K. J. SOMAIYA COLLEGE OF ENGINEERING
DEPARTMENT OF ELECTRONICS ENGINEERING
ELECTRONIC CIRCUITS
Clipper Circuits

15^{th} **June, 2020** **Numerical**

1. For the circuit shown in circuit 1 Plot:
   Input $V_{in}(t)$ and output $V_{out}(t)$ waveforms, also VTC curves

   Given:

   $V_{in}(t) = 10V_{p-p}$, sinusoidal signal with frequency 5000Hz use constant voltage model ie $V_{D(ON)} = 0.7$V, $V_B = 1$V, $R_1 = 1$kΩ

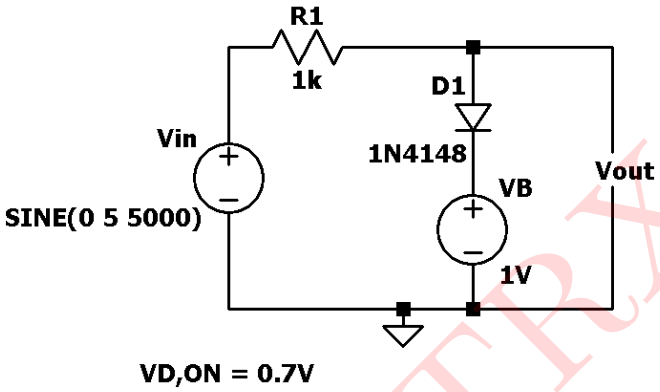

Figure 1: Circuit 1

$V_{in} = V_m sin\omega t = 10sin(2\pi \times 5000)t = 100sin10000\pi$

Solution:

Assuming a constant voltage model for diode, D_1

CASE 1: If $V_{in} < V_{D(on)} + V_B$ then D_1 is OFF, Therefore Diode D1 behaves as open circuit as follows

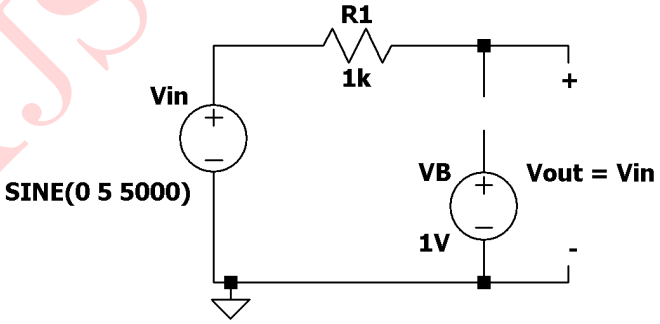

Figure 2: Circuit 1: When Diode 1 is OFF

$V_{in} < 0.7 + 1$

$V_{in} < 1.7$

$V_{in} = V_{out} \qquad (For V_{in} < 1.7)$

CASE 2: If $V_{in} > V_{D(on)} + V_B$ then D_1 is ON, Therefore Diode D1 behaves shortcircuited as follows

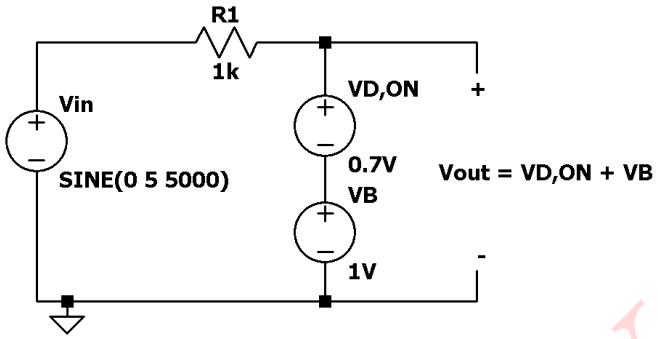

Figure 3: Circuit 1: When Diode 1 is ON

Applying KVL to the output of circuit 1

$V_{out} = V_{D(on)} + V_B$

$V_{out} = 1 + 0.7$

$V_{out} = 1.7$

For $V_{in} > V_{D(on)} + V_B$

$V_{in} > V_{D(on)} + V_B$

$V_{in} > 0.7 + 1 = 1.7$

$V_{out} = 1.7V$

Thus when D_1 is ON the positive part of the cycle is clipped

SIMULATED RESULTS:

