ECS330: Lab Exam
2020-21-II

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Q.1. Consider a message signal which is a pure sinusoidal wave of frequency f_m = 250 Hz and a carrier signal which is also a pure sinusoidal wave of frequency f_c = 750 Hz. The message signal is modulated using the double side-band suppressed carrier modulation technique. The modulated signal is passed through a coherent detector. Plot the magnitude spectrum of the output of the coherent detector.

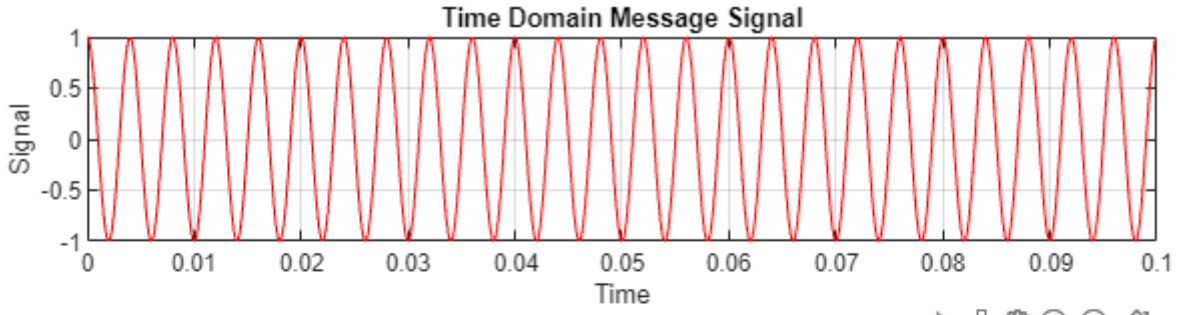
Solution:

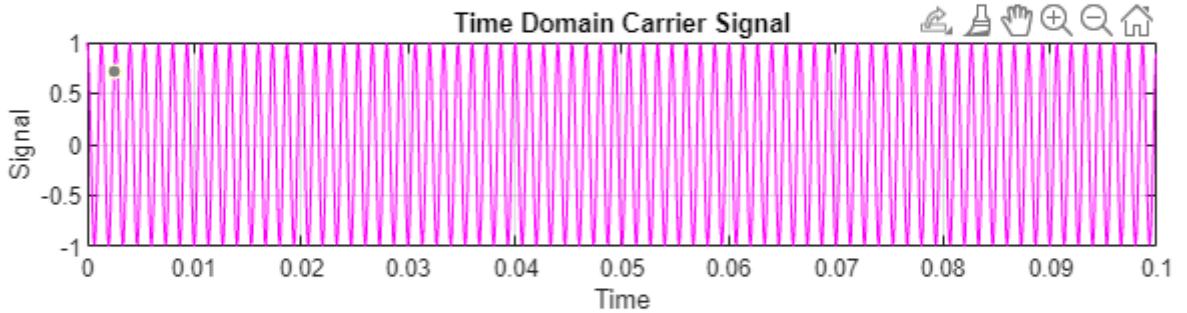
MATLAB Code:

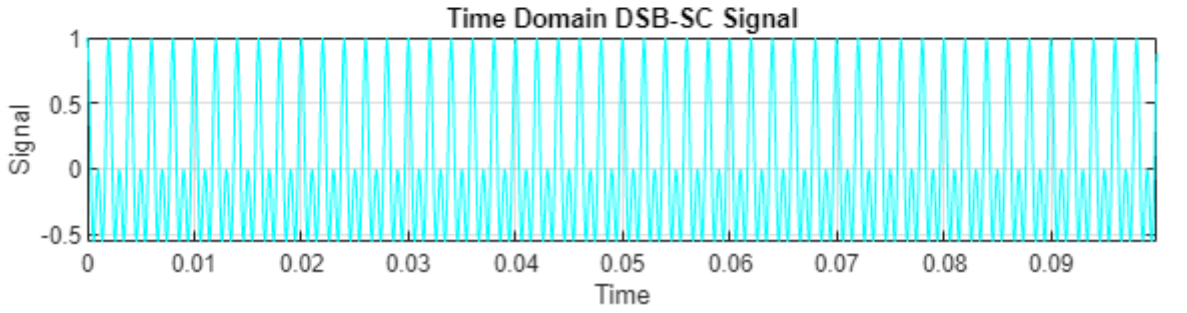
```
samp_freq = 10000;   %Sampling Frequency
L = 1000;     %Length of signals
t = (0:L-1)*(1/samp_freq);

m = cos(2*pi*250*t); %change frequency of message signal here
c = cos(2*pi*750*t);
coh = cos(2*pi*750*t);
s = c.*m;
coh_out = s.*coh;

S = fft(s);    %Fourier transform of all the signals
M = fft(m);
C = fft(c);
Y = fft(coh_out);

n = length(s);
f = (0:n-1)*samp_freq/n;  %Getting frequency values in Hertz

%plots
%All magnitude spectrum. Plots have x-axis restricted so as to not show the mirror image
of the spectrum
figure(1)
subplot(3,1,1)
plot(t,m,'r')  %Plotting time domain Message signal
title('Time Domain Message Signal')
xlabel('Time')
ylabel('Signal')
grid

subplot(3,1,2)
plot(t,c,'m')  %Plotting time domain Carrier signal
title('Time Domain Carrier Signal')
xlabel('Time')
ylabel('Signal')
grid
```

