ECE 531

Microelectronics

Assignment 2

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Problem 1:

The circuit diagram in LTSpice is shown below:

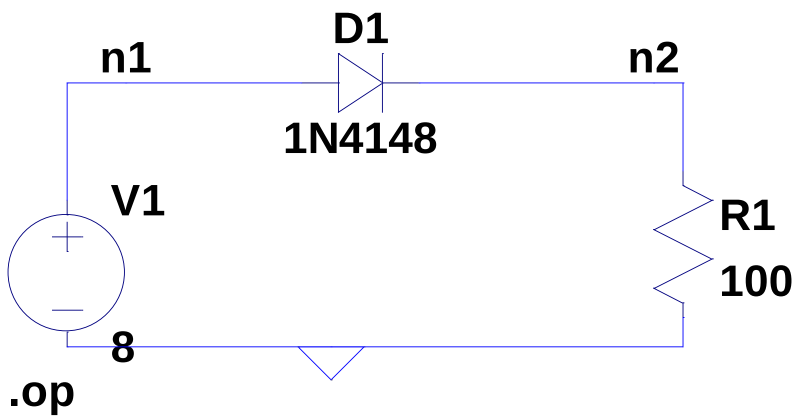


Figure1: Diode circuit

The operating point window is shown below

```
       --- Operating Point ---

V(n1):          8              voltage
V(n2):          7.18122        voltage
I(D1):          0.0718122      device_current
I(R1):          0.0718122      device_current
I(V1):          -0.0718122     device_current
```

Figure2: Operating point window

The current $I_d =$ 71.81 mA.

Problem 2: Voltage source (peak-peak) = 16 V_{p-p} frequency = 400 Hz

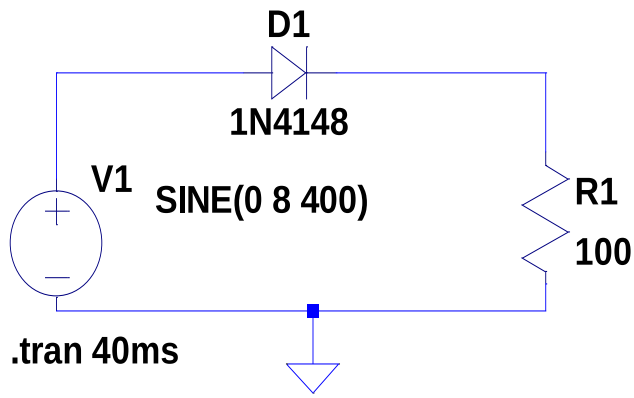


Figure 3: Half wave rectifier circuit

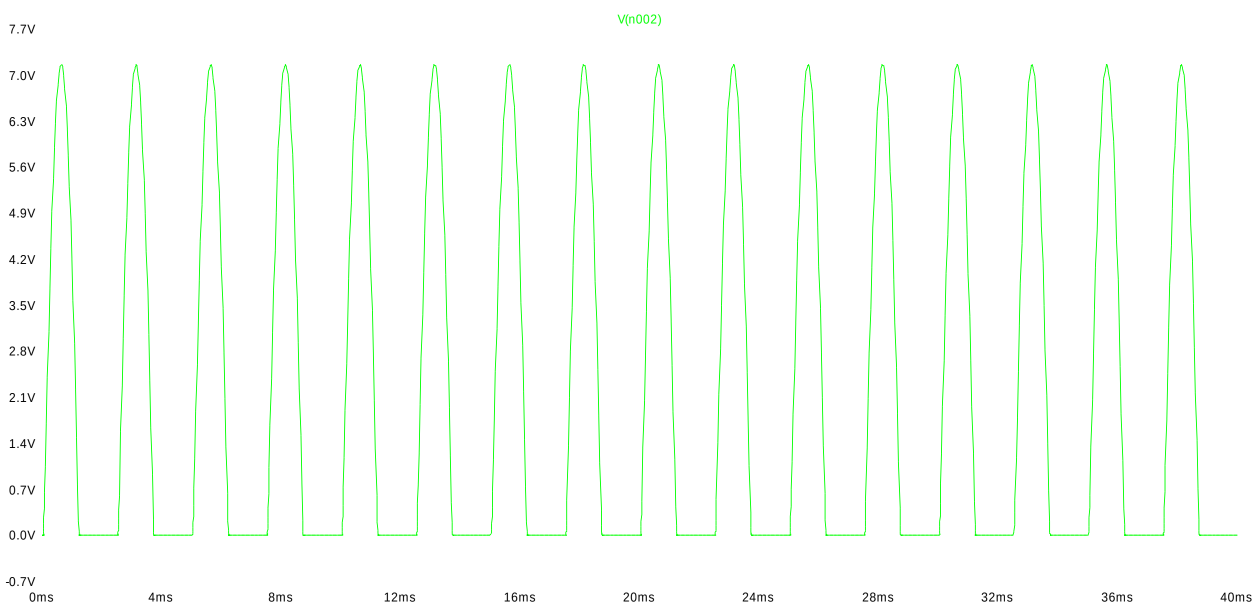


Figure 4: Rectified output simulation

Problem 3:

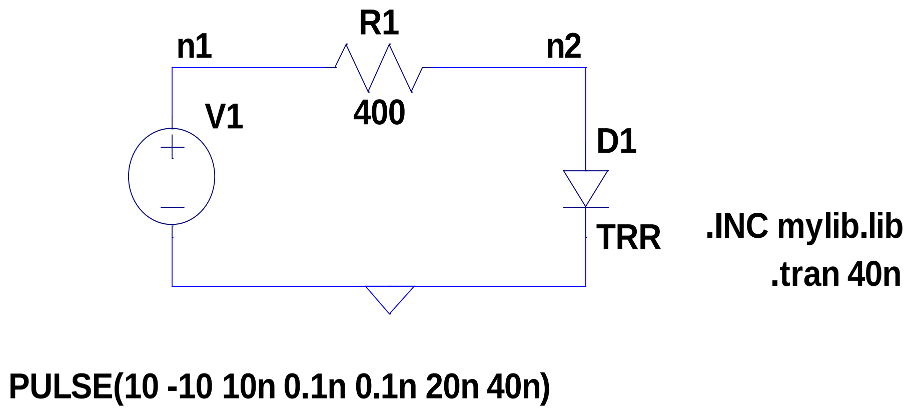


Figure 5: Diode test circuit

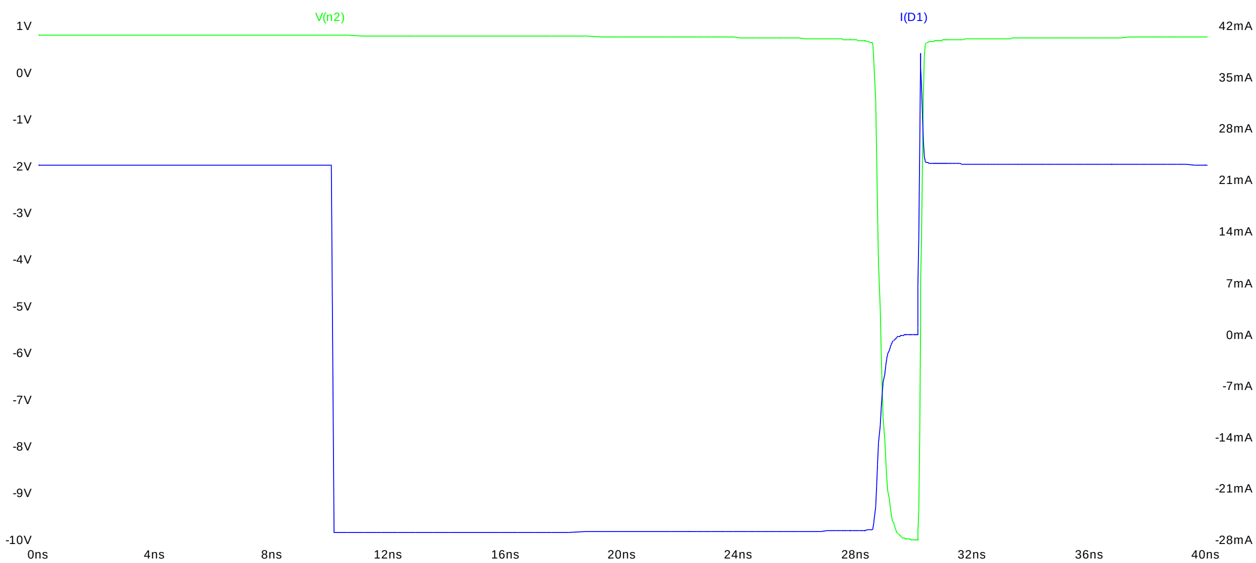


Figure 6: Simulation result of the diode circuit

Now using IS=1E-16, TT=25e-9, and VJ=0.75 for the above diode circuit

The simulation result for the above circuit using new mylib.lib is shown below

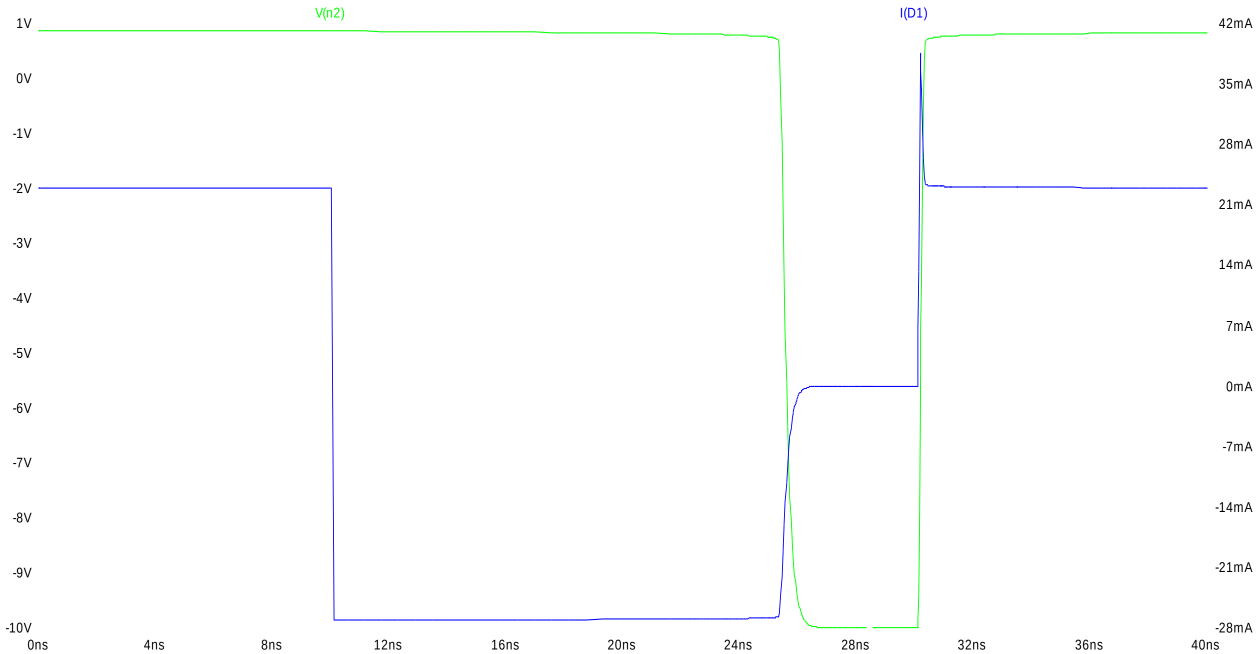


Figure 7: Simulation result using IS=1E-16, TT=25e-9, and VJ=0.75

