ECE547-ENERGY MANAGEMENT SYSTEM

The energy management systems (EMS) play an important role in supplying the voltage to the circuits. The input current to the EMS is given by Energy harvesting circuit. This current varies from few nano amperes to microamperes. The EMS circuit stores the charge in a big capacitor until a threshold point is reached. The capacitor then dumps its charge to the design. This continues until a second threshold point is reached, capacitor stops discharging and then starts charging again. This process continues. The output of the EMS design should give 2mA for four seconds. The block diagram of the design is shown in figure.1

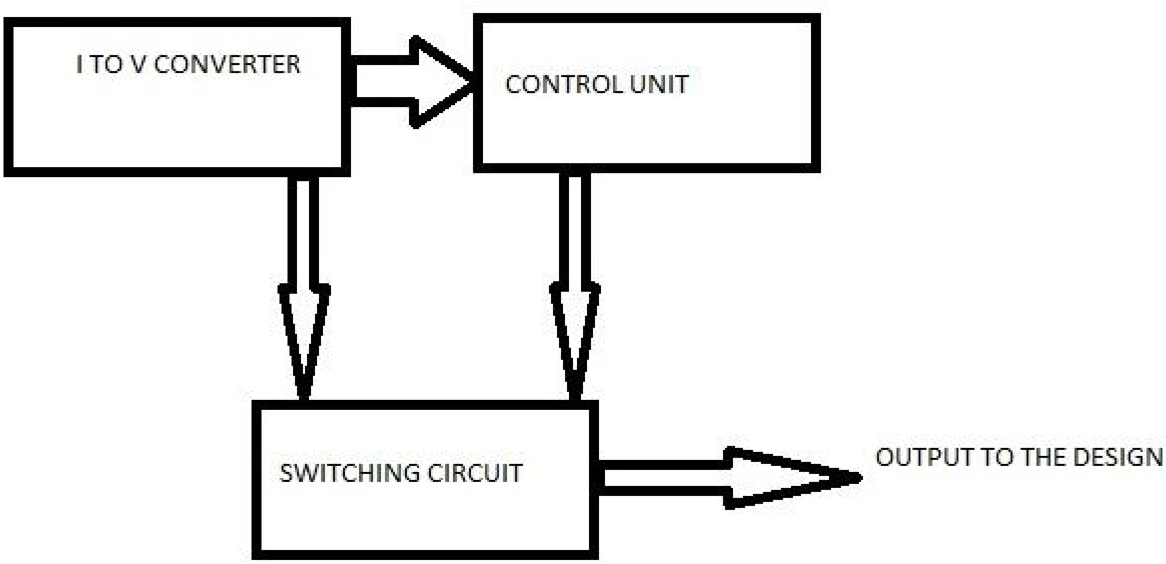

Figure 1: Block diagram of Energy Management Circuit.

EMS circuit consists of three sections that are described in the following sections.

1) I TO V CONVERTER.

2) CONTROL UNIT.

3) SWITCHING CIRCUIT.

The output of the EMS circuit has a valid voltage for more than 8 seconds.

I TO V CONVERTER (IVC)

IVC is divided into two sections.

SECTION I

The first section (circuit 1) is used to give supply voltage to the control unit. It consists of diodes and 100uF capacitor.

SECTION II

The second section (circuit 2) consists of diodes and 100mF capacitor that supplies voltage to the rest of the design.

Both the sections are implemented with three and four diodes connected back to back. The diodes are of havar model with 1um X 1um and 15 anode fingers.

The output voltage of both the circuits depends on the input current The IVC circuit is shown in figure 2.Both 100uF and 100mF capacitors are placed across the diodes. Firstly, the supply voltage to the control unit has to be high. The capacitor that is tied to supply should take less time to charge and hence it must be small.

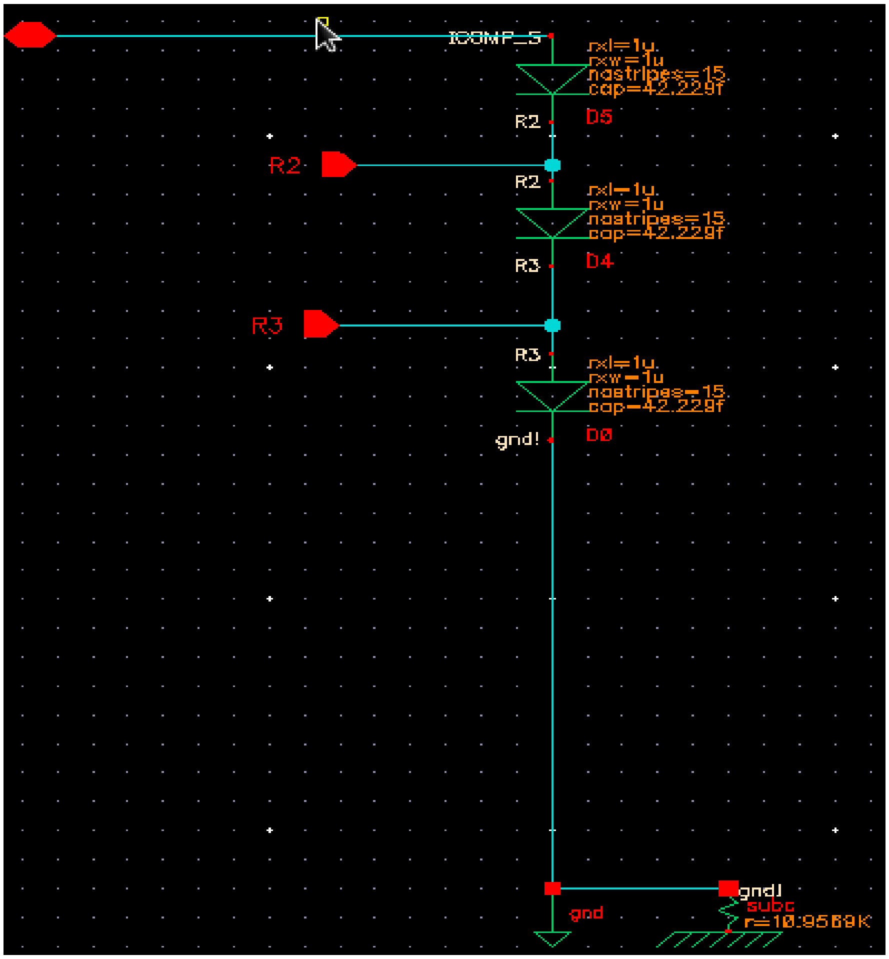

Figure 2(a): Schematic of ITOV Converter with three diodes.

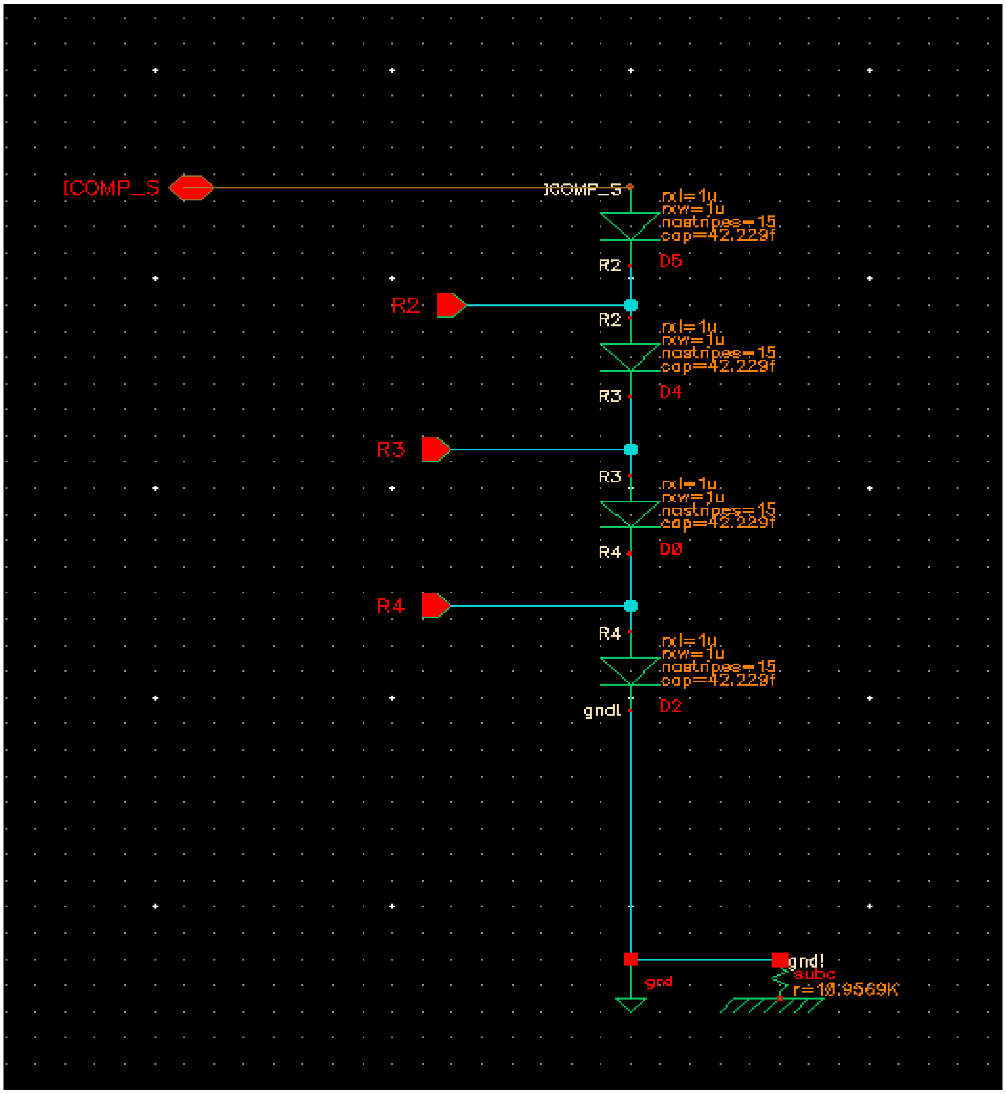

Figure 2(b): Schematic of ITOV Converter with four diodes.