Above circuit is simulated in LTspice and results are as follows

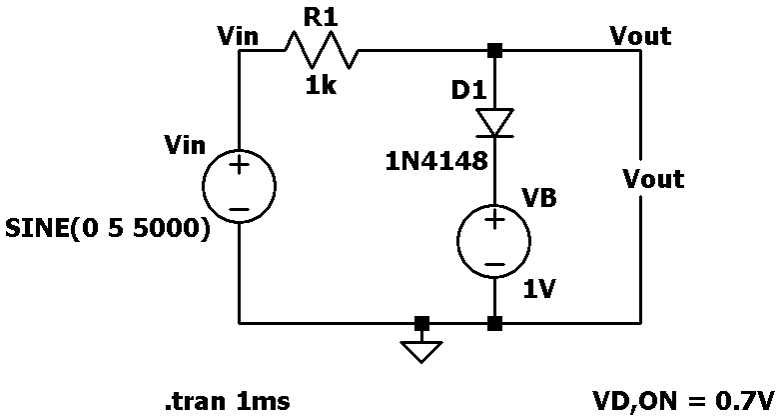

Figure 4: Circuit Schematic: Results

The input and output waveforms are shown in figure 5.

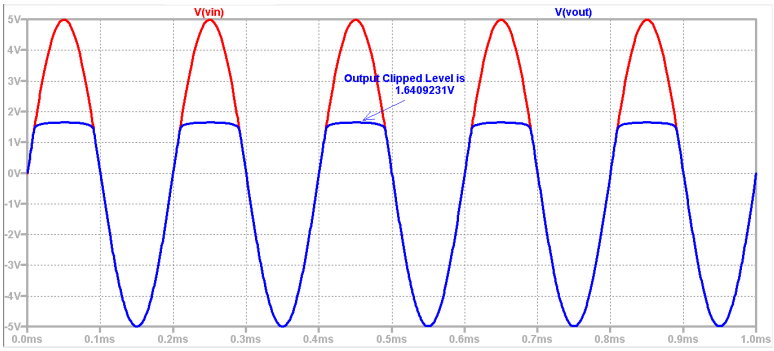

Figure 5: Input and Output Waveform

The VTC curve for the following circuit is given below in figure 6.

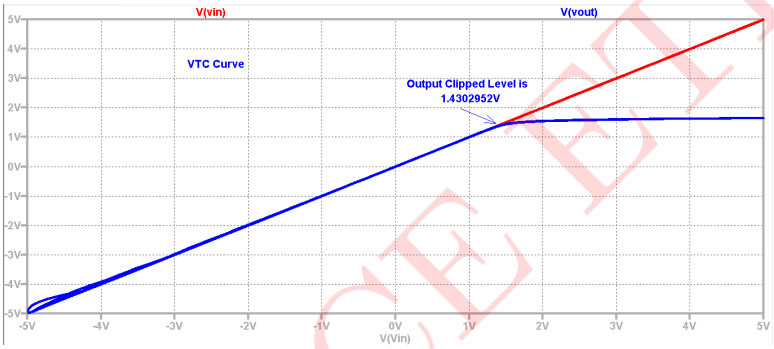

Figure 6: VTC Curve

Comparsion between observed and theoretical values :

Parameter	Observed	Theoretical
Max value of clipped output voltage	1.64092V	1.7V

Table 1: Numerical 1

2. For the circuit shown in circuit 2 Plot:
   Input $V_{in}(t)$ and output $V_{out}(t)$ waveforms

   Given:

   $V_{in}(t) = 24V_{p-p}$, triangular wave with frequency 1000Hz, $R_1 = 10\text{k}\Omega$

