FY BTech 2021-22
BEEE Lab
Expt No. 3
Zener Diode –Voltage Regulator

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Expt 6. - Steps involved in the labwork

- What is a Zener diode?
- Understanding the circuit diagram of a voltage regulator
- How to design the component values ?
- Building a circuit in Tinkercad by selecting components
- Simulate the circuit to take the readings and Complete the observation tables for part 1 & 2
- Calculate Percentage line and load regulation for the circuit

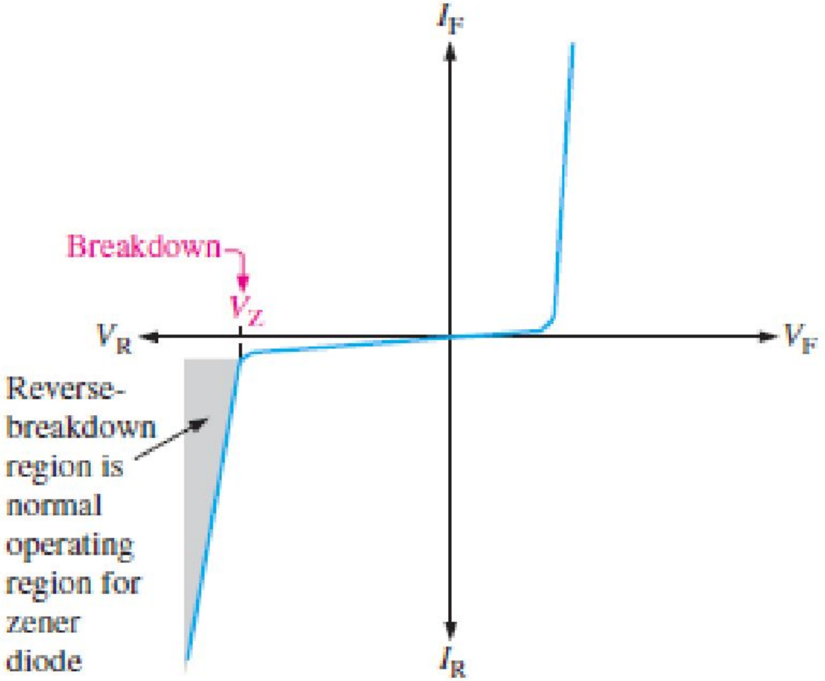


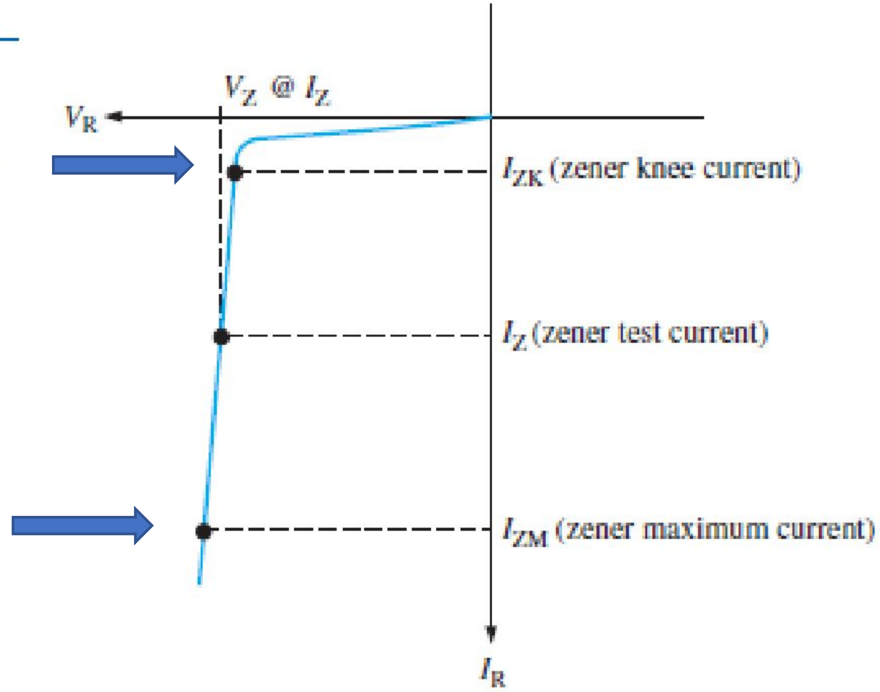
FIGURE 3–2

General zener diode V-I characteristic.