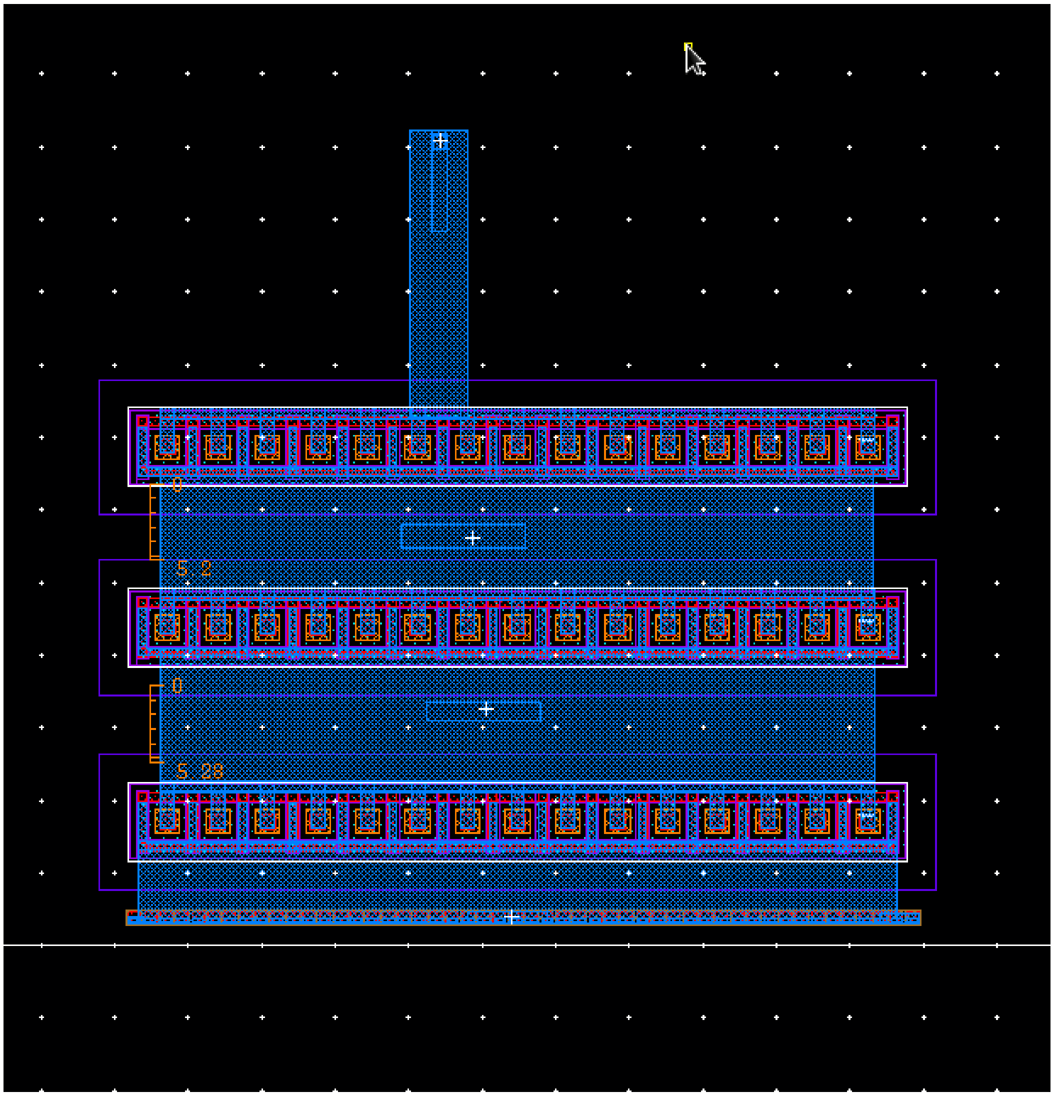

Figure 2(c): Layout of ITOV Converter with three diodes.

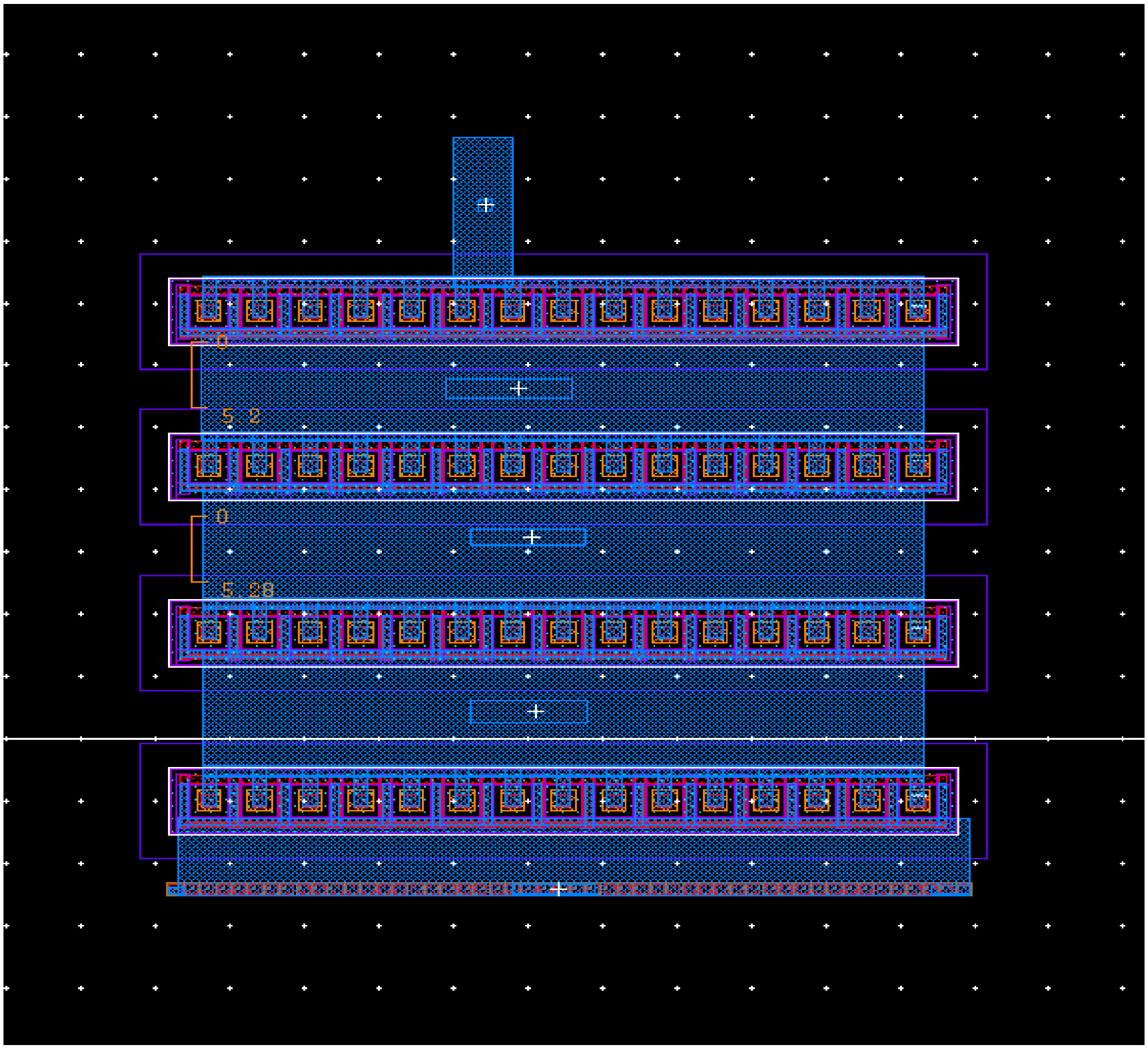

Figure 2(d): Layout of ITOV Converter with four diodes.

The simulation results of circuit1 with three and four diode configuration for 100nA and 1mA are shown in Figure 3.For 100nA and three diodes circuit1, the circuit takes 3 Kilo Seconds to charge from 0 V to 1.75 V and for 1mA, the circuit takes 3s to charge from 0V to 2.67V.

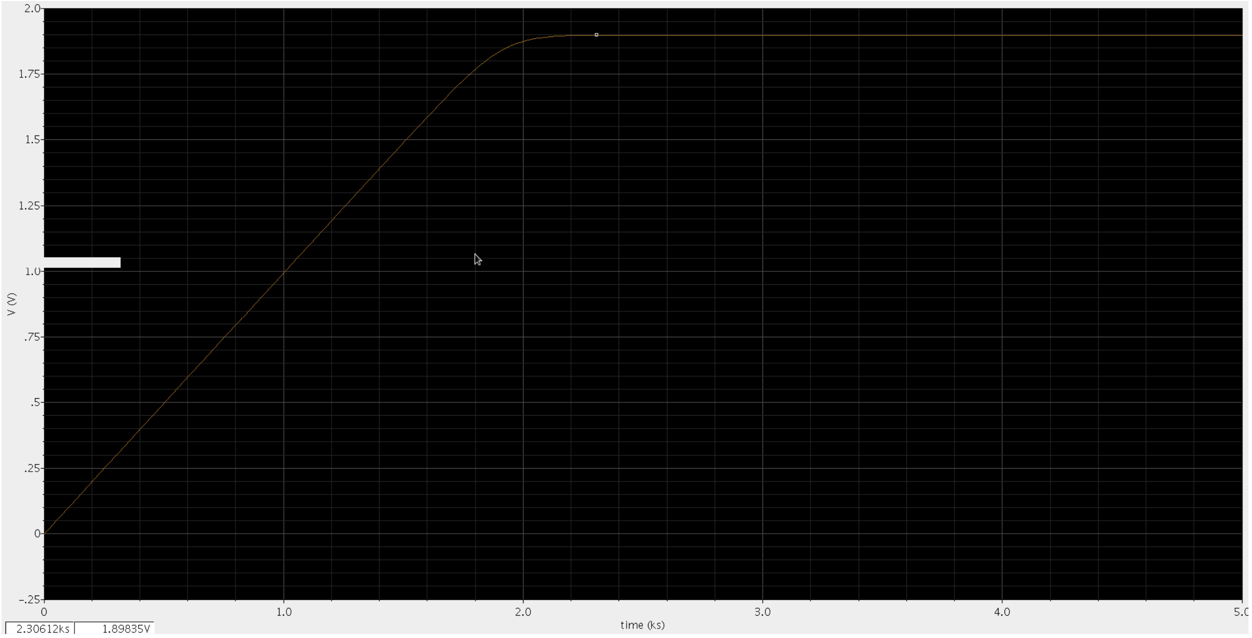

Figure 3(a) : Output of circuit1 with three diodes and 100uF capacitor across the diodes with input current is 100nA.