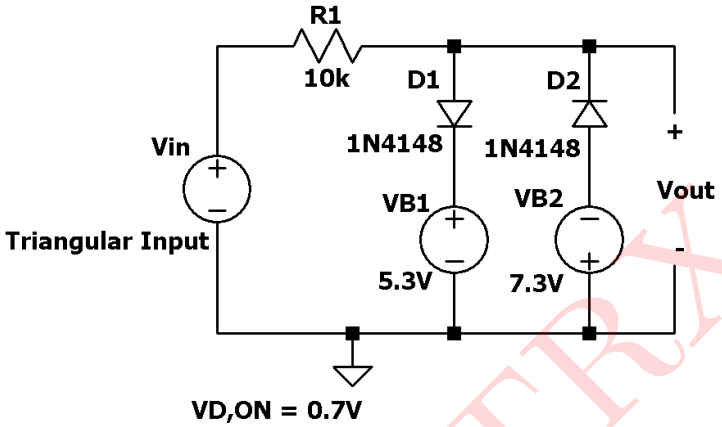

Figure 7: Circuit 2

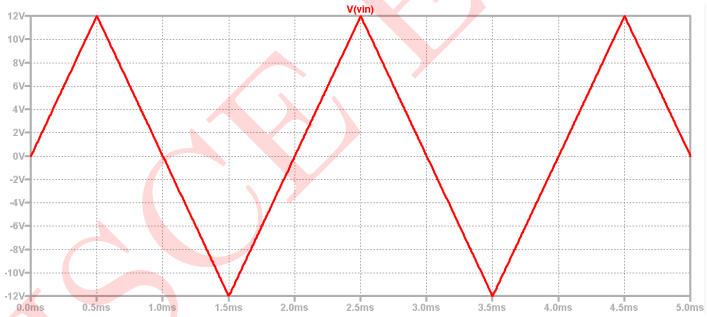

Figure 8: Circuit 2: Input waveform

Solution:

The given diodes D_1 and D_2 are silicon diodes and $V_{D(on)} = 0.7\text{V}$, $V_m = 12\text{V}$

CASE 1: When $V_{in} > V_{D(on)} + V_B, V_{in} > 6\text{V}$, Diode D_1 is forward baised and is ON also diode D_2 is reversed baised and is OFF.

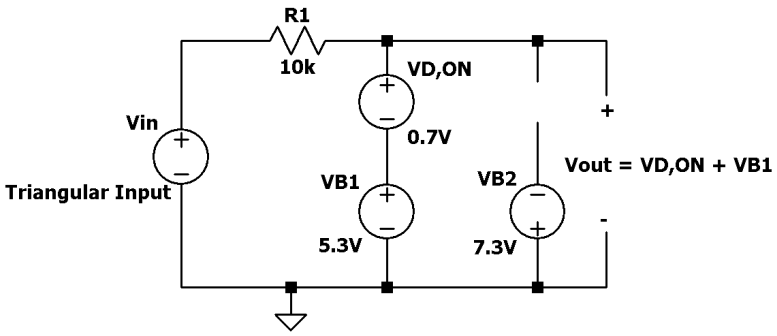

Figure 9: Circuit 2: When Diode 1 is ON and Diode 2 is OFF

The diode D_2 behaves as open circuit while current passes through diode D_1
Diode D_1 is ON because the anode voltage is greater than cathode voltage by 0.7V

$V_{out} = V_{D(on)} + V_{B1}$

$V_{out} = 0.7 + 5.3$

$V_{out} = 6\text{V}$

V_{in} >6V $\qquad (V_{in} > V_{D(on)} + V_{B1} = 6V)$

CASE 2: When $V_{in} < -V_{D(on)} - V_B, V_{in}$ <-8 V, Diode D_1 is reversed baised and is OFF also diode D_2 is forward baised and is ON.