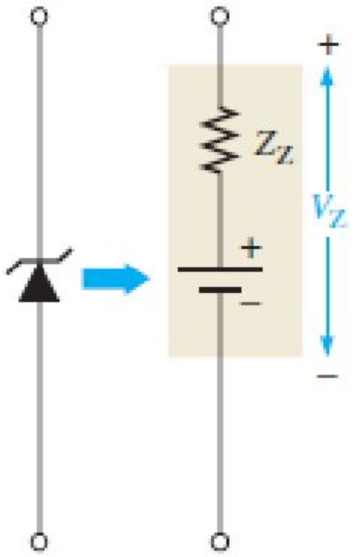
Reverse biased Zener diode behavior

FIGURE 3–3

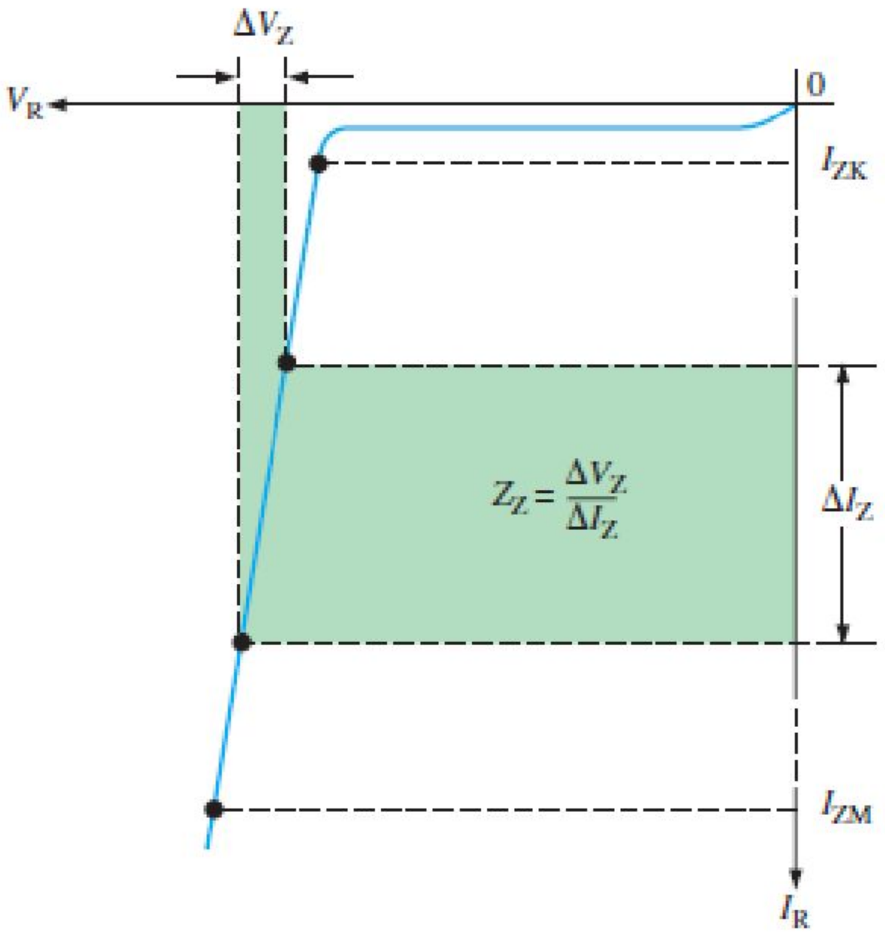
Reverse characteristic of a zener diode. V_Z is usually specified at a value of the zener current known as the test current.



Zener Diode Characteristics



(a) Practical model



(b) Characteristic curve. The slope is exaggerated for illustration.

FIGURE 3–5

Practical zener diode equivalent circuit and the characteristic curve illustrating Z_Z.