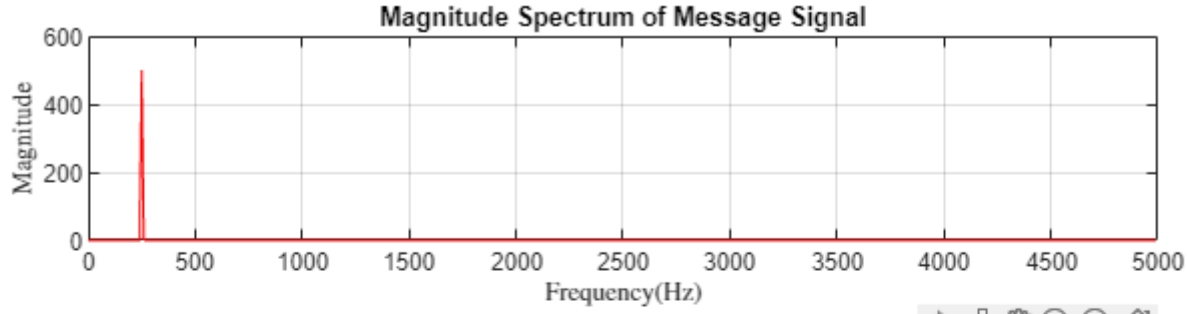
```
subplot(3,1,3)
plot(t, s,'c')  %Plotting time domain DSB-SC signal
title('Time Domain DSB-SC Signal')
xlabel('Time')
ylabel('Signal')
grid

figure(2)
subplot(3,1,1)  %Plotting Magnitude Spectrum of Message Signal
plot(f(1:floor(length(m)/2)), abs(M(1:floor(length(m)/2))),'r')
title('Magnitude Spectrum of Message Signal')
xlabel('Frequency(Hz)','Interpreter','latex')
ylabel('Magnitude','Interpreter','latex')
grid

subplot(3,1,2)  %Plotting Magnitude Spectrum of Carrier Signal
plot(f(1:floor(length(c)/2)), abs(C(1:floor(length(c)/2))), 'm')
title('Magnitude Spectrum of Carrier Wave}')
xlabel('Frequency(Hz)')
ylabel('Magnitude')
grid

subplot(3,1,3)  %Plotting Magnitude Spectrum of DSB-SC Signal
plot(f(1:floor(length(s)/2)), abs(S(1:floor(length(s)/2))),'c')
title('Magnitude Spectrum of DSB-SC Signal')
xlabel('Frequency(Hz)')
ylabel('Magnitude')
grid

figure(3)
subplot(2,1,1)  %Plotting time domain Output of Coherent Detector signal
plot(t, coh_out)
title('Time Domain Output of Coherent Detector')
xlabel('Time')
ylabel('Signal')
hold on
plot(t, m)
hold off
grid

subplot(2,1,2)  %Plotting Magnitude Spectrum of Output of Coherent Detector Signal
plot(f(1:floor(length(coh_out)/2)), abs(Y(1:floor(length(coh_out)/2))),'c')
title('Magnitude Spectrum of Output from Coherent Detector')
xlabel('Frequency(Hz)')
ylabel('Magnitude')
grid
```