From the above simulation:

The forward bias current $i_F = 22.862062mA$

The reverse bias current $i_R = -27.089319mA$

τ_T =25e-9

Diode storage time $t_S = \tau_T * \ln\left(\frac{i_F - i_R}{-i_R}\right)$

$$= \tau_T * \ln\left(\frac{22.86+27.08}{27.08}\right)$$

$$= \tau_T * 0.612$$

Diode storage time t_S= 15.3 ns

Result from simulation

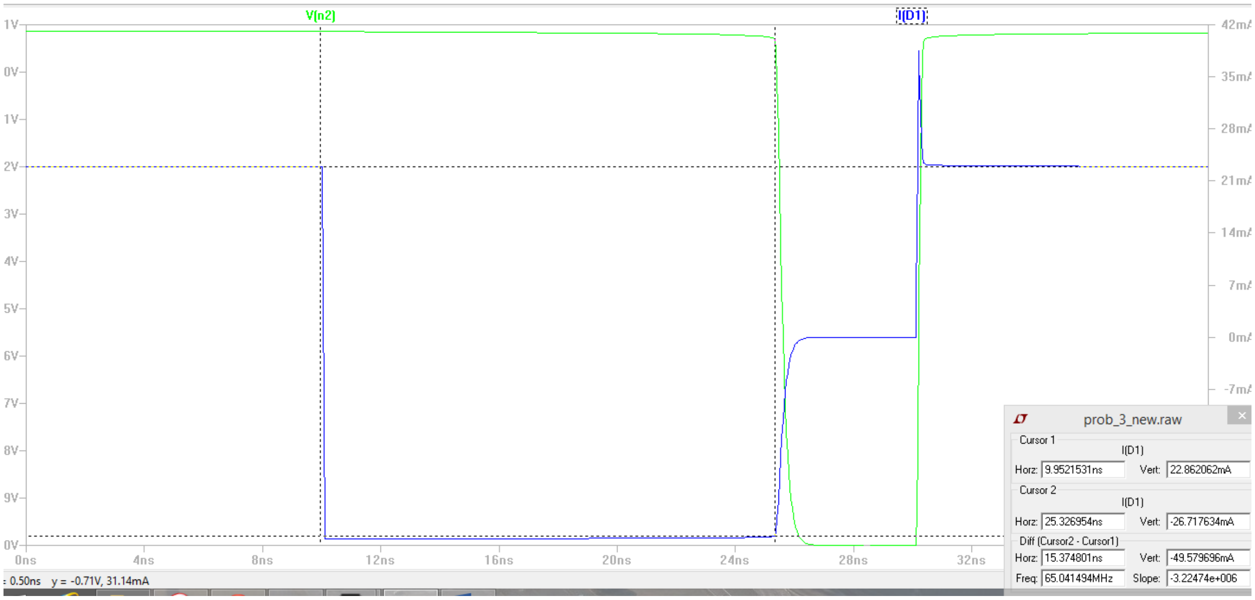


Figure 8: Simulation result and diode storage time

Problem 4:

Layout figure

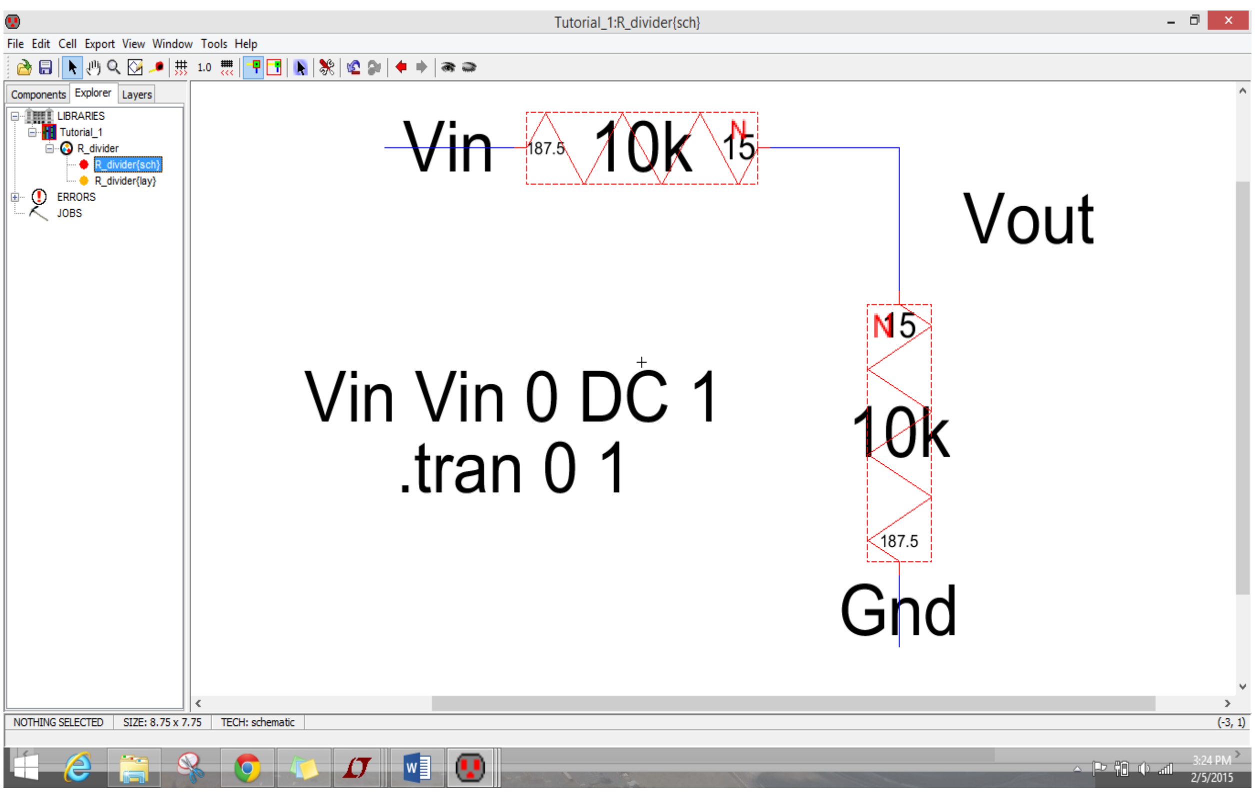