Datasheet of a Zener diode

1N4728A to 1N4764A

Vishay Semiconductors

VISHAY

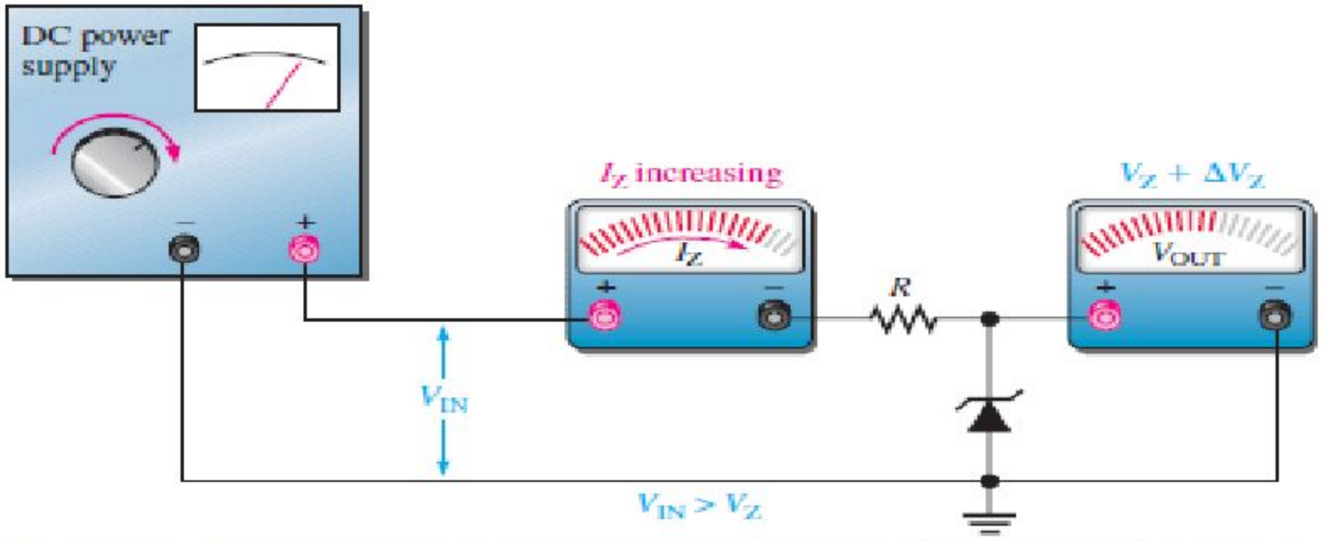
Electrical Characteristics

1N4728A...1N4764A

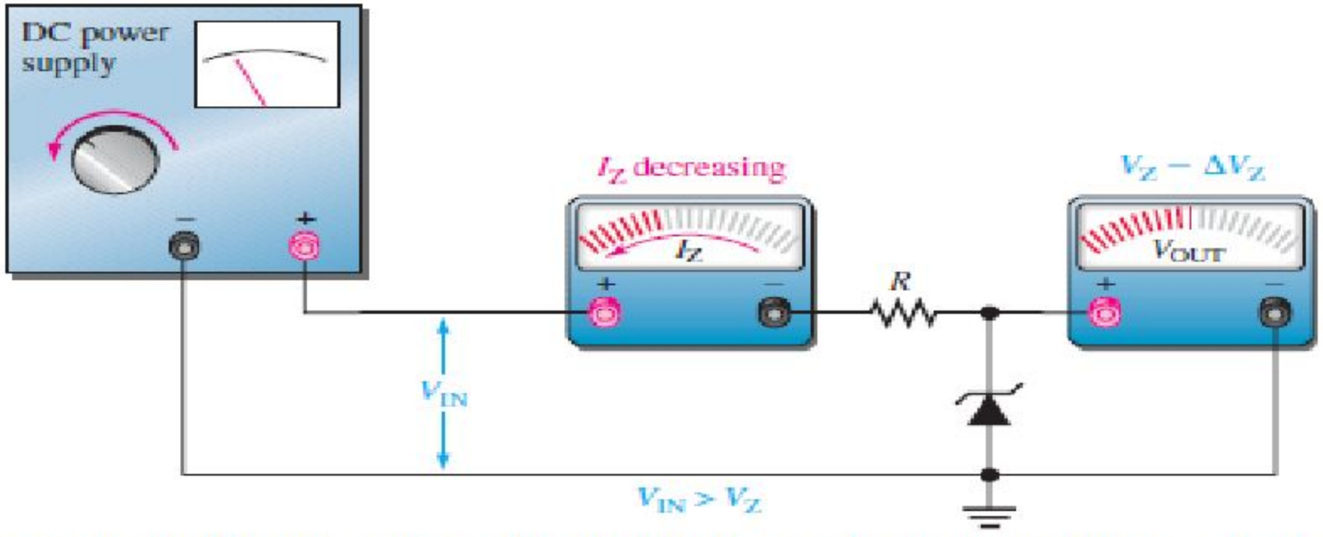
Partnumber	Nominal Zener Voltage[1)]	Test Current	Maximum Dynamic Impedance			Maximum Reverse Leakage Current		Surge Current[3)]	Maximum Regulator Current[2)]
	V_Z at I_{ZT}	I_{ZT}	Z_{ZT} at I_{ZT}	Z_{ZK} at I_{ZK}	I_{ZK}	I_R	Test Voltage V_R	at T_A = 25 °C I_R	I_{ZM}
	V	mA	Ω	Ω	mA	µA	V	mA	mA
1N4728A	3.3	76	10	400	1	100	1	1380	276
1N4729A	3.6	69	10	400	1	100	1	1260	252
1N4730A	3.9	64	9	400	1	50	1	1190	234
1N4731A	4.3	58	9	400	1	10	1	1070	217
1N4732A	4.7	53	8	500	1	10	1	970	193
1N4733A	5.1	49	7	550	1	10	1	890	178
1N4734A	5.6	45	5	600	1	10	2	810	162
1N4735A	6.2	41	2	700	1	10	3	730	146
1N4736A	6.8	37	3.5	700	1	10	4	660	133
1N4737A	7.5	34	4	700	0.5	10	5	605	121
1N4738A	8.2	31	4.5	700	0.5	10	6	550	110

FIGURE 3–9

Zener regulation of a varying input voltage.



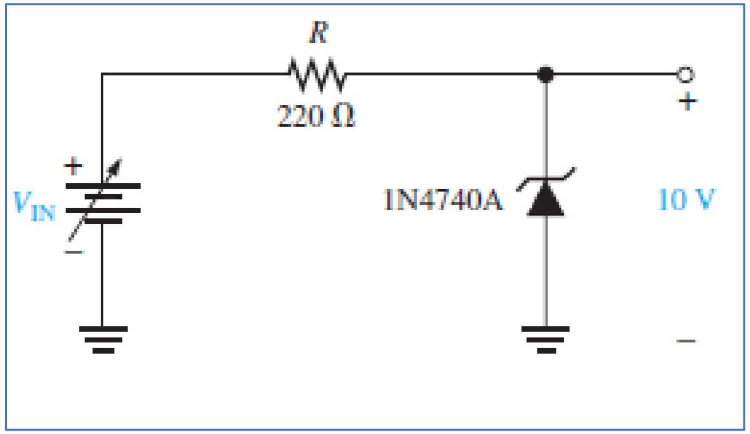
(a) As the input voltage increases, the output voltage remains nearly constant ($I_{ZK} < I_Z < I_{ZM}$).