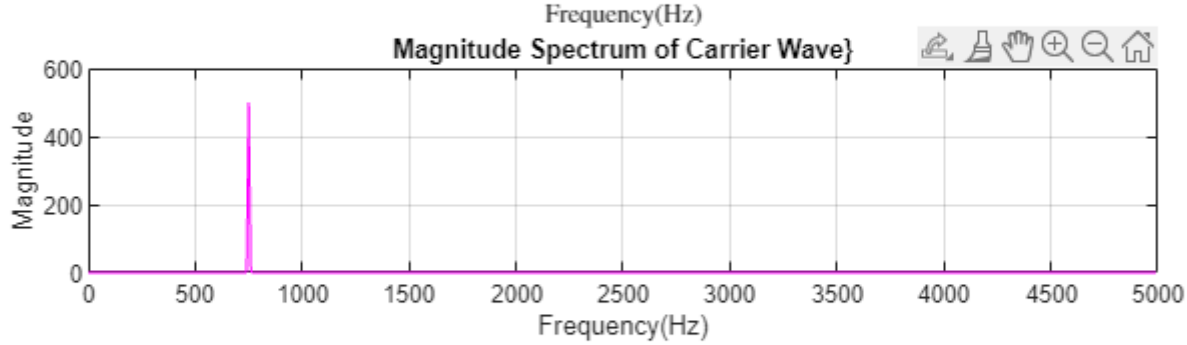
Outputs:

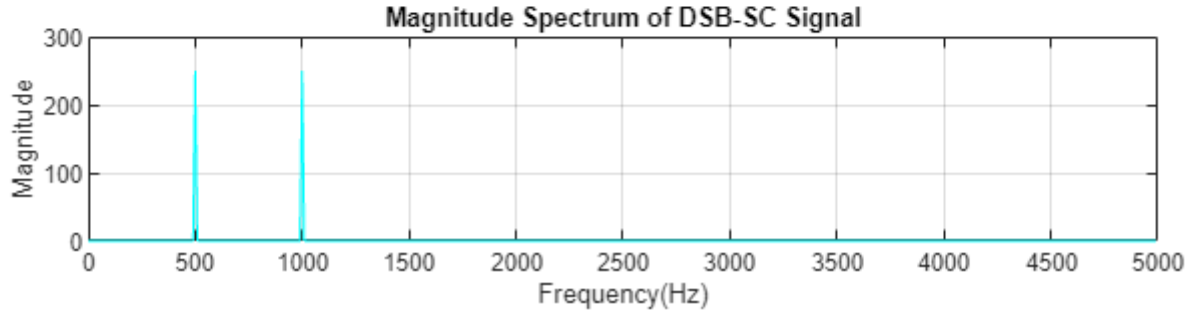

Time Domain Message Signal
Signal
Time

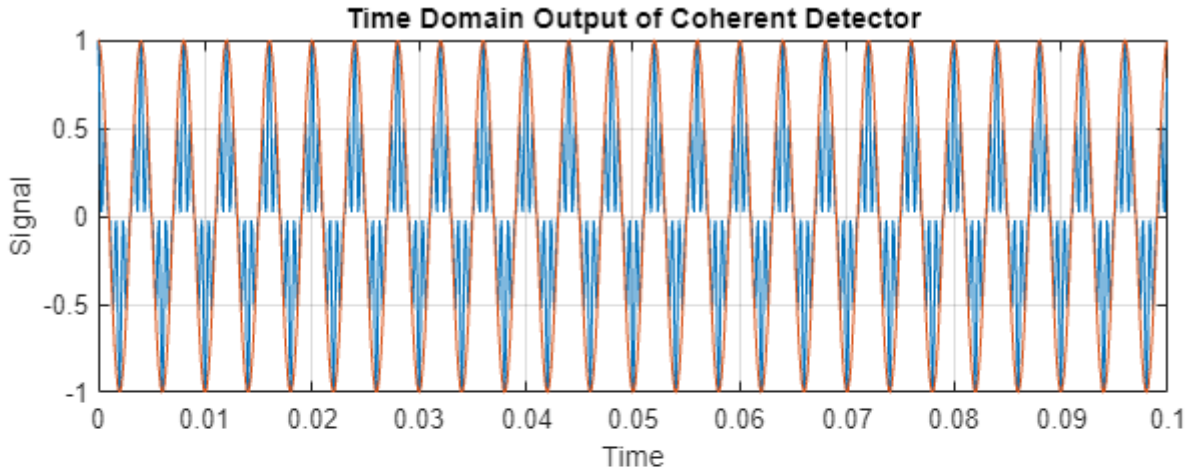

Time Domain Carrier Signal
Signal
Time

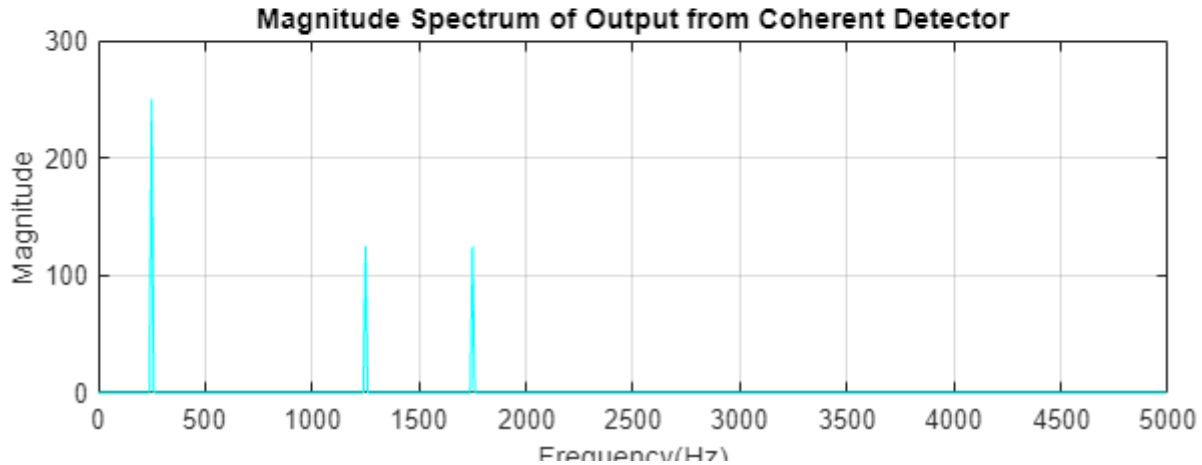

Time Domain DSB-SC Signal
Signal
Time


Magnitude Spectrum of Message Signal
Magnitude
Frequency(Hz)

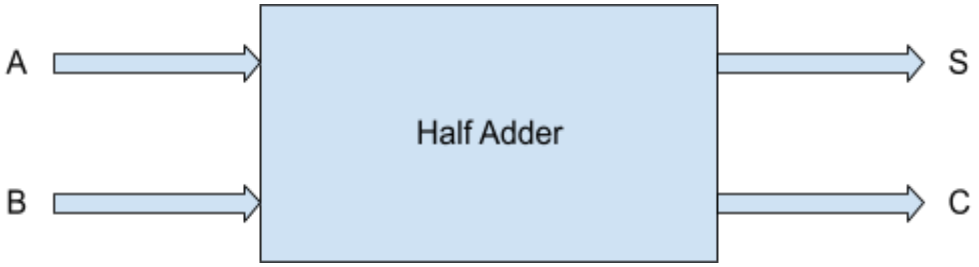

Magnitude Spectrum of Carrier Wave}
Magnitude
Frequency(Hz)


Magnitude Spectrum of DSB-SC Signal
Magnitude
Frequency(Hz)





Q.2. a. Draw the circuit diagram of a half adder circuit and label your circuit accordingly. You may use LT Spice for the same. Write down the truth table for a half adder.
b. Suppose you have an unlimited number of half adder ICs available with you. Let those ICs be represented by the following schematic. The variables in the diagram below have their usual meaning.