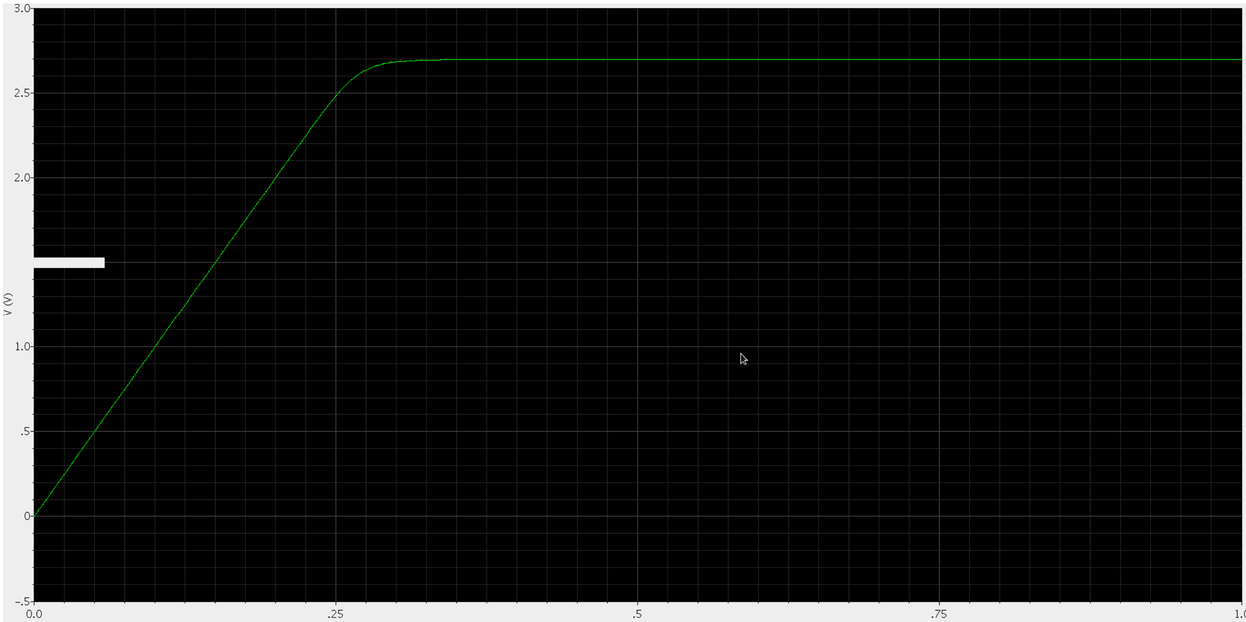

Figure 3(b) : Output of circuit1 with 100uF capacitor across the diodes and input current is 1mA.

For 100nA and four diodes circuit1, the circuit takes 3 Kilo Seconds to charge from 0 V to 2.5 V and for 1mA, the circuit takes 0.4s to charge from 0V to 3.5V.

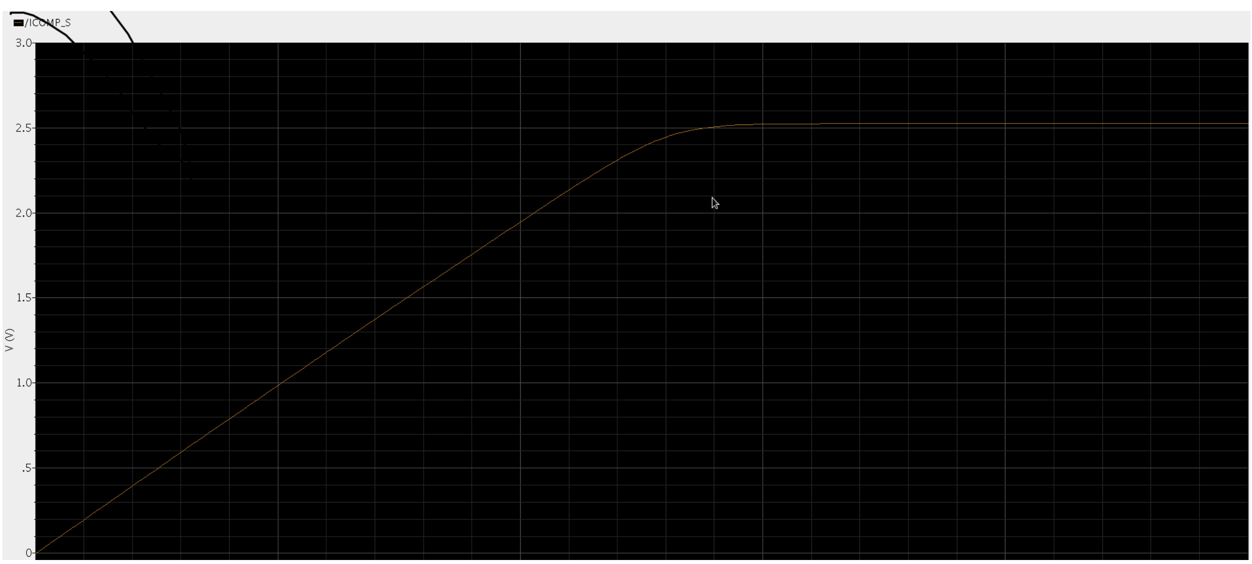

Figure 3(c) : Output of circuit1 with four diodes and 100uF capacitor across the diodes with input current is 100nA.

Figure 3(d) : Output of circuit1 with four diodes and 100uF capacitor across the diodes with input current is 100nA.

The simulation results of circuit 2 for 100nA and 1mA with three and four diode configuration is shown in figure 4. For 100nA and three diodes, the circuit takes 2 Mega Seconds to charge from 0 V to 1.75 V and for 1mA, the circuit takes 250 seconds to charge from 0V to 2.67V.

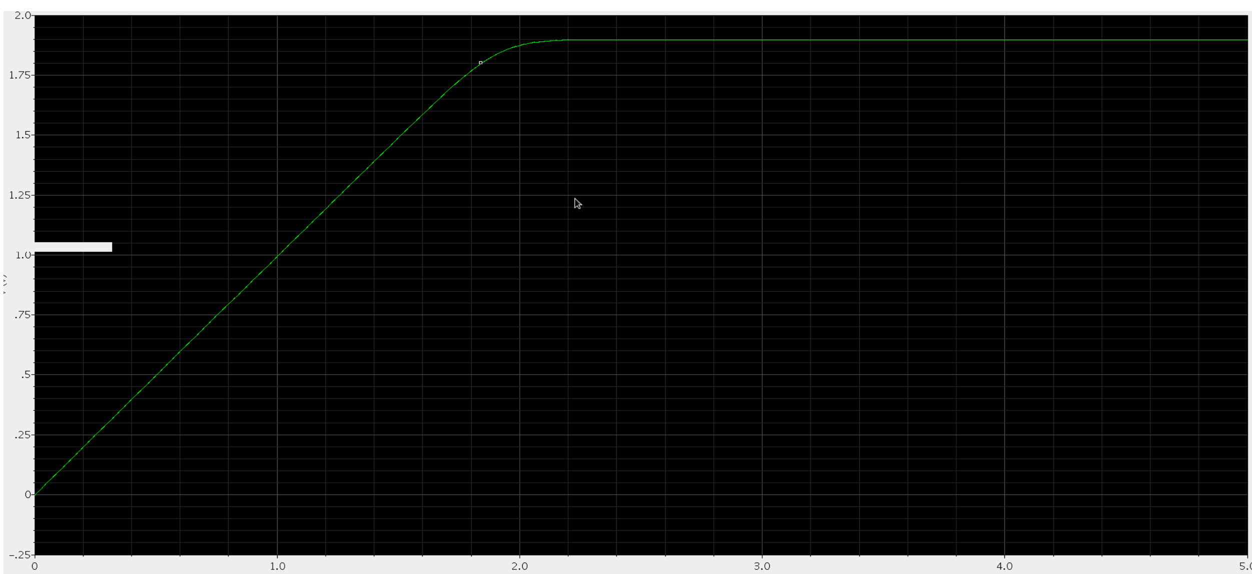

Figure 4(a) : Output of circuit2 with 100mF capacitor across three diodes and 100nA input current.