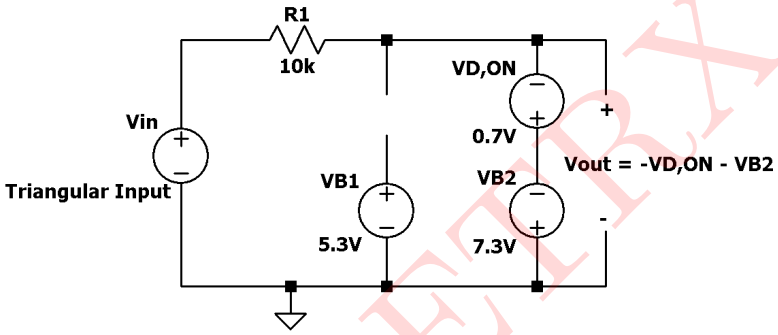

Figure 10: Circuit 2: When Diode 1 is OFF and Diode 2 is ON

The diode D_1 behaves as open circuit while current passes through diode D_2

$V_{out} = -V_{D(on)} - V_{B2}$

$V_{out} = 8\text{V}$

$\therefore V_{out}$ is -8V for $V_{in} < -8$V

For $V_{out} < 6V$ and $V_{in} > -8$ both diodes are reversed bias and $V_{out} = V_{in}$

SIMULATED RESULTS:

Above circuit is simulated in LTspice and results are as follows

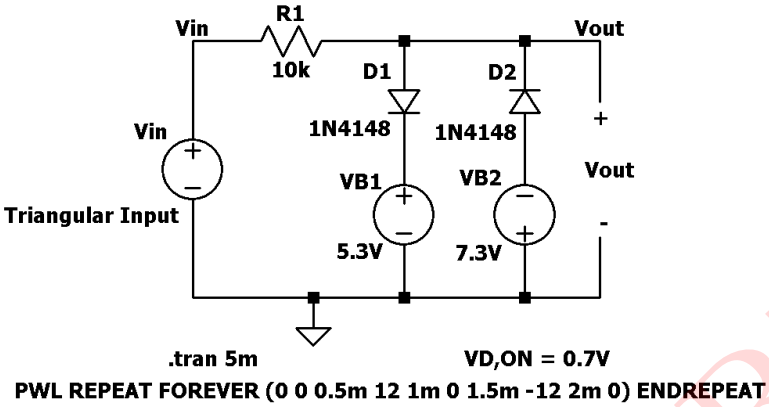

Figure 11: Circuit Schematic: Results

The input and output waveforms are shown in figure 12.

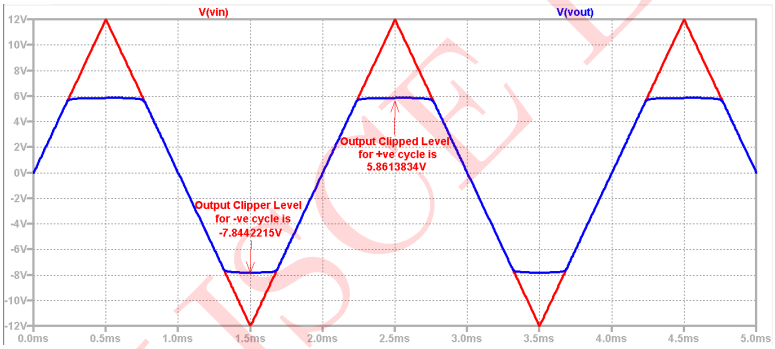

Figure 12: VTC Curve

Comparsion between observed and theoretical values :

Parameters	cycles	Observed	Theoretical
Max value of clipped output voltage	positive(+)	5.8613	6V
	negative(-)	-7.8442V	-8V

Table 2: Numerical 2

3. For the circuit shown in circuit 3 Plot:
   Input $V_{in}(t)$ and output $V_{out}(t)$ waveforms

   Given:

   $V_{in}(t) = 10V_{p-p}$, square wave with frequency 1000Hz, $R = 10\text{k}\Omega$, $C = 10\ \mu\text{F}$