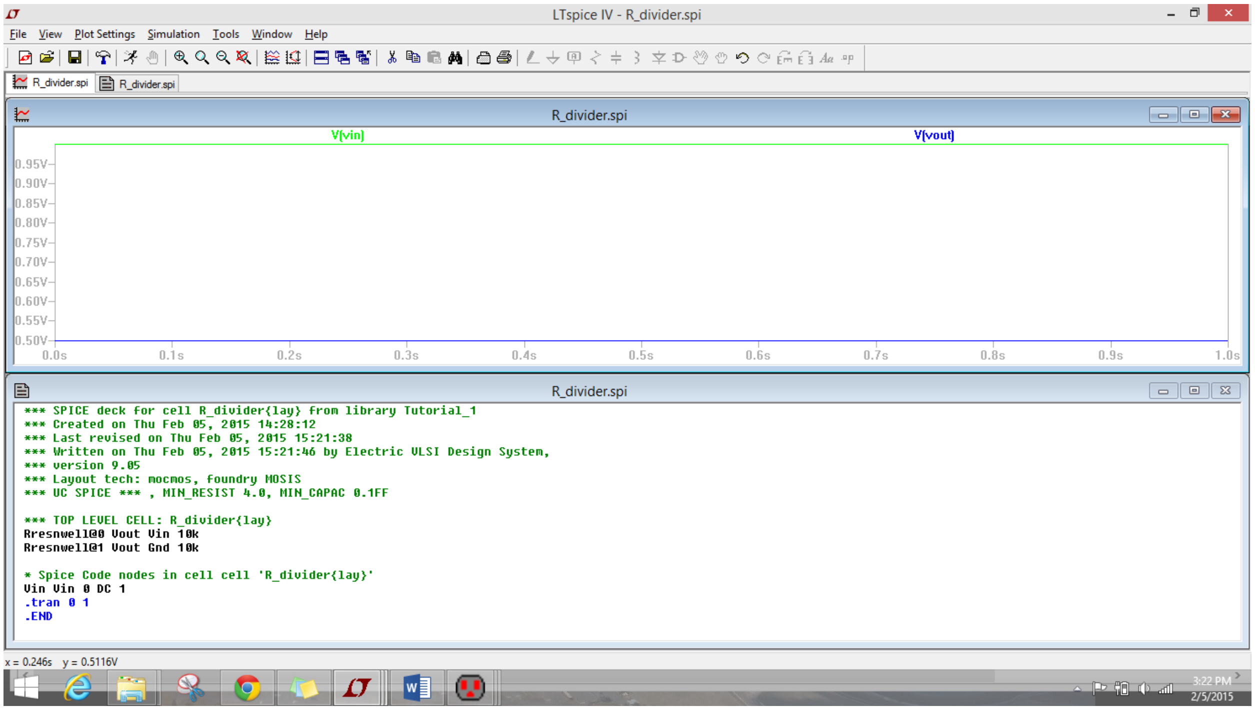
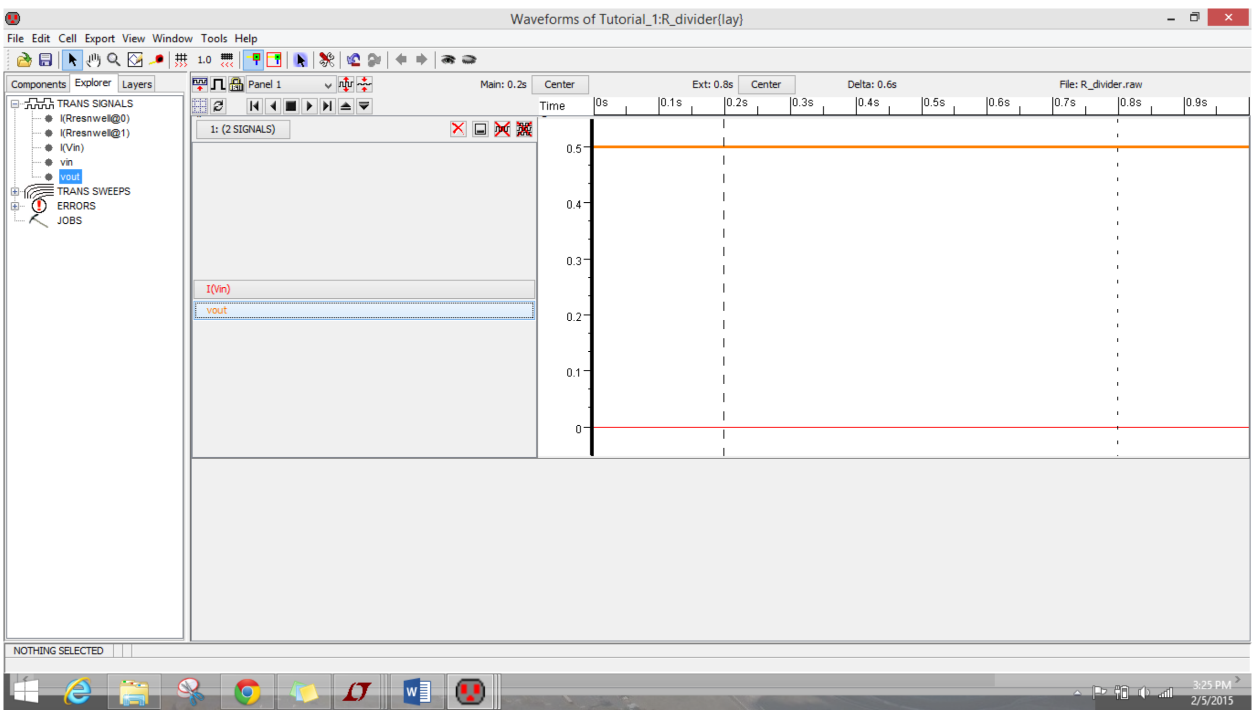