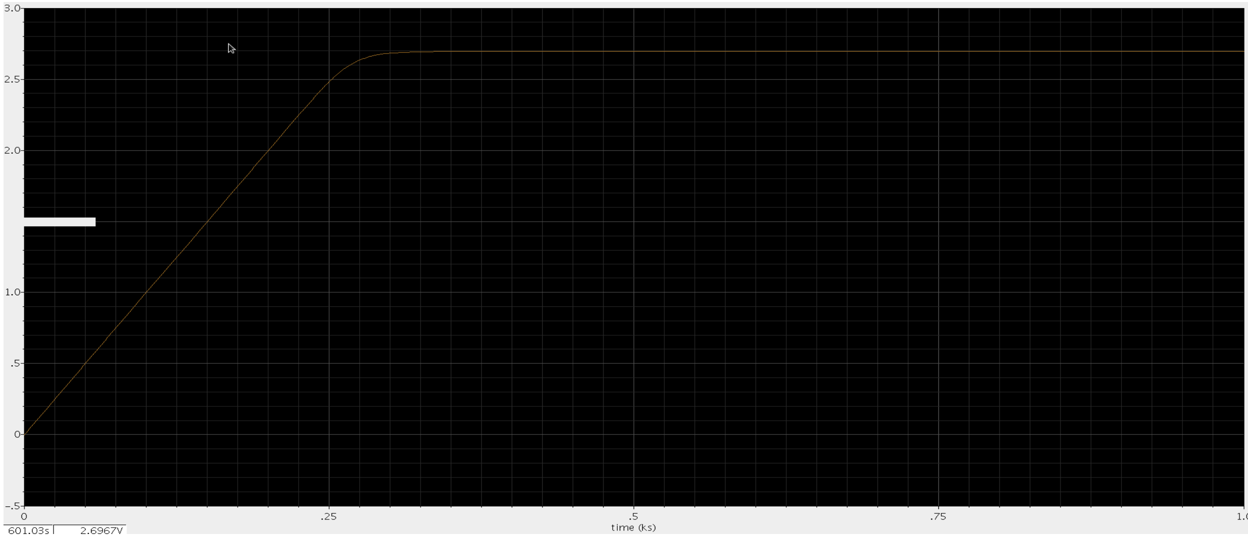

Figure 4(b) : Output of circuit2 with 100mF capacitor across three diodes and 1mA input current.

For 100nA and four diodes, the circuit takes 2.7 Mega Seconds to charge from 0 V to 2.5 V and for 1mA, the circuit takes 400 seconds to charge from 0V to 3.5V.

Figure 4(c) : Output of circuit2 with 100mF capacitor across four diodes and 100nA input current.

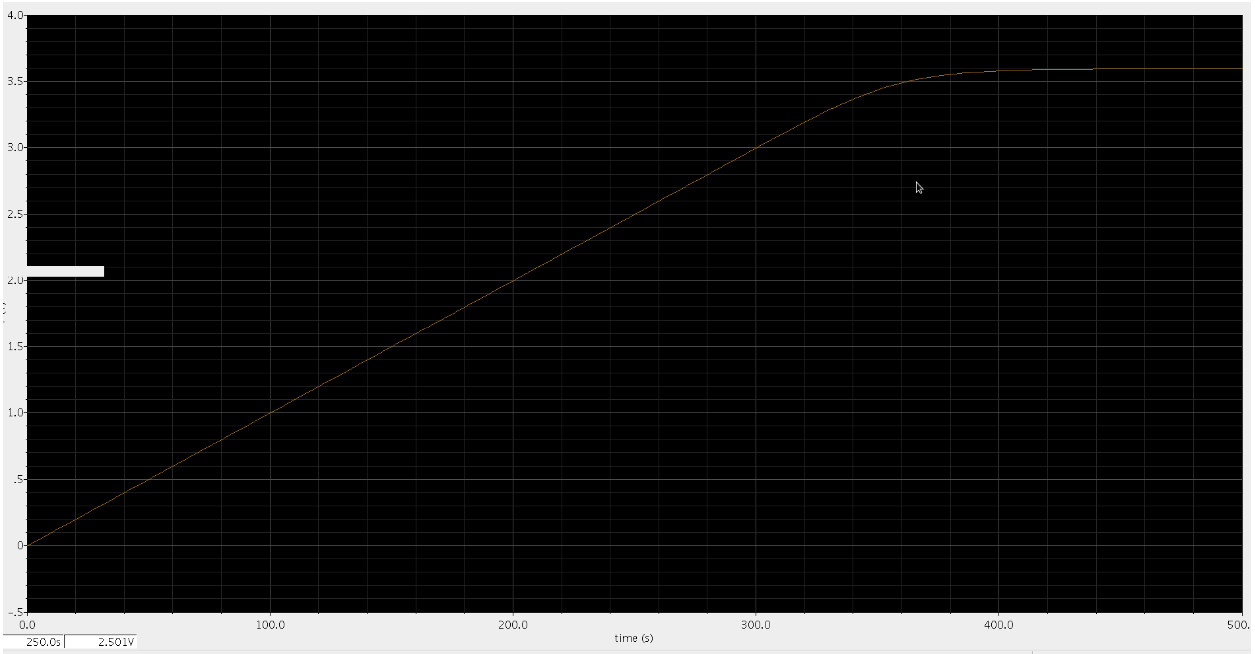

Figure 4(d) : Output of circuit2 with 100mF capacitor across four diodes and 1mA input current.

CONTROL UNIT

The control unit is a hysteresis comparator. The current drawn by the comparator is controlled by current mirror. As the comparator must operate for low currents, wilson current mirror is used for this application. The comparator with Wilson current mirror draws of about 70nA.

The hysteresis comparator is shown in figure 5.

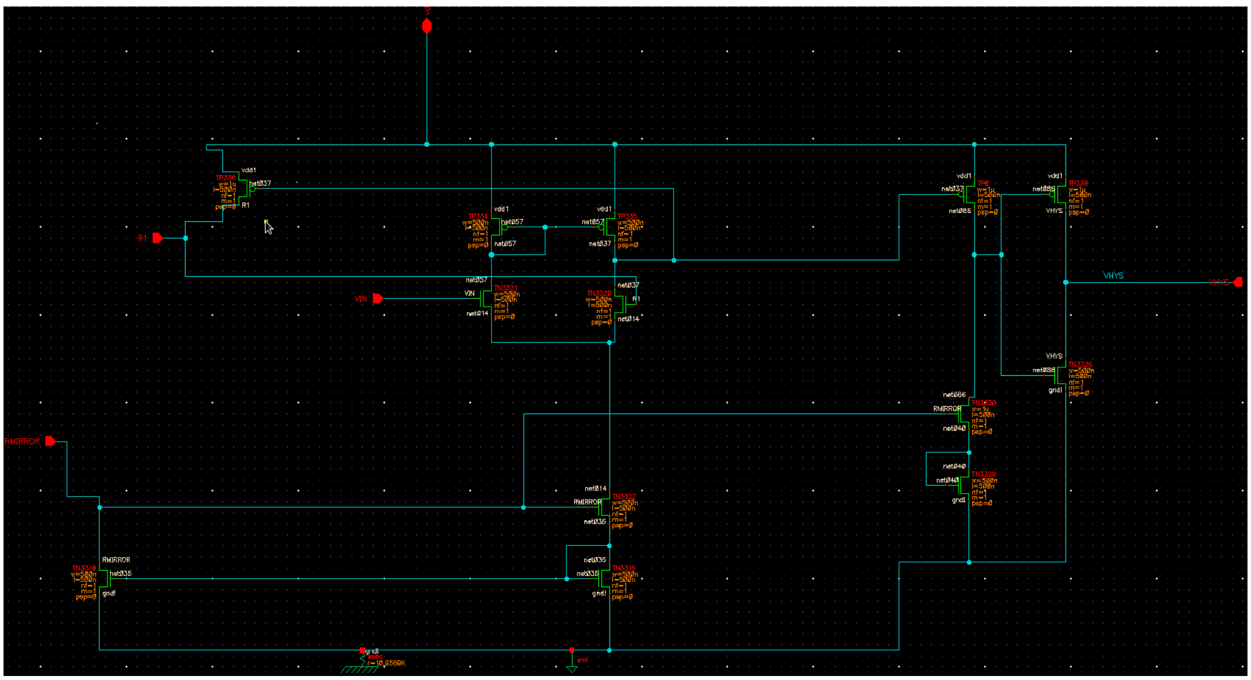

Figure 5(a): Schematic of Hysteresis Comparator.