Using only the half adder ICs draw a circuit schematic of a two-bit parallel adder. Implement the schematic of the full adder in LTSpice and check your results for:

1. A=10 & B=00
2. A=11 & B=10

Solution:

a. The truth table for the half-adder is:

Input		Output	
A	B	S	C
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

Here is the circuit diagram of a half-adder:

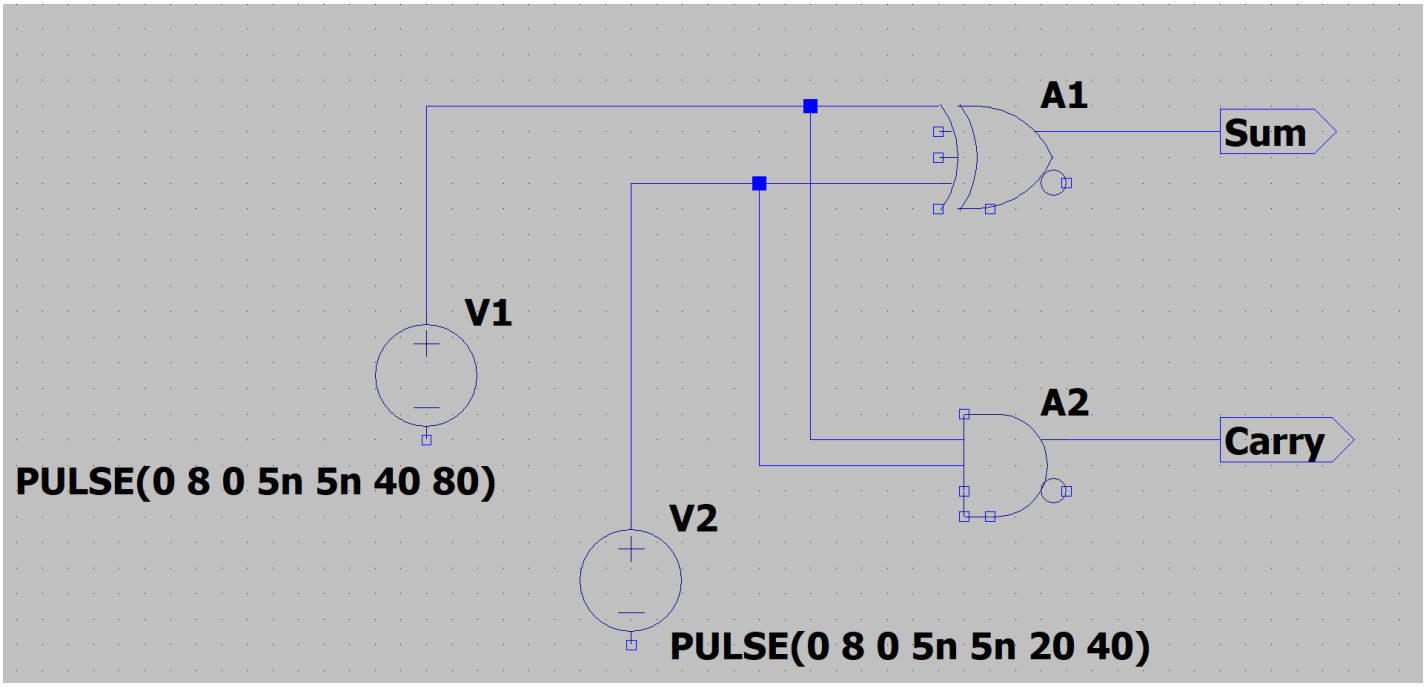


Fig.: The XOR gate gives out the sum and the and gate is giving out the carry in the diagram above

b. Here I have implemented a 2-bit parallel adder using only half adders. The full image can be seen here.