Figure 9: Schematic figure of voltage divider


LTspice IV - R_divider.spi
R_divider.spi
V(vin)
V(vout)
*** SPICE deck for cell R_divider{lay} from library Tutorial_1
*** Created on Thu Feb 05, 2015 14:28:12
*** Last revised on Thu Feb 05, 2015 15:21:38
*** Written on Thu Feb 05, 2015 15:21:46 by Electric VLSI Design System,
*** version 9.05
*** Layout tech: mocmos, foundry MOSIS
*** UC SPICE *** , MIN_RESIST 4.0, MIN_CAPAC 0.1FF
*** TOP LEVEL CELL: R_divider{lay}
Rresnwell@0 Vout Vin 10k
Rresnwell@1 Vout Gnd 10k
* Spice Code nodes in cell cell 'R_divider{lay}'
Vin Vin 0 DC 1
.tran 0 1
.END
x = 0.246s y = 0.5116V


Waveforms of Tutorial_1:R_divider{lay}
TRANS SIGNALS
I(Resnwell@0)
I(Resnwell@1)
I(Vin)
vin
vout
TRANS SWEEPS
ERRORS
JOBS
Main: 0.2s
Ext: 0.8s
Delta: 0.6s
File: R_divider.raw
I(Vin)
vout
NOTHING SELECTED

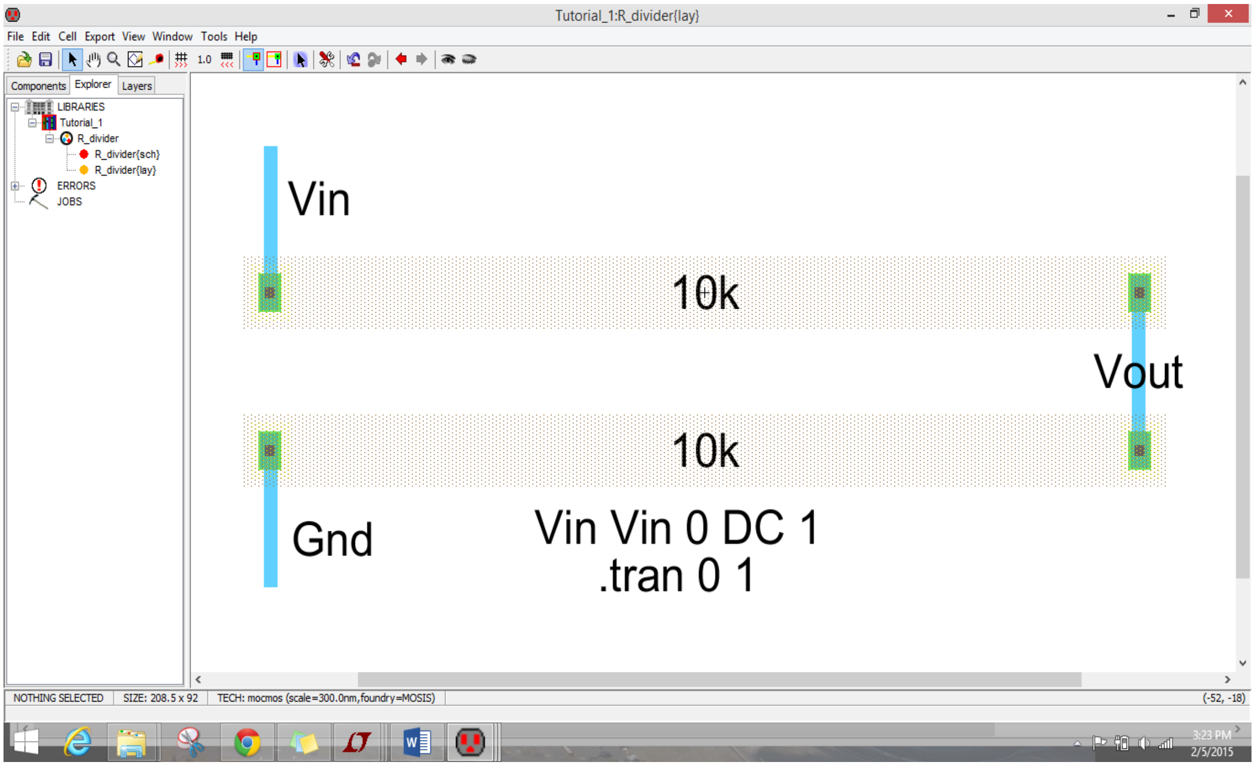
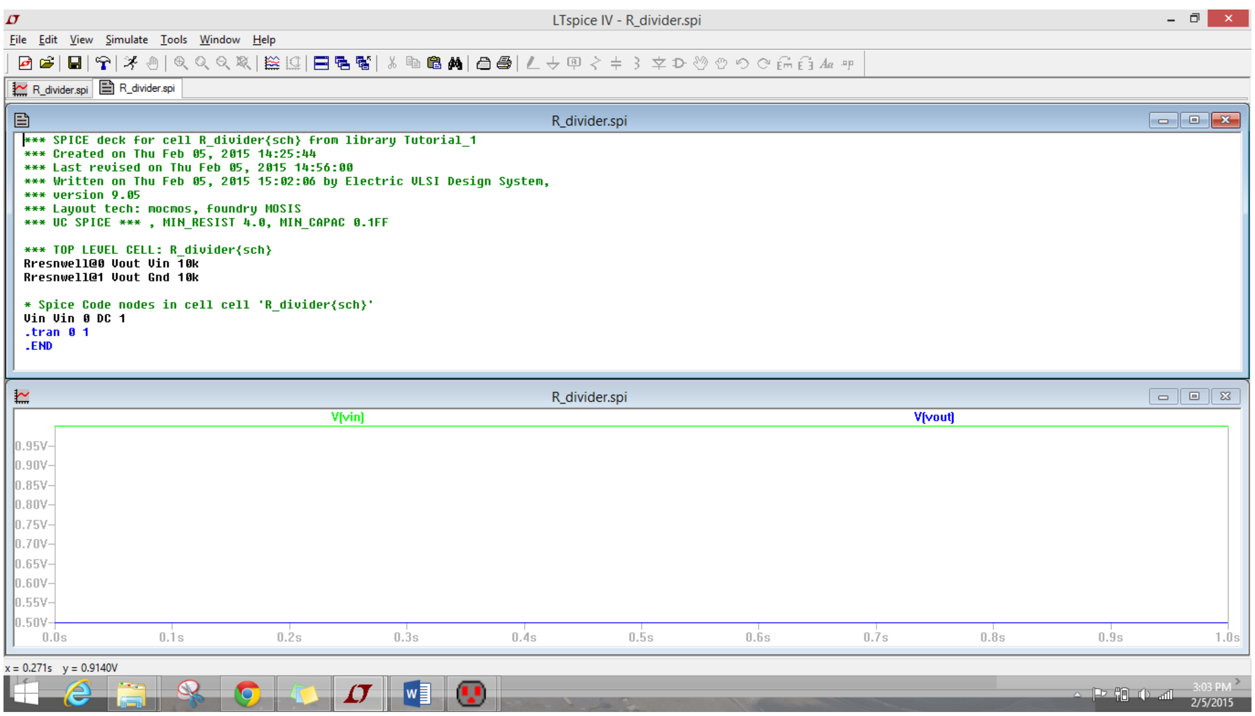
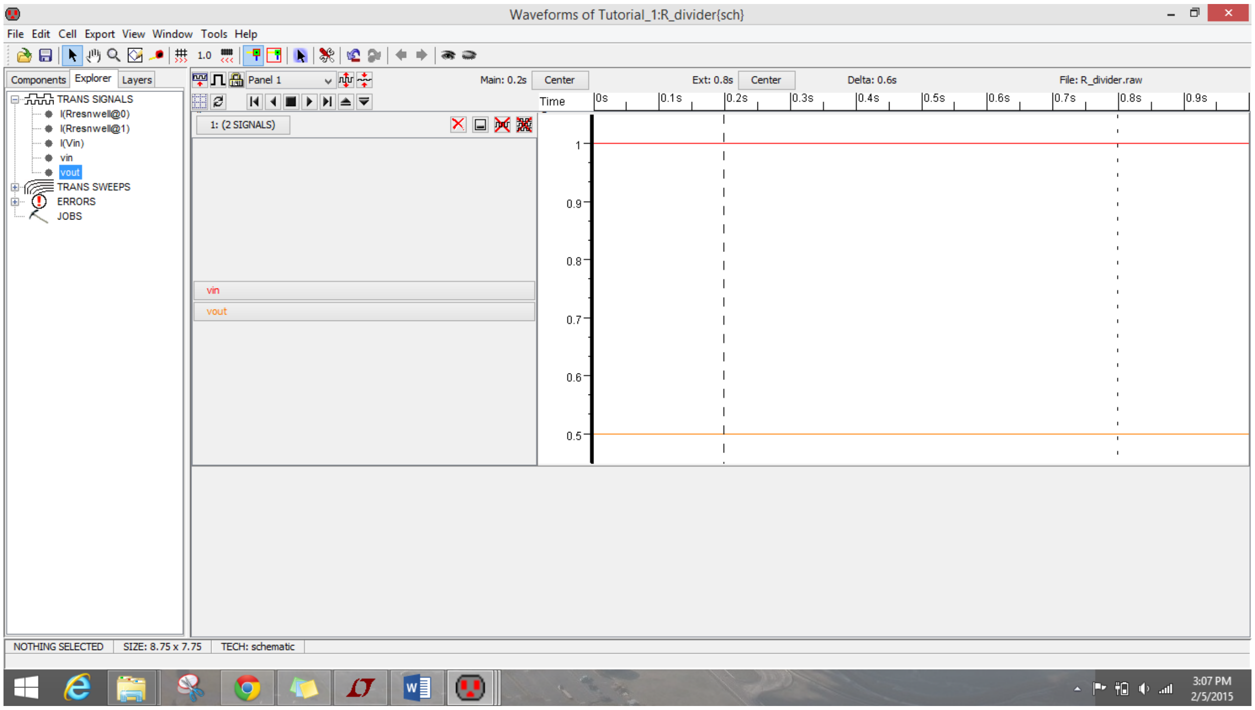