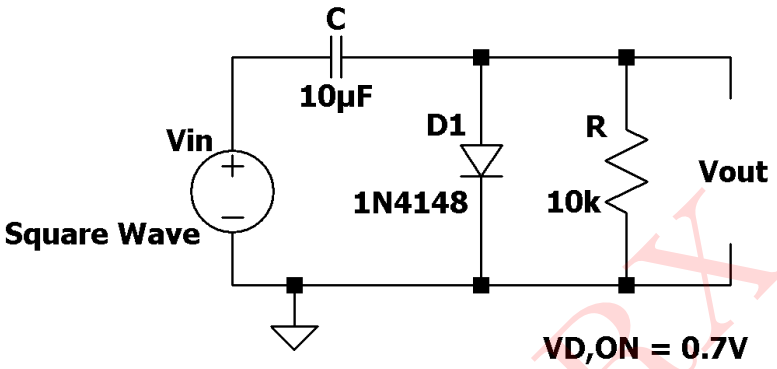

Figure 13: Circuit 3

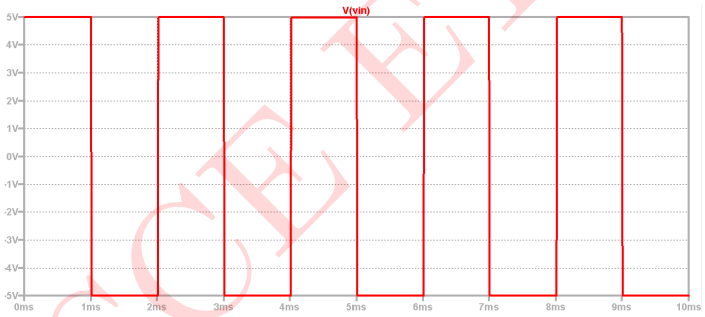

Figure 14: Circuit 3: Input waveform

Solution:

The given diode D_1 is a silicon diode we will prefer constant voltage model $V_{D(on)}$ = 0.7V, V_m = 5V

Assumption: RC time constant is large enough to ensure that voltage across capacitor does not discharge sugnificantly during the period diode is OFF

CASE 1: During the positive half cycle Diode D_1 is ON when $V_{in} > V_{D(on)}$, When diode D_1 is ON the anode voltage is greater than cathode voltage by 0.7V

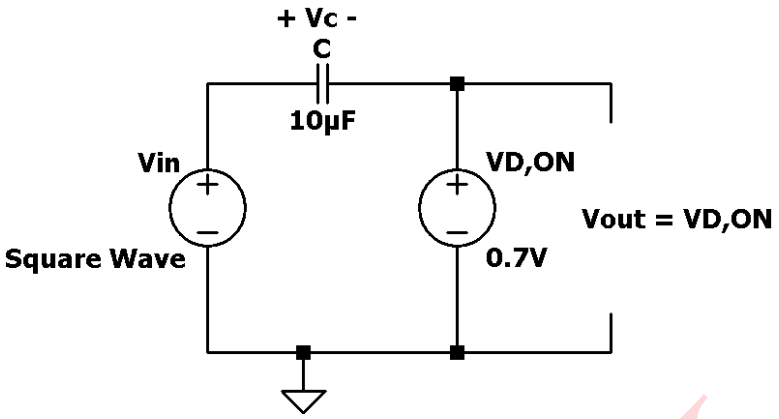

Figure 15: Circuit 3: When Diode D1 is ON

$V_{out} = V_{D(on)} = 0.7\text{V}$

At the same time Capacitor C charges and voltage across capacitor V_C reaches output to V_m