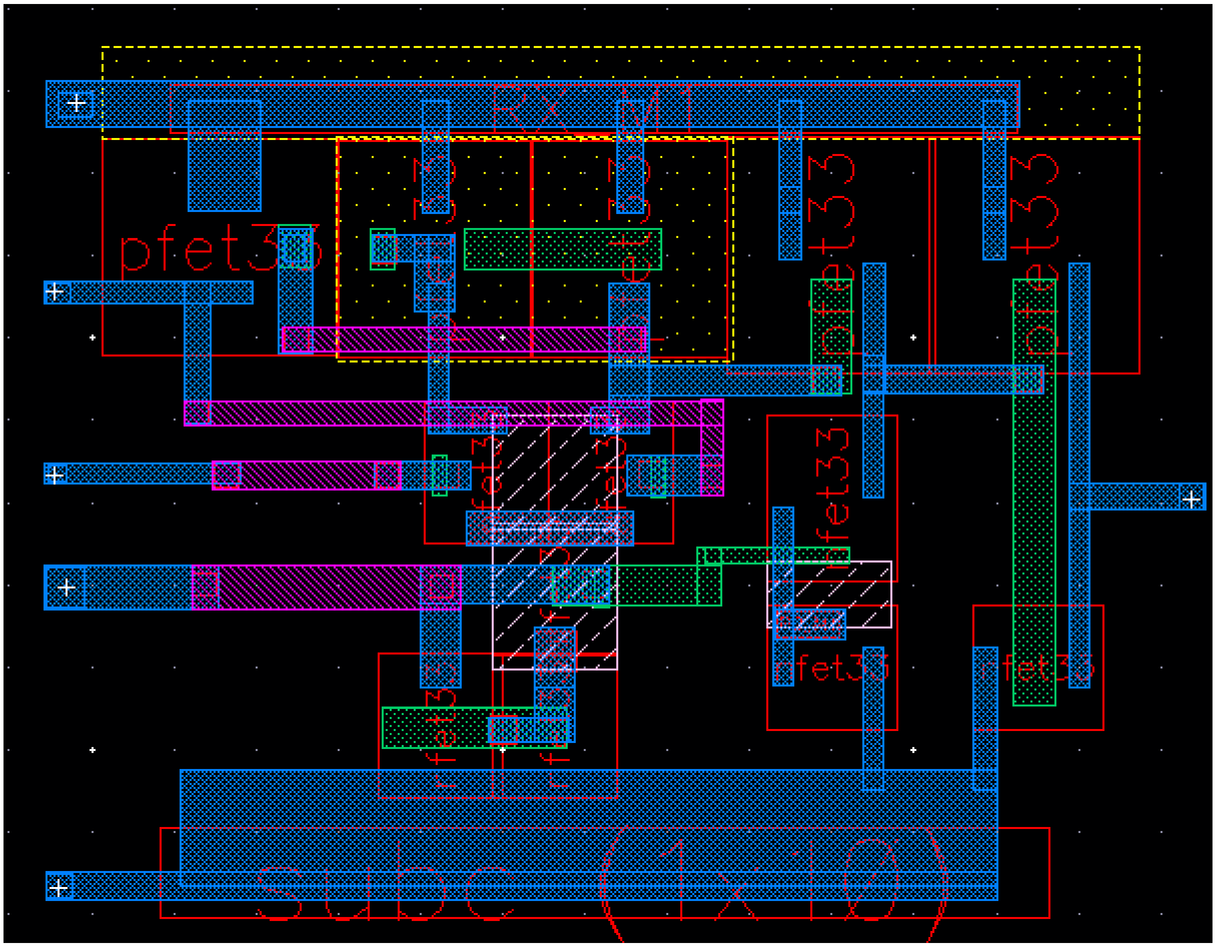

Figure 5(b): Layout of Hysteresis Comparator

Operation

The Upper and lower threshold points of hysteresis comparator are determined as follows

THRESHOLD POINTS

At initial time t=0 seconds, the output of the comparator is 0.This 0 Volts is the input to the control gate which shorts drain and source of the control gate. The supply voltage will be seen at the other input of the difference amplifier that acts as upper threshold point.

When the input of the comparator is at the upper threshold point the comparator output switches from 0 Volts to supply Voltage.

At this time the input to the control gate is high and it will be in OFF state. Then the lower threshold point is given by

VTLP = Vsupply * R1/(R1+R2).

When the input of the comparator is at lower threshold point the comparator output switches from the supply voltage to 0 Volts.

The hysteresis and transient simulation results of the comparator for 1.75 V and 2.67 V are shown in figure 6 and figure 7.

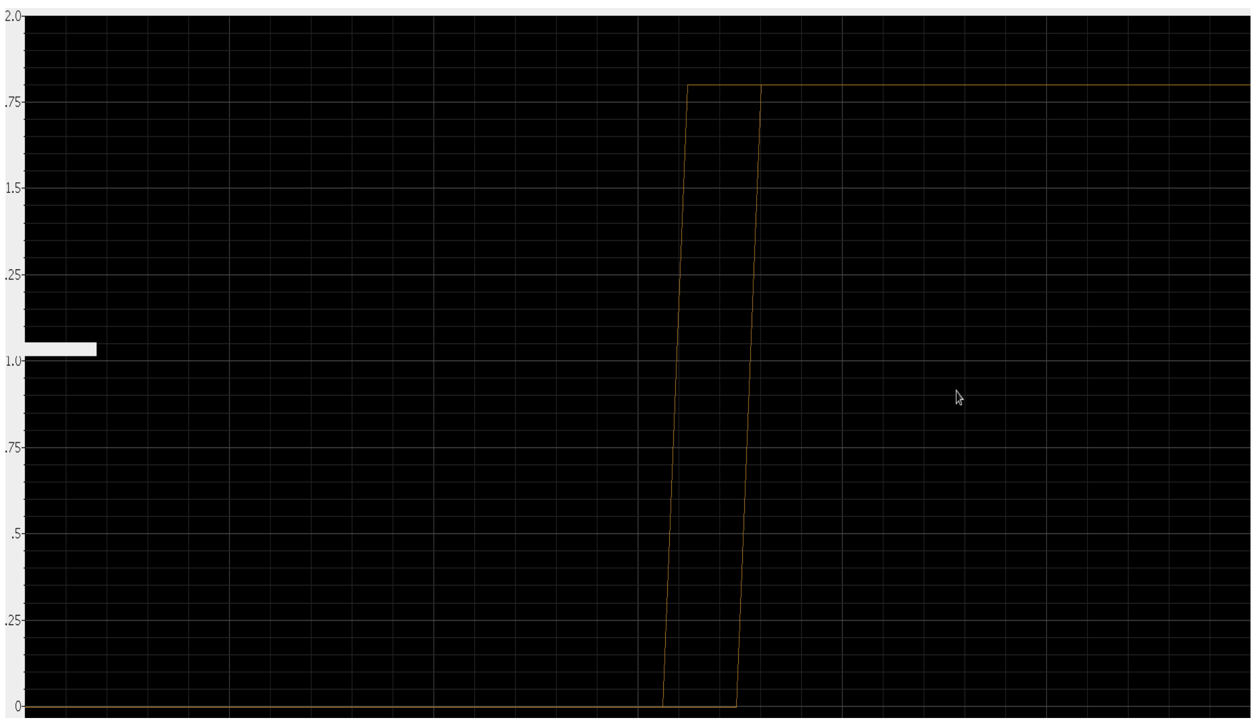

Figure 6(a) : Hysteresis response for supply voltage 1.8 Volts.

Figure 6(b) : Hysteresis response for supply voltage 2.67 Volts.

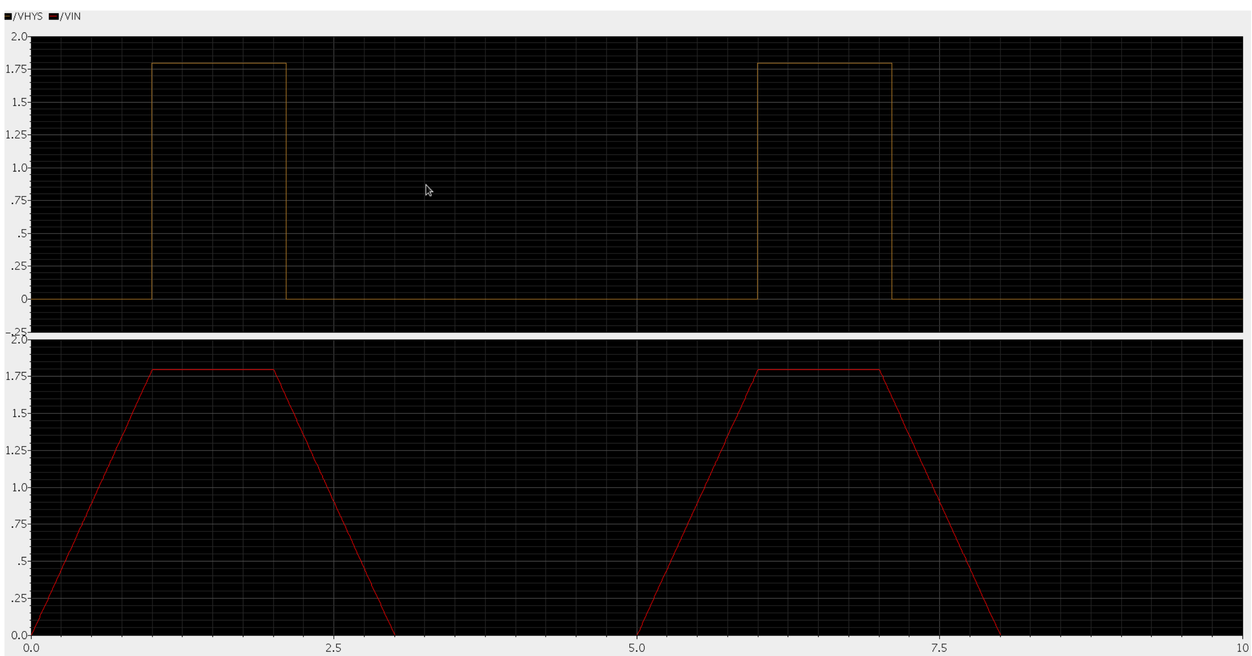

Figure 7(a) : Transient response for supply voltage is 1.8 Volts.

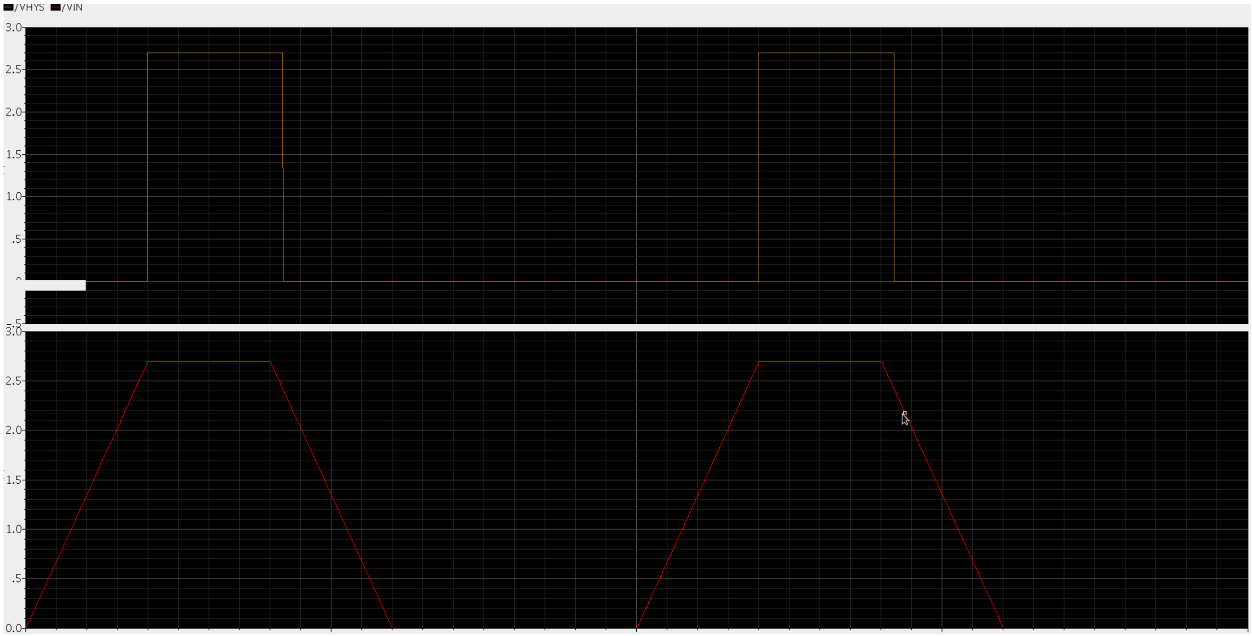

Figure 7(b) : Transient response for supply voltage is 2.7 Volts.