Figure 10: Layout figure





Problem 5:

Crosstalk is the electric or magnetic coupling between circuits. It is caused due to the coupling of electromagnetic energy from an active signal line to a passive line. This coupling can be capacitive or inductive. The effect of crosstalk will disturb the operation of high speed digital systems by causing false triggering.

Crosstalk is an unwanted interference from one conductor to another. It is a problem associated with time varying signals in a circuit.

Consider two metal wires, a signal voltage propagation on one conductor couples current onto another conductor. The current is given by

$$I_m = C_m * \frac{dV_A}{dt}$$

Where C_m is mutual capacitance. I_m is the coupling current. Va is the signal voltage on the source conductor.

<u>Ground Bounce:</u> It describes a local variation in the power and ground supplies at a circuit. It is a problem associated with both time varying and DC signals.

Ground bounce is also defined as common impedance coupling due to shared ground conductors.

Problem 6:

Schottky Diode: The schottky diode is also known as hot carrier diode is a semiconductor diode which has a low forward voltage drop and a very fast switching action. The silicon diode has a typical voltage drop of 0.6 to 0.7 volts, while the schottky diode has a voltage drop of 0.15 to 0.45 volts. Due to this low voltage drop the diode has a higher switching speed and a better system efficiency.

Construction:

For the schottky diode, a metal-semiconductor junction is formed which creates a schottky barrier. The typical metals used are molybdenum, platinum, chromium or tungsten. The semiconductor would be a typical n-type silicon. The metal side acts as an anode and the n-type semiconductor acts as a cathode. This results in a very fast switching and low forward voltage drop.

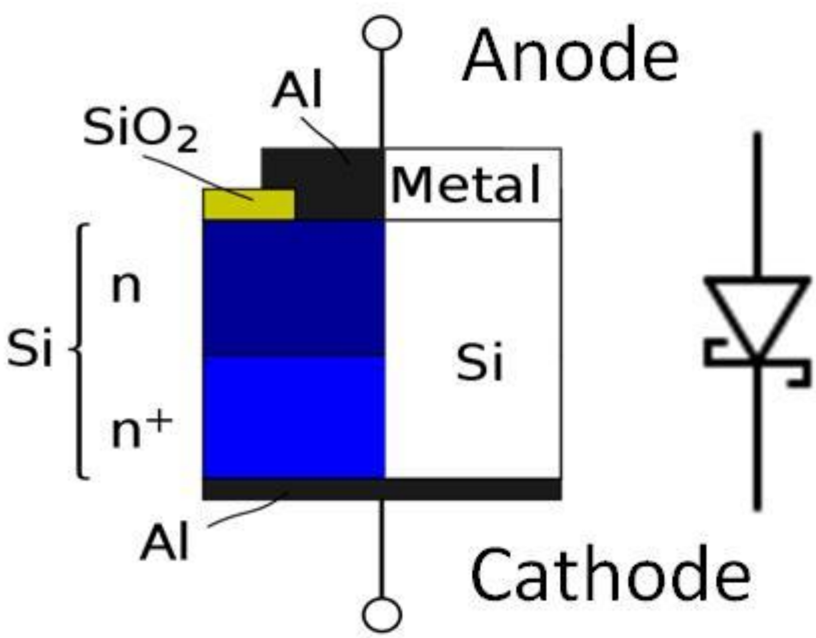


Figure 11: Schottky diode

Zener Diode:

A zener diode is a diode which allows the current to flow in the forward direction in the same way as an idle diode, but it also allows the current to flow in the reverse direction when the voltage crosses a certain value which is known as breakdown voltage or Zener voltage.

The reverse breakdown is mainly due to electron quantum tunnelling under high electric field strength. This is known as Zener effect. But some diodes describe the Zener effect as a cause of an avalanche breakdown. The effect is predominant above 5.6 V.

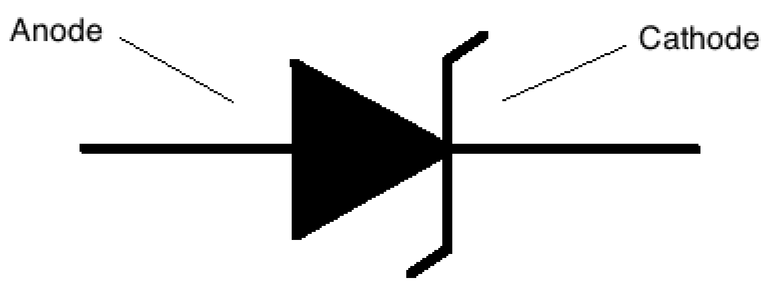


Figure 12: Zener diode

Comparison of Schottky diode with a silicon diode:

The Schottky diode has a low forward voltage drop when compared to a silicon diode. Its voltage drop is between 0.15 to 0.45 volts. Due to this it has very fast switching speed.

The Schottky diode has a metal-Semiconductor junction where as a silicon diode has a semiconductor-semiconductor junction.

The Schottky diode has fast recovery. So it is used in SMPS for high frequencies.

They have much lower breakdown voltage drop of 20-40 V. So they are used for low voltage rectifier applications.

Comparison of Zener diode and silicon diode:

A zener diode is similar to a silicon diode, but it is works in reverse bias. It has almost the same properties but it is specially designed to have a reduced breakdown voltage called as zener voltage.

For normal silicon diode, if the voltage exceeds the breakdown voltage, the diode no longer blocks current.

References:

http://en.wikipedia.org/wiki/Zener_diode

http://en.wikipedia.org/wiki/Schottky_diode

http://www.powerguru.org/characteristics-of-schottky-diodes/

http://www.te.com/documentation/whitepapers/pdf/3jot_2.pdf