Applying KVL on the circuit 1

$V_{in} - V_{D(on)} - V_C = 0$

$V_C = V_{in} - V_{D(on)}$

$V_C = 5 - 0.7 = 4.3\text{V}$

CASE 2: During negative half cycle diode D_1 is OFF for entire negative cycle

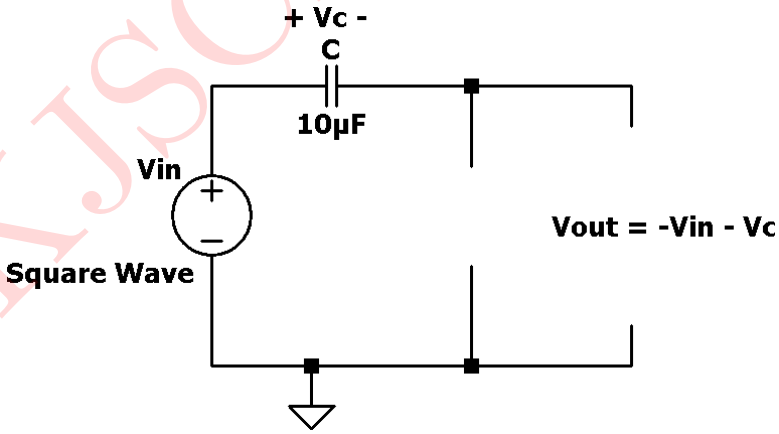

Figure 16: Circuit 3: When Diode D1 is OFF

During negative half cycle capacitor holds the charges $V_C = 4.3$ V and acts as a battary or a voltage source

Applying KVL on the given figure

$V_{in} - V_{out} - V_C = 0$

$V_{out} = -V_{in} - V_C$

$V_{out} = -5 - 4.3$

V_{out} = -9.3V

SIMULATED RESULTS:

Above circuit is simulated in LTspice and results are as follows

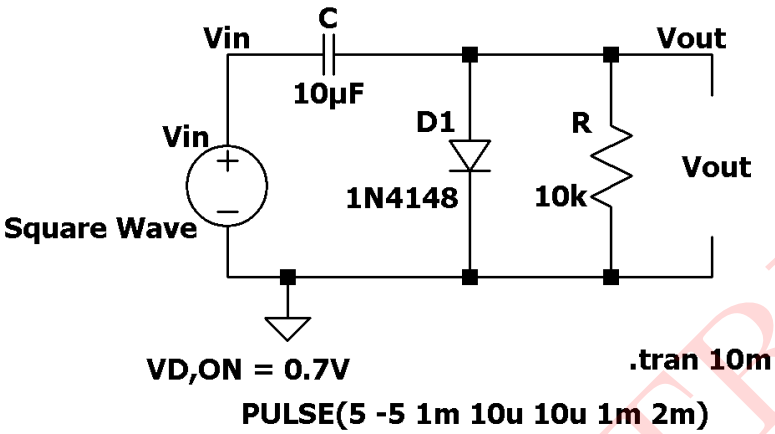

Figure 17: Circuit Schematic: Results

The input and output waveforms are shown in figure 18.

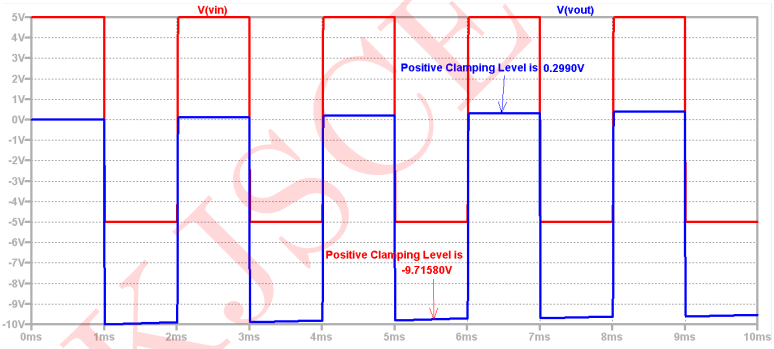

Figure 18: VTC Curve

Comparsion between observed and theoretical values :

Parameters	cycles	Observed	Theoretical
Max value of clipped output voltage	positive(+)	0.299V	0.7V
	negative(-)	-9.715V	-9.3V

Table 3: Numerical 3

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