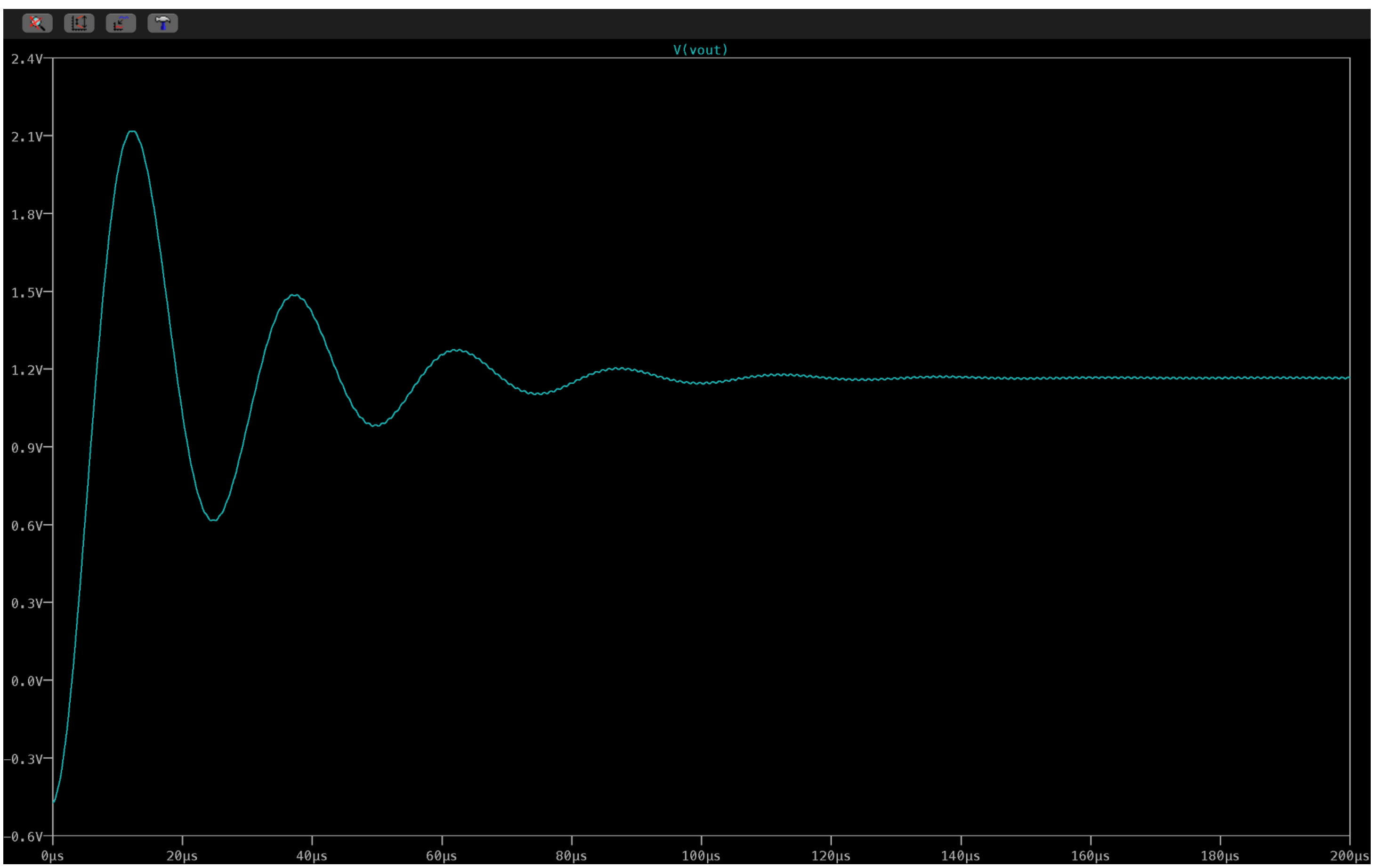
So we can replace S1 with a MOSFET considering that V_{DS} will be greater than 1.7 mV and the gate charge should be minimized. Also we can replace S2 with a diode considering that it can bear 5V in reverse bias condition and also looking at the current rating as the average current through the inductor is the same as the average current through the diode when V_C is 0V.

So I have selected "BSF030NE2LO" for MOSFET and "RB068MM-30" for Schottky diode. Also I have retained the R, L and C values from experiment 7 as the switching frequency used here is also the same.