SWITCH

The switch is designed with PMOS transistor. It is PMOS pass transistor. The width of the switch is high approximately 1mm to drive the maximum current to the output.

DESIGN

The schematic and layout of the design is shown in the figure 8.

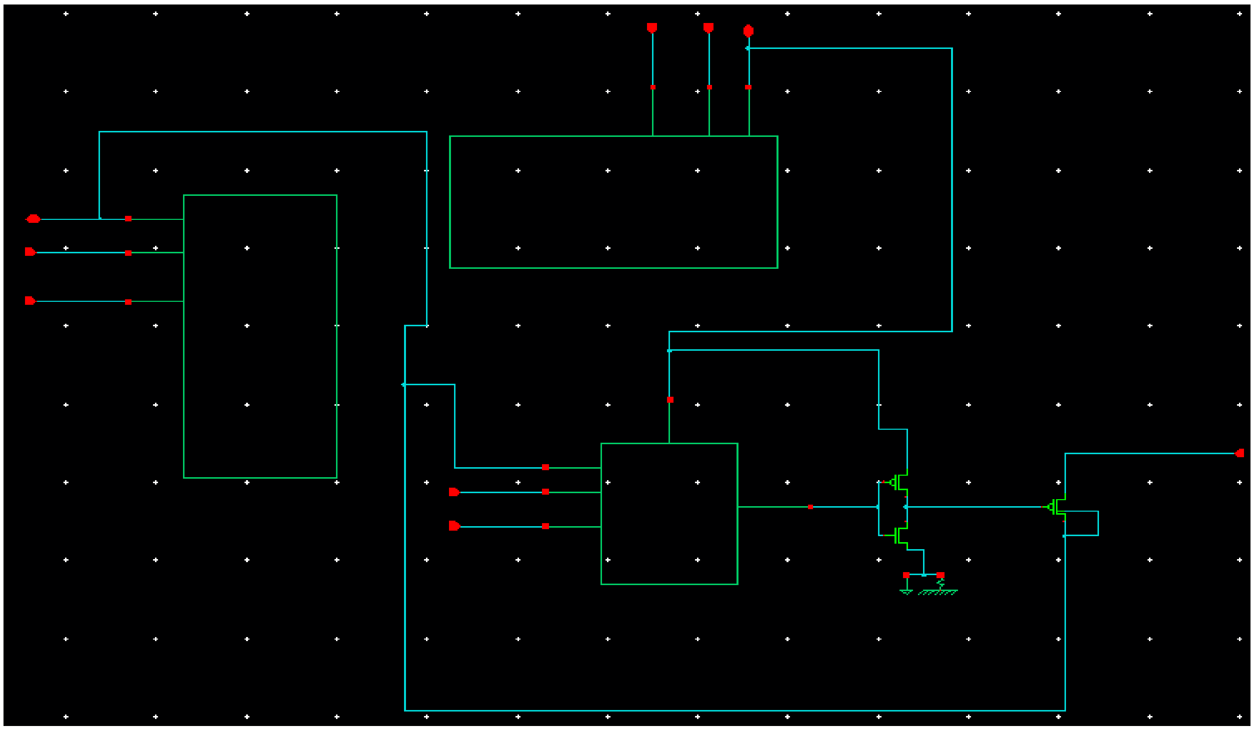

Figure 8(a) : Schematic of Energy Management System.

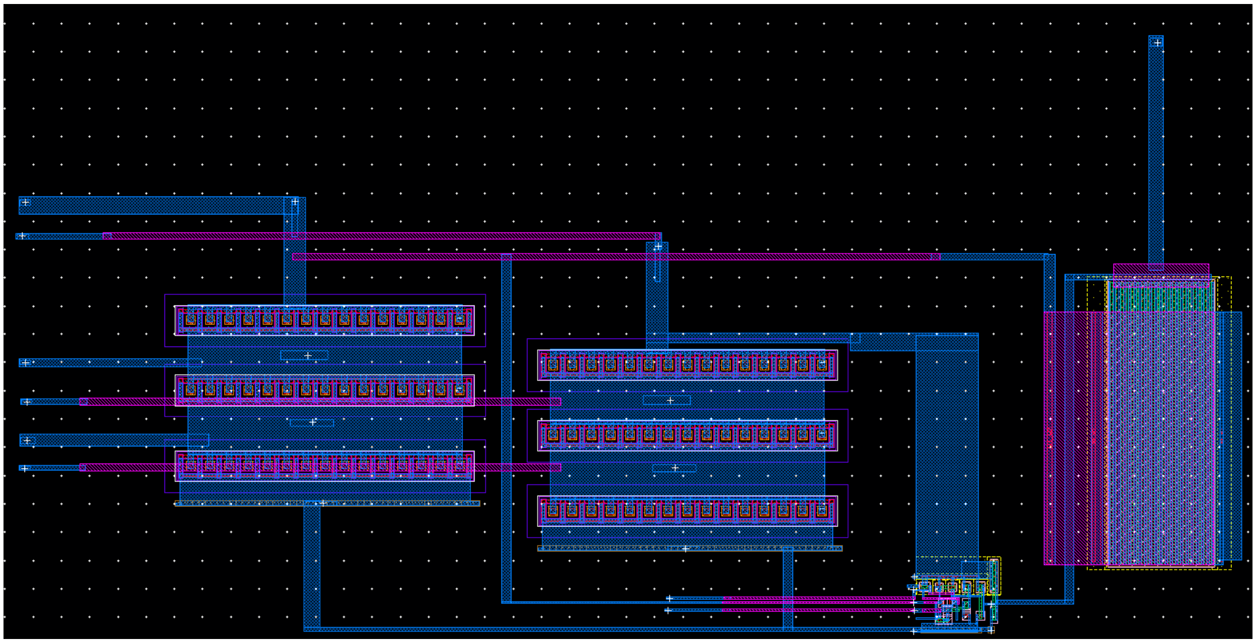

Figure 8(b): Layout of Energy Management System with three diodes.

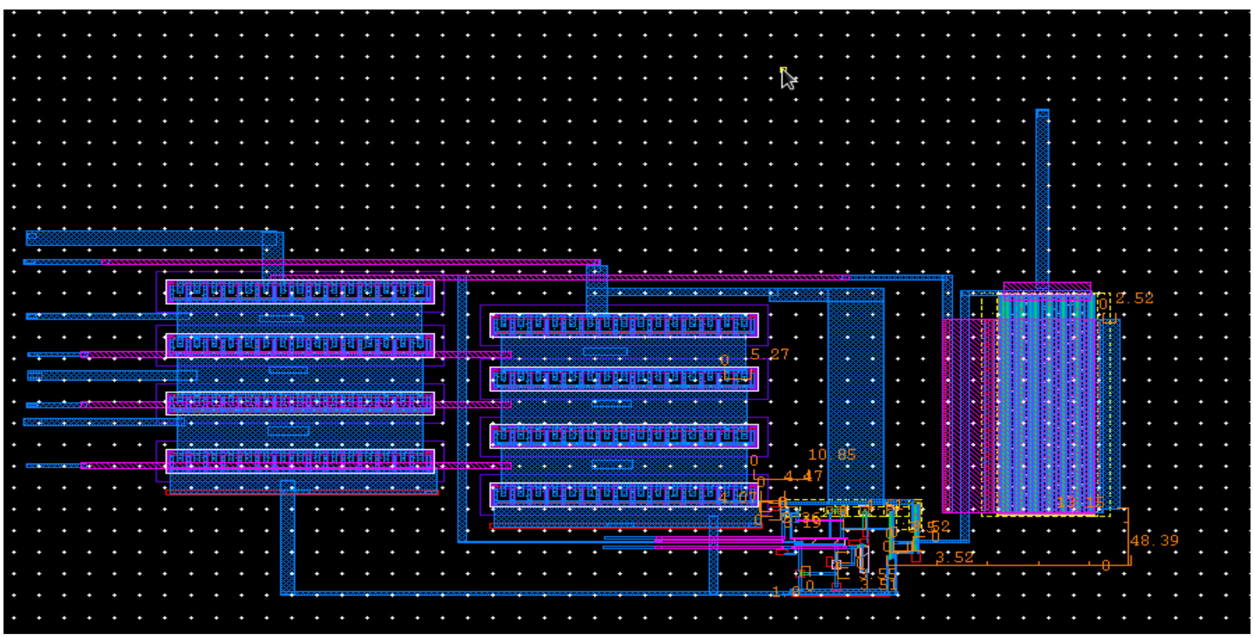

Figure 8(b): Layout of Energy Management System with four diodes.

SIMULATION RESULTS

The simulation result of the total design for 100nA is shown in figure 9(a).