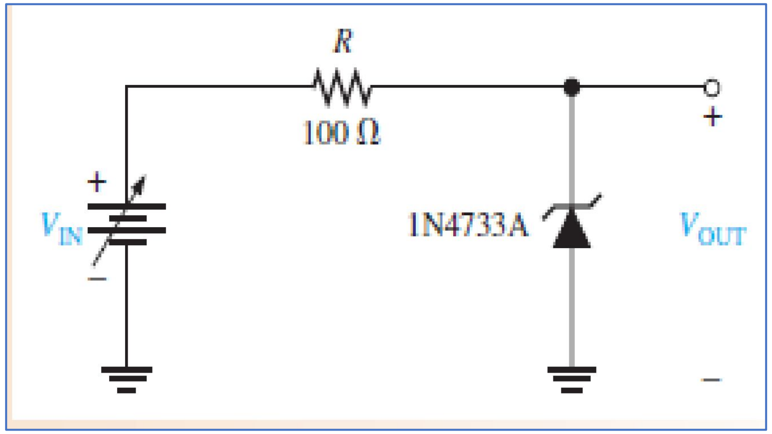
(b) As the input voltage decreases, the output voltage remains nearly constant ($I_{ZK} < I_Z < I_{ZM}$).

Zener Regulation with a Variable Input Voltage

Zener diode regulators can provide a reasonably constant dc level at the output, but they are not particularly efficient. For this reason, they are limited to applications that require only low current to the load. Figure 3–9 illustrates how a zener diode can be used to regulate a dc



Load resistance RL not connected



No Load condition

Zener Regulation with a Variable Load

Figure 3–13 shows a zener voltage regulator with a variable load resistor across the terminals. The zener diode maintains a nearly constant voltage across R_L as long as the zener current is greater than I_{ZK} and less than I_{ZM}.

$I_T = I_Z + I_L$

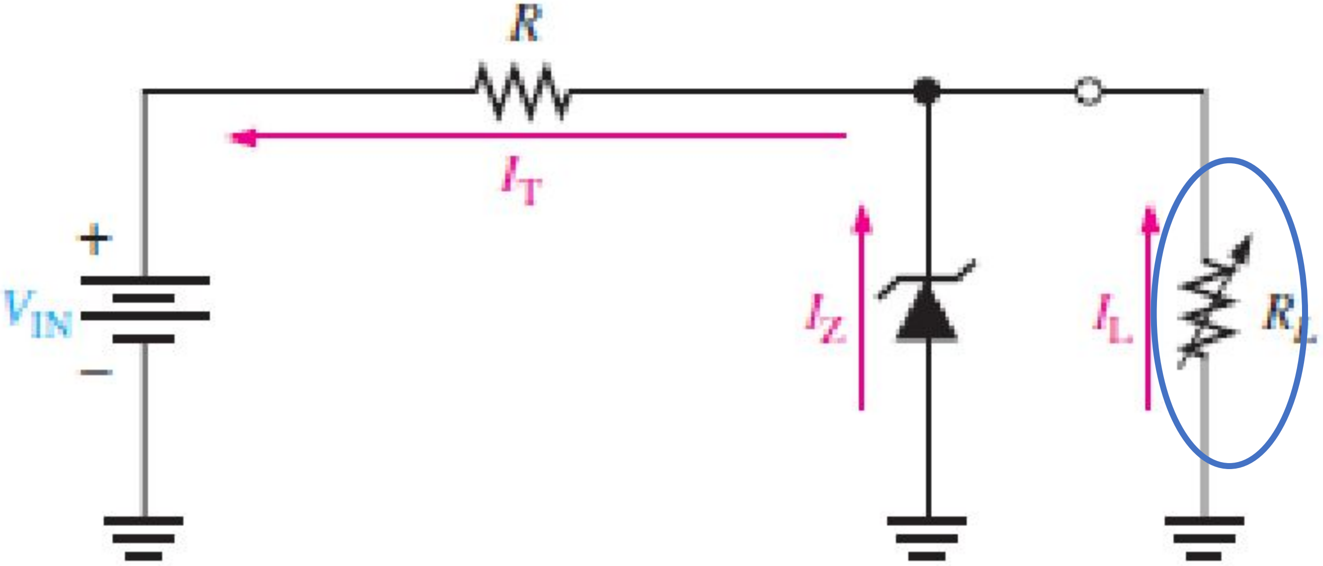
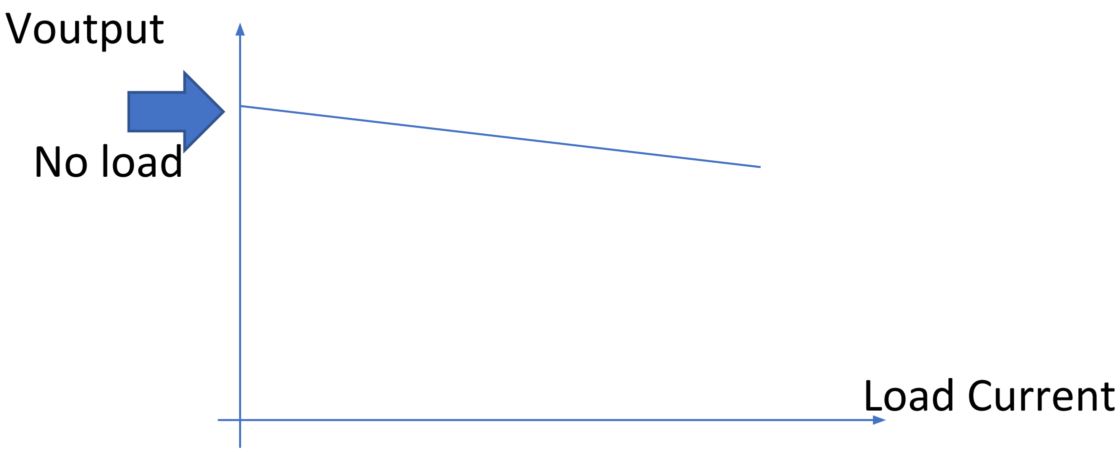