Implementation in LTSpice



Output Plot



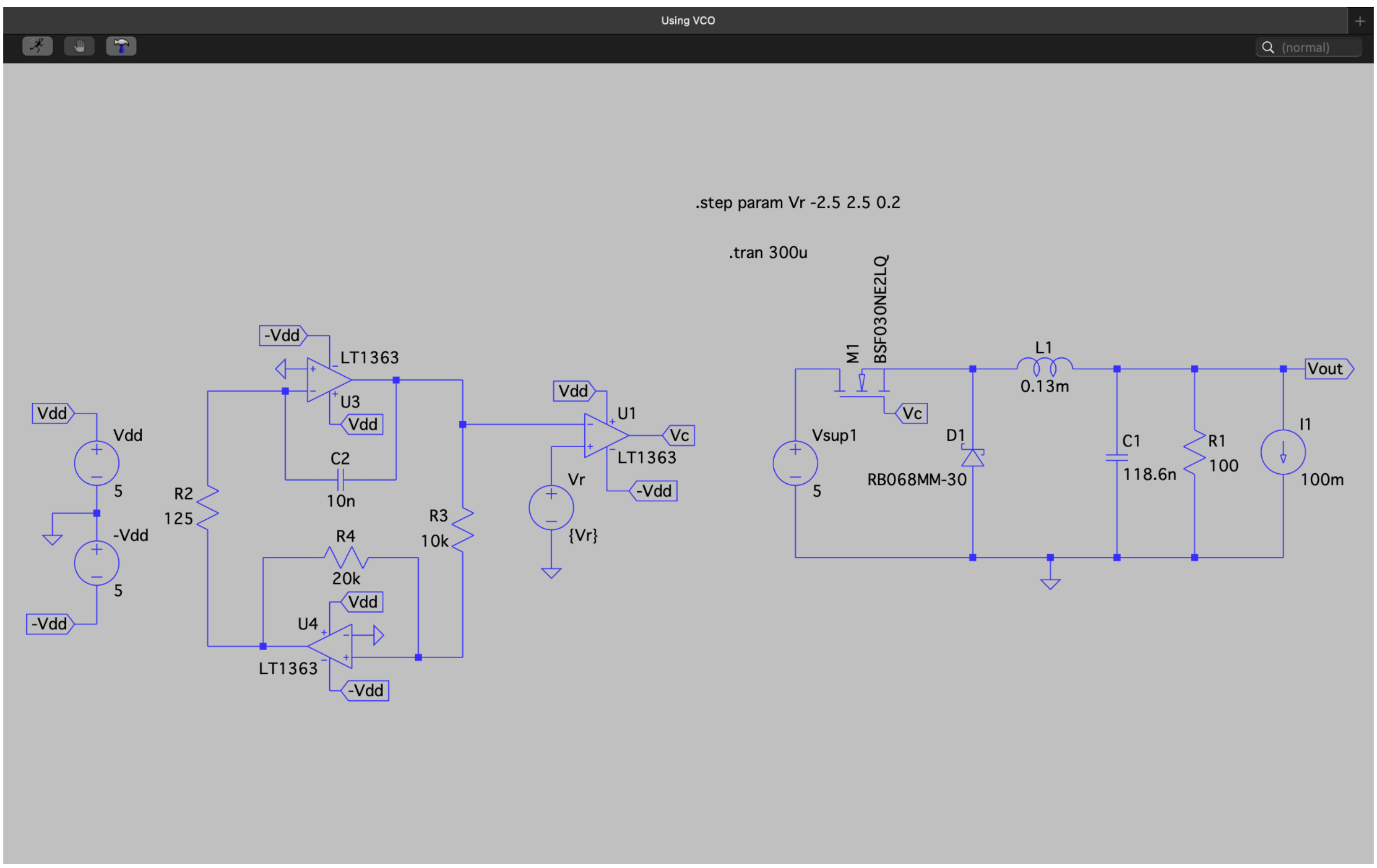
2. **To drive the switches with oscillator having input voltage to control duty cycle**

From class lectures, we can use a comparator (op-amp) which has two inputs - triangular wave and a reference voltage against which the comparator will compare and clip the voltage.