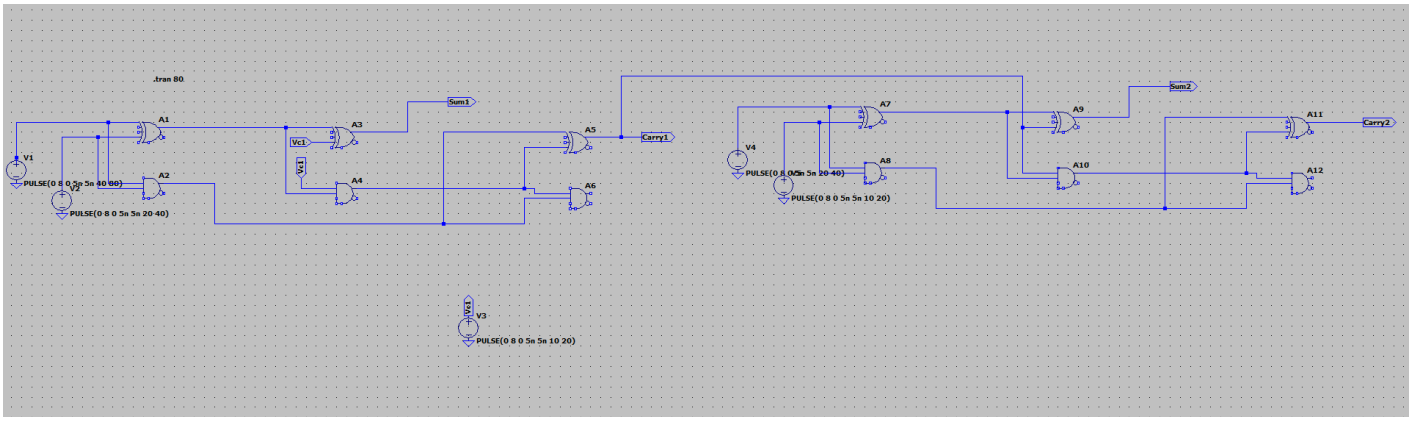


Fig.: The circuit diagram of a 2-bit parallel adder

Now the output of the 2-bit parallel adder is attached below:
The full image of the output can be seen here.