FIGURE 3–13

Zener regulation with a variable load.

From No Load to Full Load

When the output terminals of the zener regulator are open ($R_L = \infty$), the load current is zero and *all* of the current is through the zener; this is a no-load condition. When a load resistor (R_L) is connected, part of the total current is through the zener and part through R_L. The total current through R remains essentially constant as long as the zener is regulating. As R_L is decreased, the load current, I_L, increases and I_Z decreases. The zener diode continues to regulate the voltage until I_Z reaches its minimum value, I_{ZK}. At this point the load current is maximum, and a full-load condition exists. The following example will illustrate this.

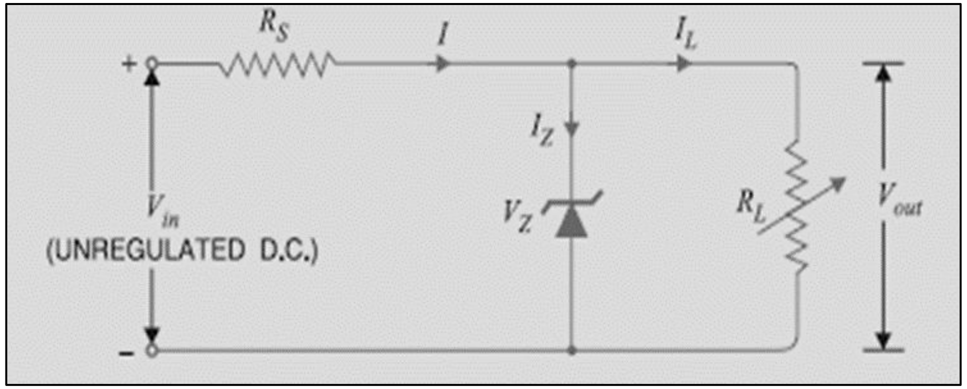


Design and simulate Zener regulator for following specifications in Tinkercad

- **Data given**:

  V_z=5.1V, Izknee=1mA, Izmax=178mA

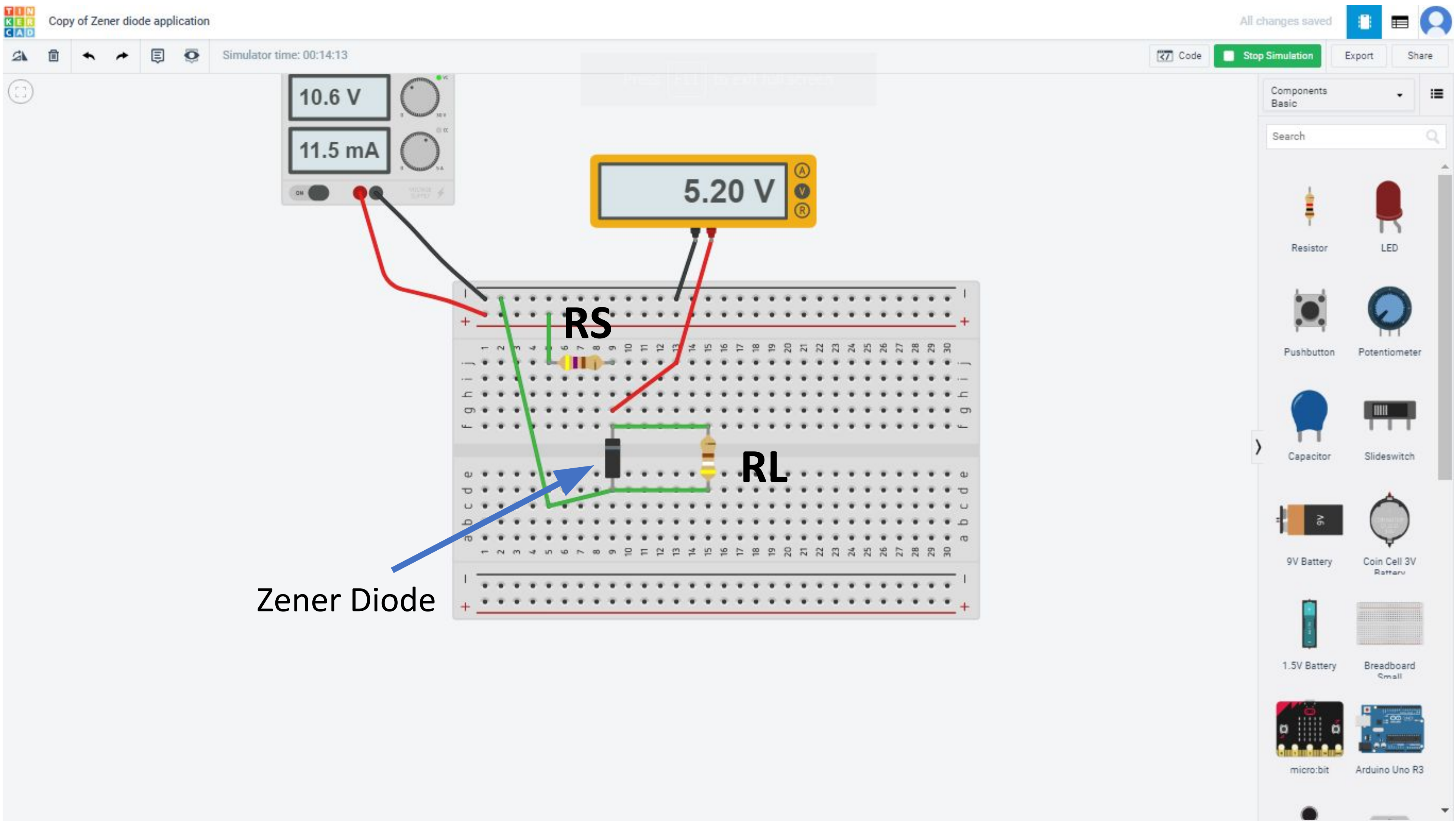
  Vin=15V, Rs=220 Ohms



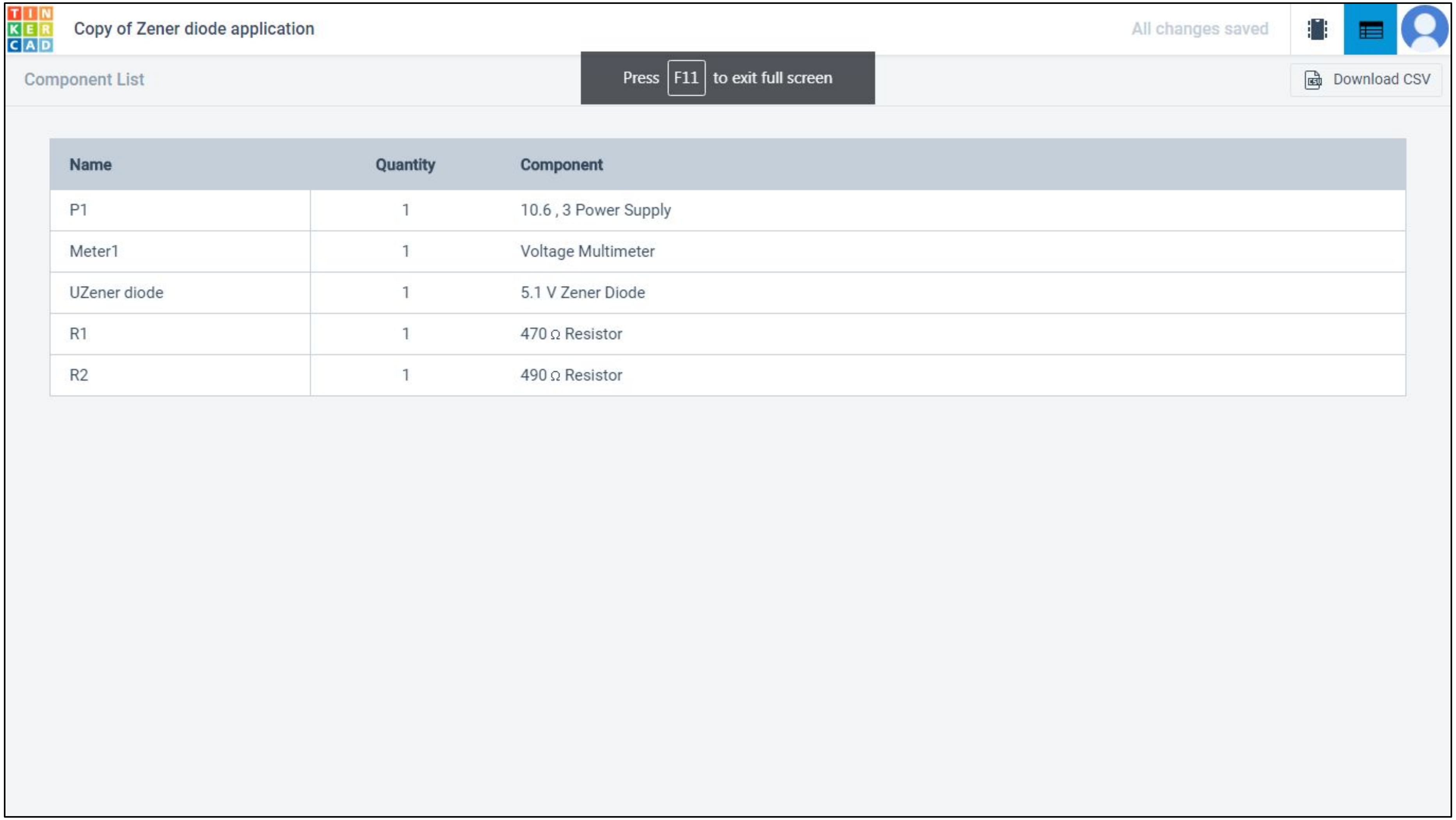
- Part 1: For load regulation , Find RLmin and RLmax