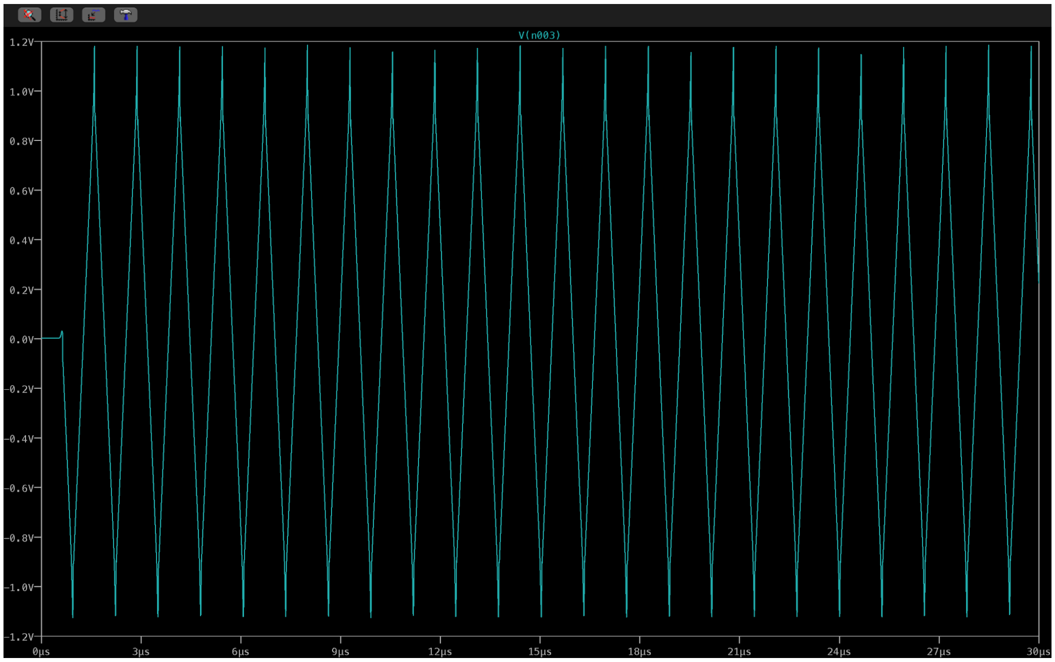
For the triangular wave generator, we can use the voltage controlled oscillator that we designed in experiment 5. The issue with that generator is that the voltage range is quite small, so I've changed the resistance values such that $R_4 = 2R_3$. Also I have used the LT1363 op-amp as the slew rate for LF347 was very low for 1 MHz frequencies.

So when V_R increases, $V_R - V_{traingle}$ is positive for more time and hence the duty cycle increases. To simulate various values of V_R , I've used the .step function.