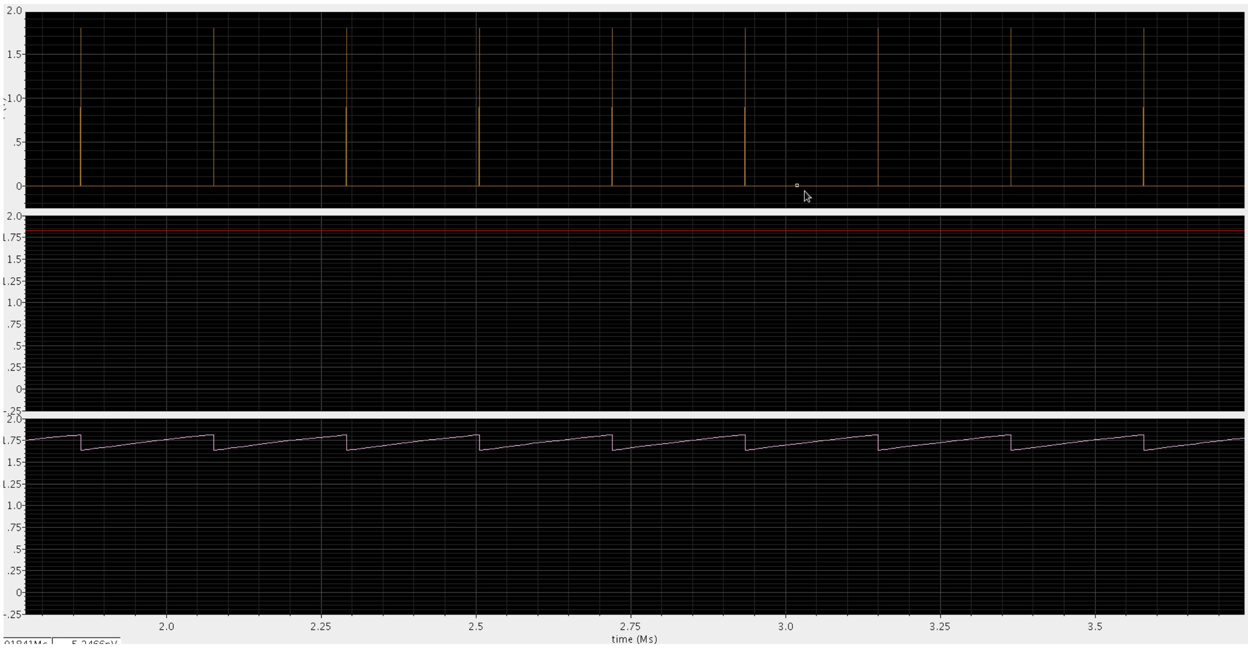

Figure 9(a) : Output of EMS , Supply Voltage 1.8 Volts to the comparator and input to the comparator. This is implemented by using three diode configuration.

The simulation result for 1mA is shown in figure 9(b).

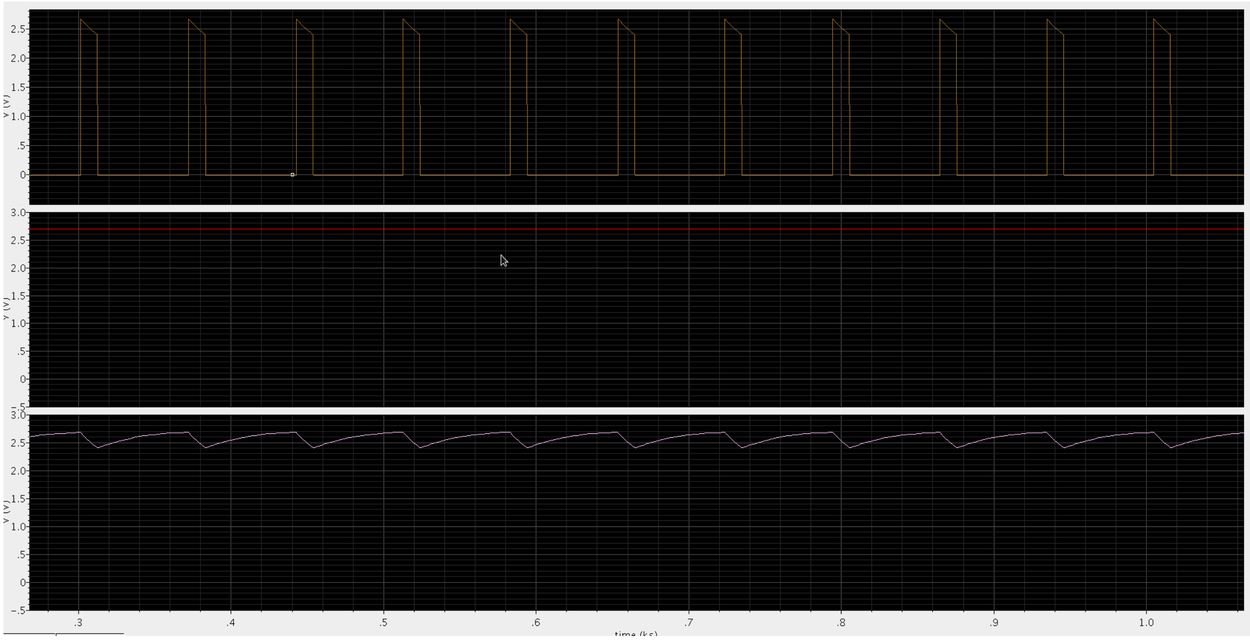

Figure 9(b) : Output of EMS , Supply Voltage 2.7 Volts to the comparator and input to the comparator. This is implemented by using three diode configuration.

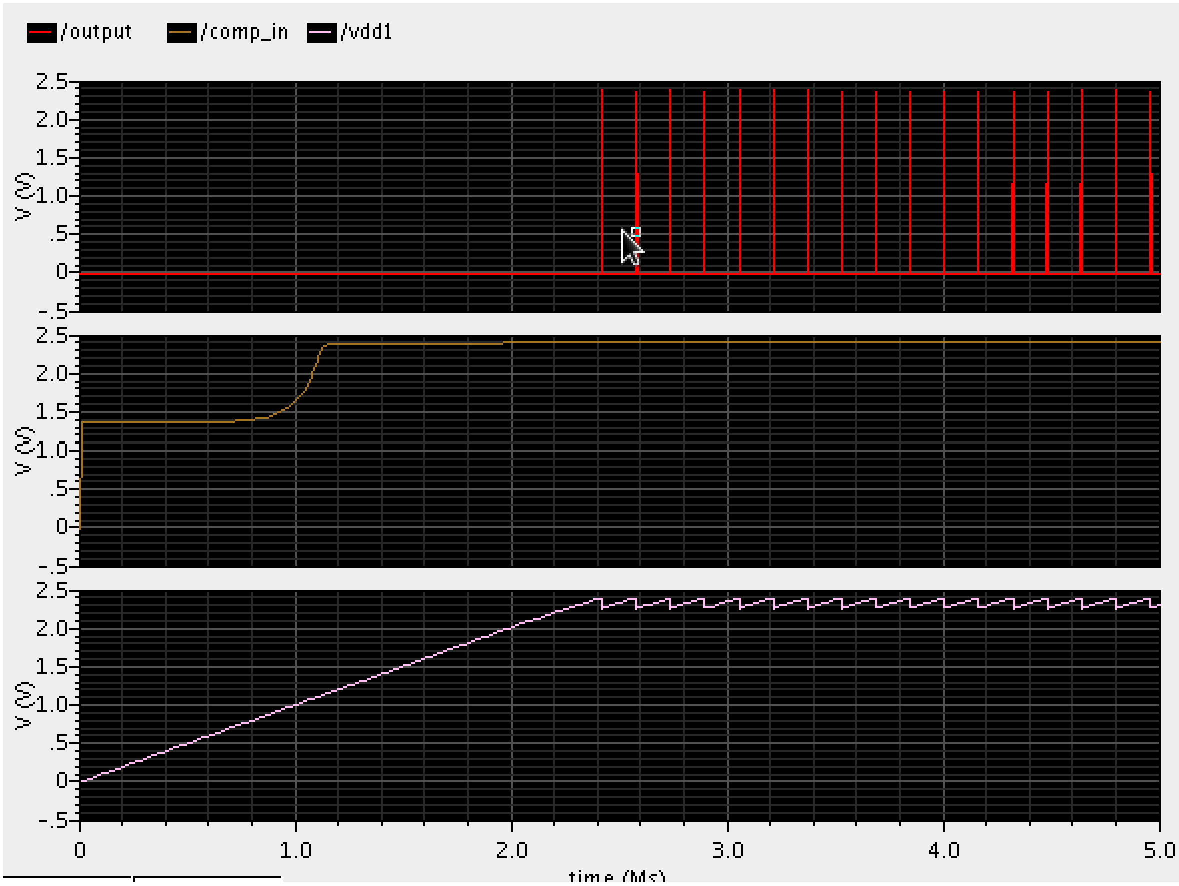

Figure 9(c) : Output of EMS , Supply Voltage 2.5 Volts to the comparator and input to the comparator. This is implemented by using four diode configuration.