- Part 2: For line regulation with RL=1.2Kohms, find V_{inmin} and V_{inmax}

Tinkercad circuit design for Zener Regulator



Component List in Tinkercad circuit



Name	Quantity	Component
P1	1	10.6 , 3 Power Supply
Meter1	1	Voltage Multimeter
UZener diode	1	5.1 V Zener Diode
R1	1	470 Ω Resistor
R2	1	490 Ω Resistor

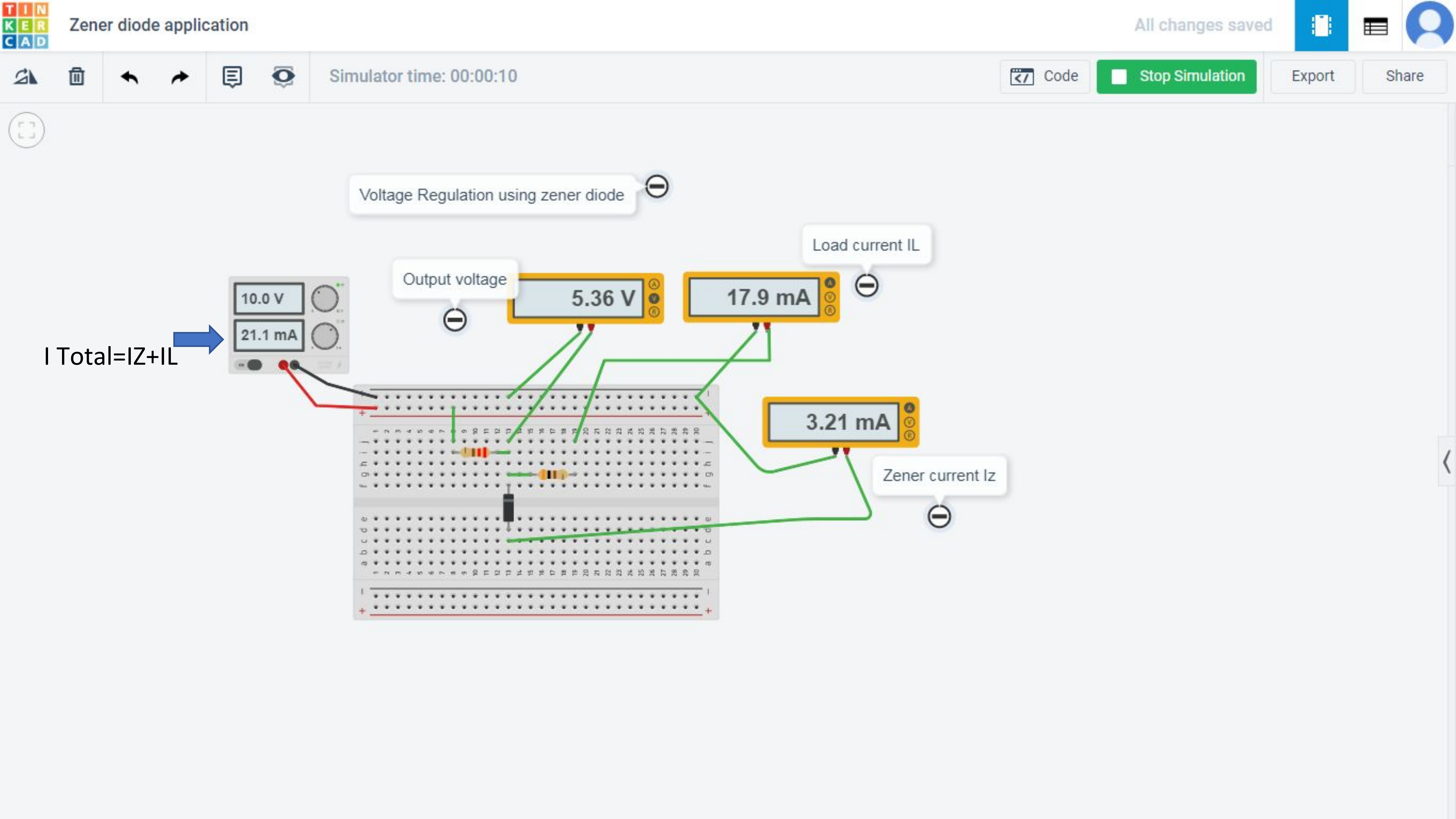
Load Regulation by changing R_L

Note down output voltage and IL for 5 different values of RL with a constant Vin

Sr. No	I_L (mA)	V_o (V)	R_L (Ω)
1	I_{L1} =	V_{o1} =	
2	I_{L2} =	V_{o2} =	
3	I_{L3} =	V_{o3} =	
4	I_{L4} =	V_{o4} =	
5	I_{L5} =	V_{o5} =	