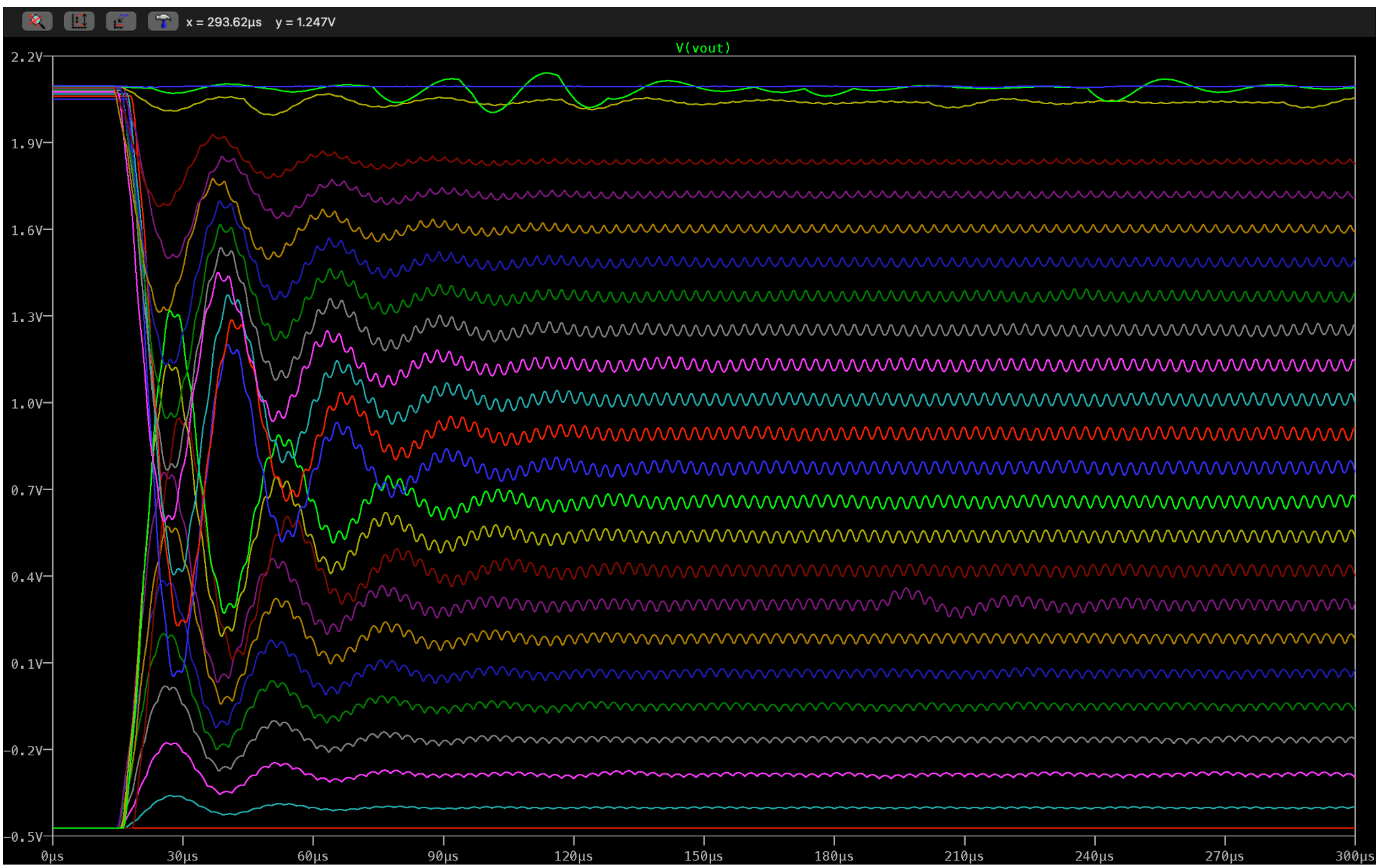
Implementation in LTSpice



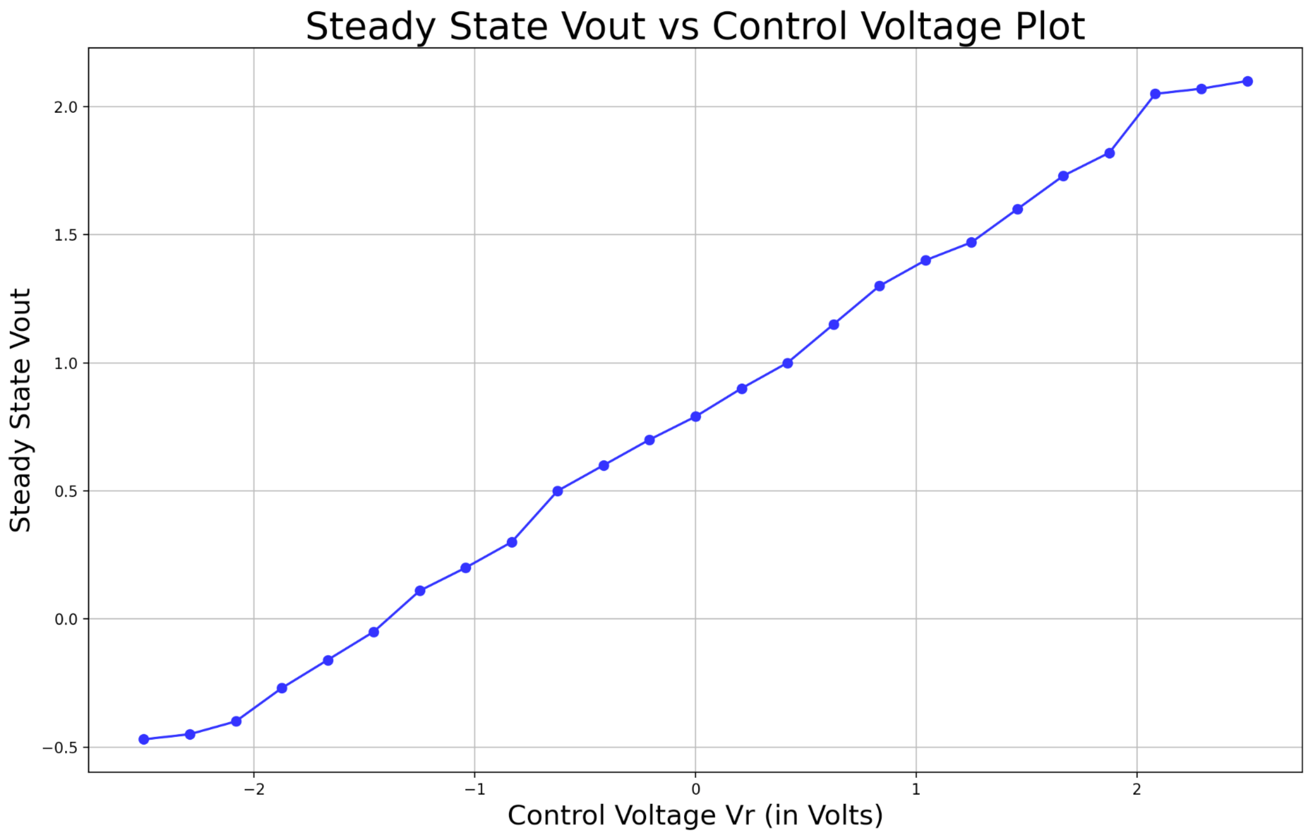
Triangular Waveform at $V_R = 0$



Output Plot for various V_R



Steady State V_{out} vs Various V_R



Some observations-

1) The transient and steady state responses are similar to the ones from experiment 7, slight deviation due to resistance of MOSFET and diode.
2) Steady State V_{out} vs V_R is almost linear plot, slight deviation due the oscillator.