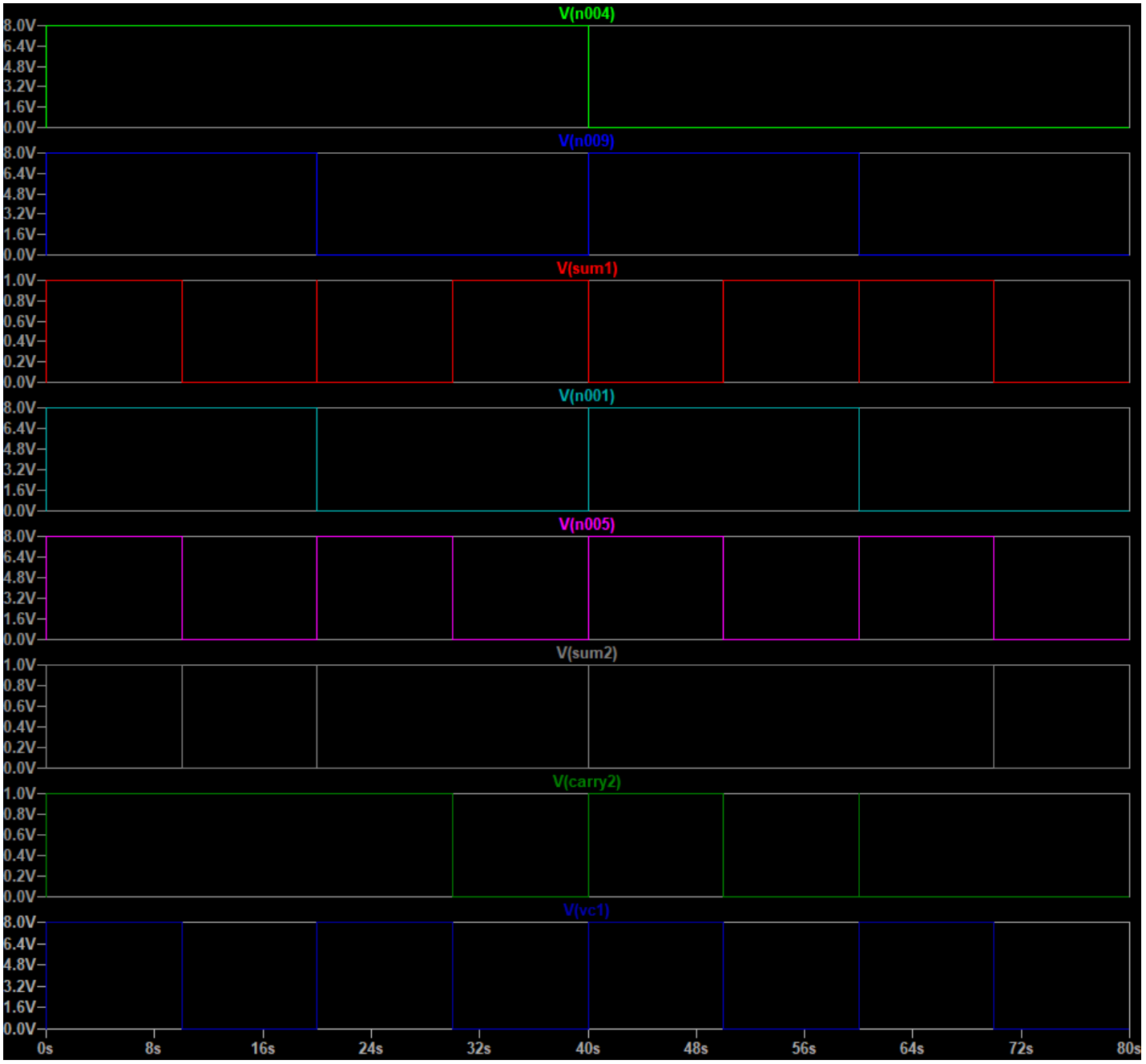


Fig.: The output of a 2-bit parallel adder

Answers of 1 and 2 are:

1. 110
2. 111

Q.3. Design a wave shaping circuit using diodes, which can clip the signal amplitude when it is greater than 2V. Consider a sine wave as an input with a frequency of 10kHz and a peak value of 4V. Show the input and output waveforms.

Solution:
Clipper Circuit: Clipping circuits are used to remove a part of a signal which is above or below a reference level. Clipping circuits are also known as limiters, amplitude selectors, or

slicers. The half-wave rectifier is also a good basic example of a clipper circuit where the reference level is zero and the signal below zero voltage (i.e. negative) are not allowed to pass through. To alter the reference level to the desired value, a DC voltage source is put in series with the diode. Depending on the polarity of the DC source and direction of the diode the circuit will clip the input signal above or below the reference level set by the user.

Clipper circuit:

- Source voltage: sinusoidal voltage source with amplitude 4V and frequency 10kHz.
- Reference voltage source = DC source of 1.33V
- Series resistance = 1kohm
- Load resistance = 10kohm

Diagram:

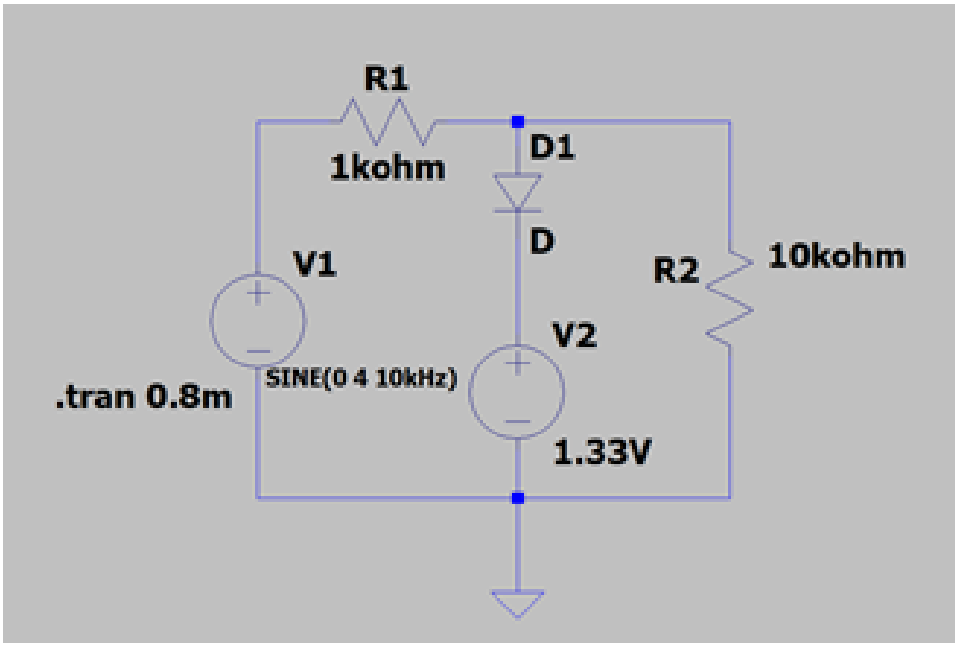


Fig.: Schematic diagram of the clipper circuit

Output:

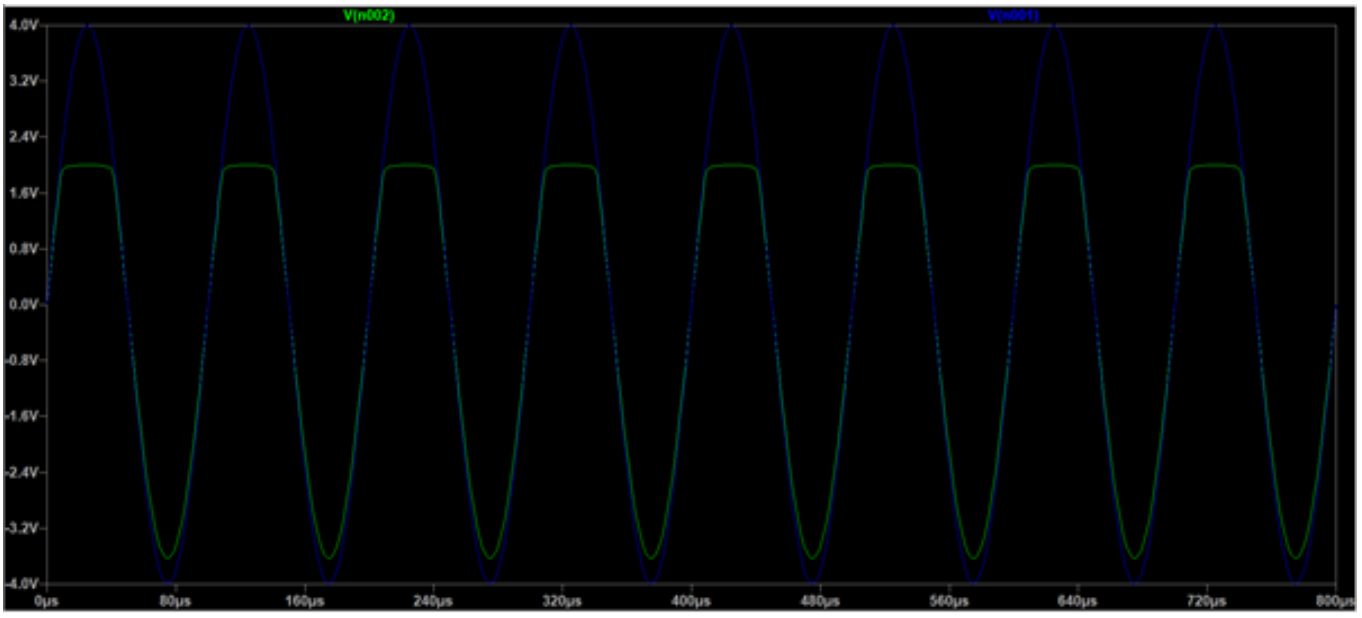


Fig.: The output of the clipper circuit

- Maximum output voltage = 2.00V (in its ON state, the voltage is clipped to go beyond that)
- Minimum output voltage = -3.63V (in diodes OFF state)
- The maximum Voltage drop across 1kohm resistor in the ON state of the diode (calculating from the plot itself, since it will essentially be the difference between the output and the input voltages) = 4-2 = **2V.**
- The maximum Voltage drop across 1kohm resistor in OFF state of the diode (calculating from the plot itself, since it will essentially be the difference between the output and the input voltages) = -3.63 – (-4) = **0.37V.**

Discussion:

The graph we obtained for voltage (across load resistance) in both ON and OFF states of the diode (plotted in green) and input source voltage (plotted in blue), on the y-axis vs time (in us), on the x-axis.

In the first half cycle, when the diode is in ON state, the voltage across the load resistance is obtained from the voltage drop across the diode and reference voltage source (which is 0.67+1.33 = **2V**, since both of them are connected with the same polarities and thus are added).

In the next half-cycle, however, the diode turns OFF and the voltage across the load is obtained by considering source voltage, series resistance and the load resistance circuit, which is found out to be -3.63V, and the terminal having the diode acts as an open circuit. Thus, voltage for the load output voltage is clipped to 2V and our objective is accomplished.