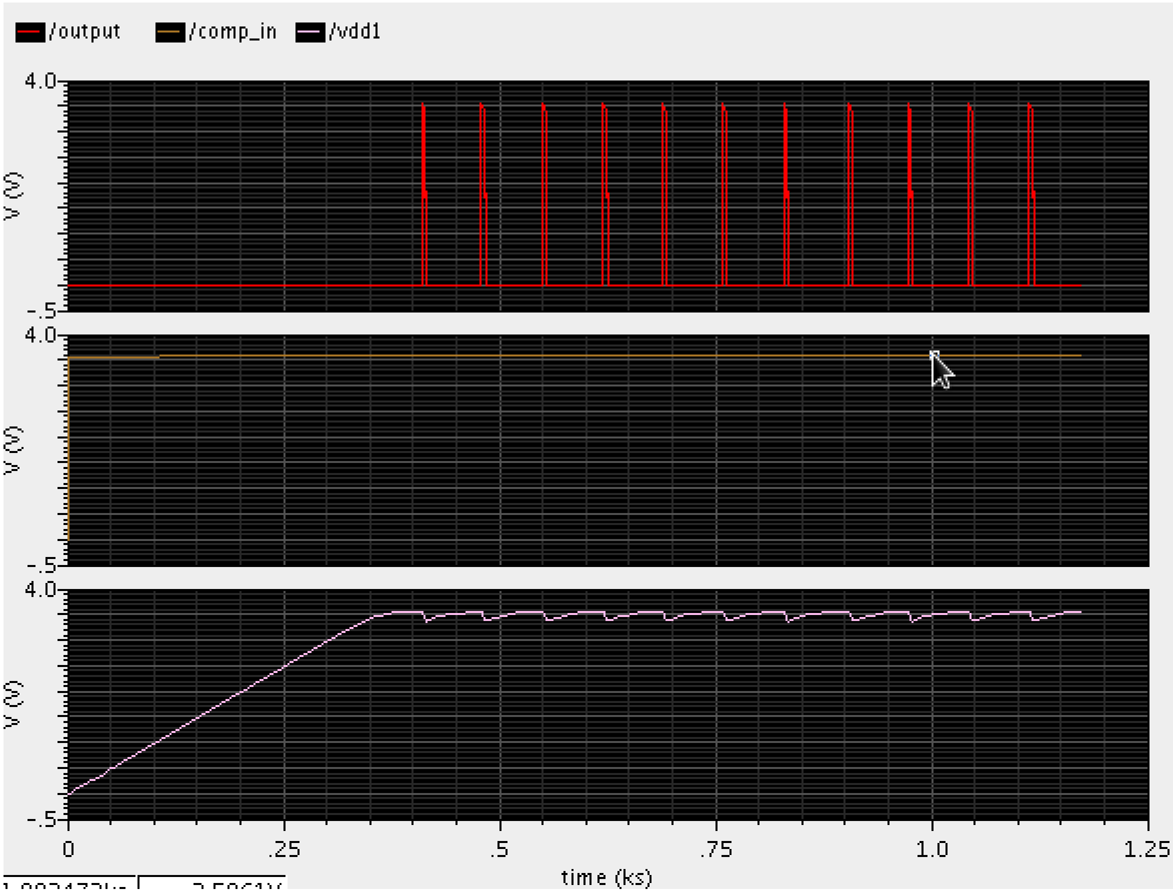

Figure 9(d) : Output of EMS , Supply Voltage 3.5 Volts to the comparator and input to the comparator. This is implemented by using four diode configuration.

The schematic and layout of the entire design is shown in figure 10.

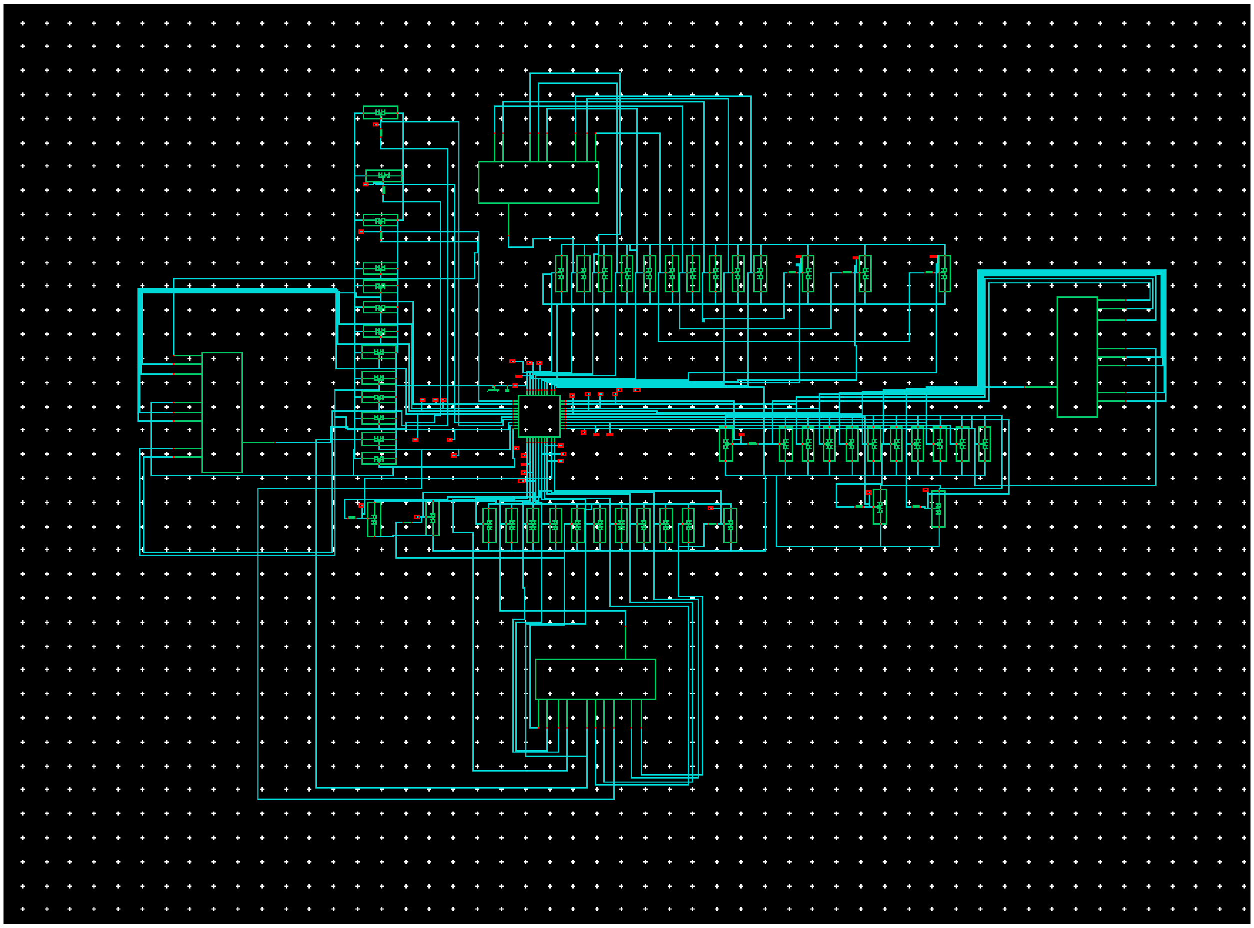

Figure 10(a) : Schematic of the chip.

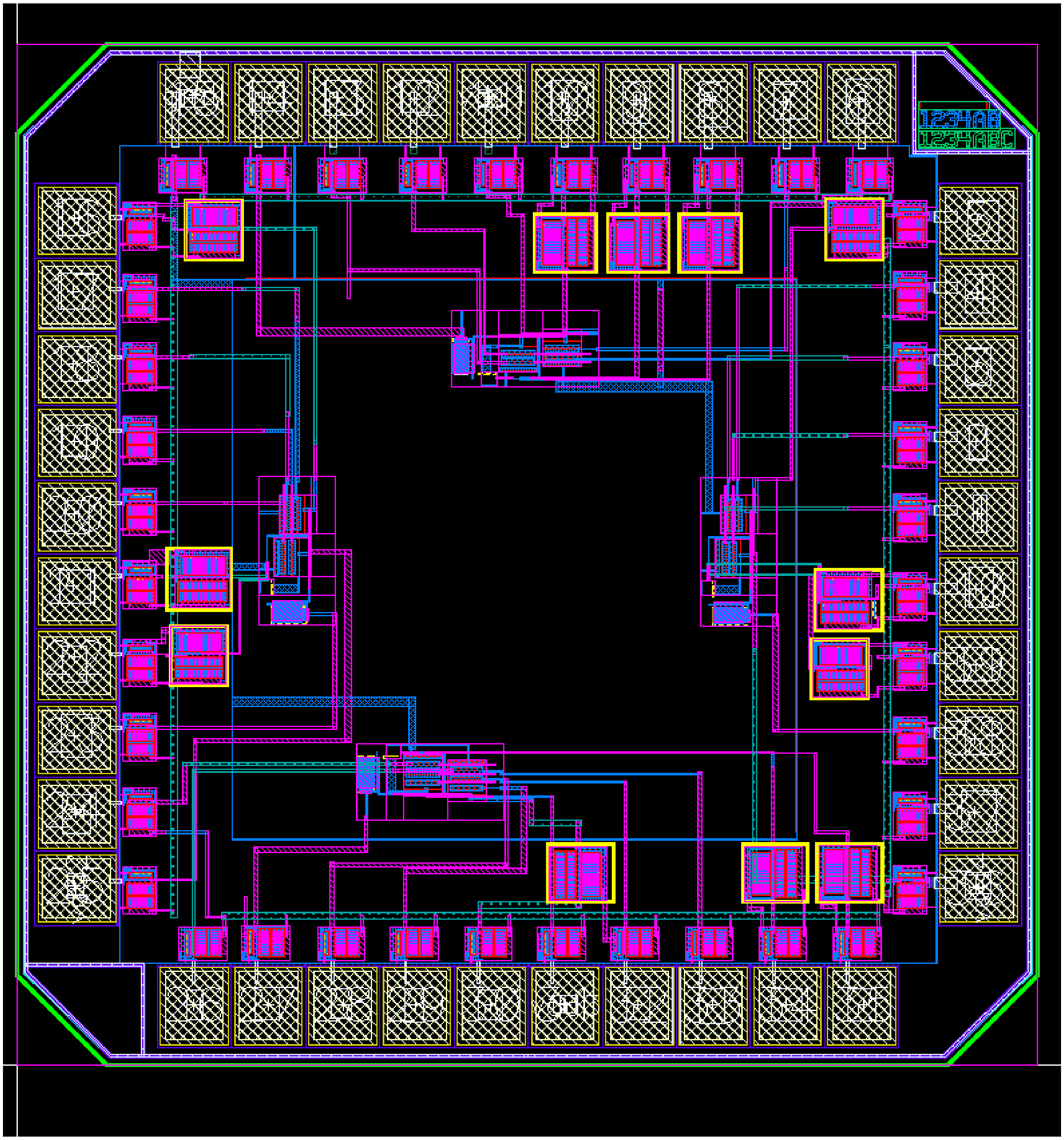

Figure 10(b) : Layout of the chip.