Percentage Load Regulation

% Load regulation = (VNL-VFL)/ VFL x100


Zener diode application
All changes saved
Simulator time: 00:00:10
Code
Stop Simulation
Export
Share
Voltage Regulation using zener diode
Output voltage
5.36 V
Load current IL
17.9 mA
10.0 V
21.1 mA
I Total=IZ+IL
3.21 mA
Zener current Iz

Observations for load and line regulation

For Load regulation: Vin = ________(Constant)

Sr. No	I_L **(mA)**	V_o **(V)**	R_L **(Ω)**
1	I_{L1} =	V_{o1} =	
2	I_{L2} =	V_{o2} =	
3	I_{L3} =	V_{o3} =	
4	I_{L4} =	V_{o4} =	
5	I_{L5} =	V_{o5} =	

Plot a graph for Vo vs IL

For Line regulation: R_L = ________(Constant)

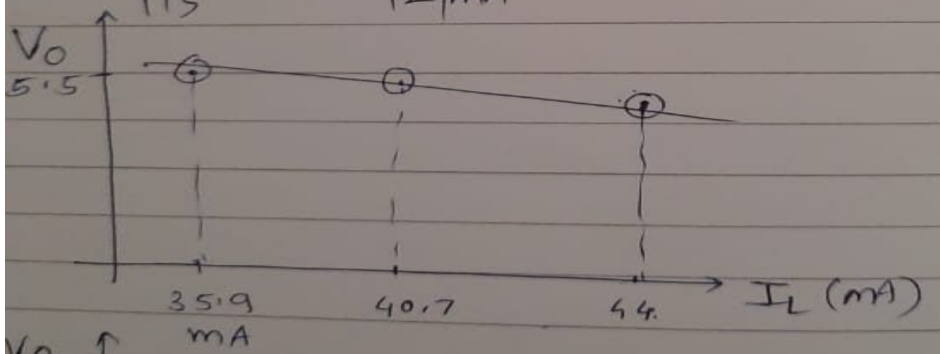
Sr. No	V_{in}**(V)**	V_o **(V)**
1	V_{in1} =	V_{o1} =
2	V_{in2} =	V_{o2} =
3	V_{in3} =	V_{o3} =
4	V_{in4} =	V_{o4} =
5	V_{in5} =	V_{o5} =

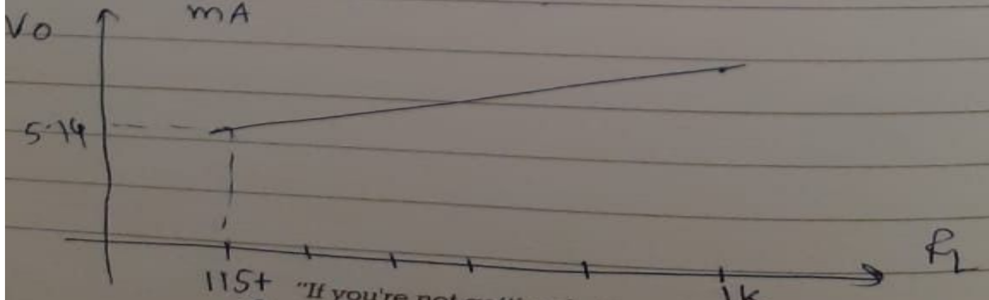
Plot a graph for Vo vs Vin

23-11-20

Zener Regulator in Tinkercad
Load Regulation

R_L	I_L(mA)	V_L = Voutput	I_Z
115+250Ω	44.5	5.14	0.3mA
115+270Ω	42.1	5.29	2.04mA
115+300Ω	41.6	5.31	2.4
115+400Ω	40.7	5.36	3.11
115+500Ω	39.8mA	5.4	3.8mA
115+700Ω	38.2	5.48	5.11
115+1K	35.9	5.58	6.89mA
115	129mA		25.2mA





What is Line Regulation?

- Line Regulation is the change in output voltage due to variation of the input voltage with all other factors held constant. It is expressed as a percent of the nominal output voltage. A power supply with tight line regulation delivers optimum voltages throughout the operating range.
- The line regulation gives the ability of a power supply to maintain the specified output voltage despite the changes or variations in the input line voltage. The value is calculated from the ratio of the change in the output voltage to the change in the input voltage, but usually expressed as a percentage:
- Line Regulation = $\Delta V_o / \Delta V_i$

Calculations

- 1.Percentage Line Regulation

  % Line Regulation = $(\Delta V_o/\Delta V_{in}) \times 100$

- 2.Percentage Load Regulation

  % Load regulation = $(V_{NL}-V_{FL})/ V_{FL}$ x100

Thank You!