PSPICE SIMULATIONS WITH THE RESONANT INVERTER

POWER ELECTRONICS

COLORADO STATE UNIVERSITY

Created by Colorado State University student

PURPOSE**:** The purpose of this lab is to simulate the resonant inverters using OrCAD® to better familiarize the student with some of its operating characteristics. This lab will explore some of the following aspects of the resonant inverters:

- Discontinuous Conduction Mode
- Inductor sizing
- Differential voltage across the inductor
- Time it takes for the converter to reach steady state
- Output Ripple voltage and selection of the capacitor.
- Ripple current through the capacitor
- Equivalent Series Resistance (ESR) of the output capacitor.
- Effects of changing and removing load resistance
- Effects of the ON resistance of the switch
- Efficiency
- Effects of changing frequency

NOTE: The simulations that follow are intended to be completed with OrCAD®. It is assumed that the student has a fundamental understanding of the operation of OrCAD®. OrCAD® provides tutorials for users that are not experienced with its functions.

PROCEDURE:

Part 1: Build the schematic shown in Figure 1.

V1 is an AC voltage source (VAC) from the source library. It needs to be set for 5volts.

L1 is an ideal inductor from the Analog Library. Set for16μH.

R1 is an ideal resistor from the Analog Library. Set for 10Ω.

C1 is an ideal capacitor from the Analog library. Change the value to 0.16μ F.

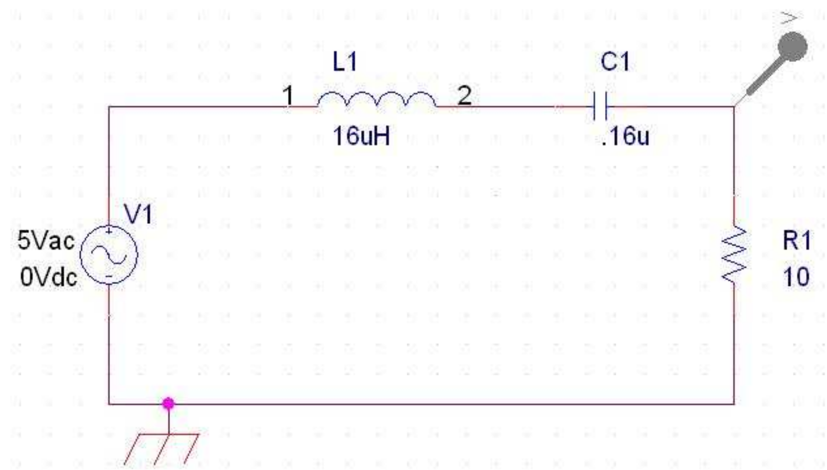
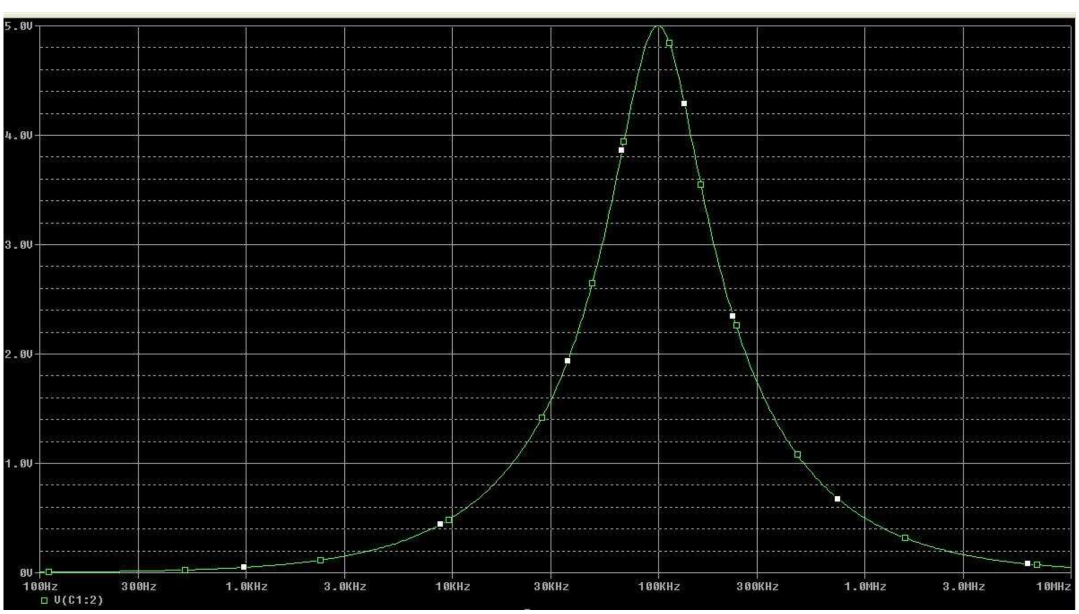


Figure 1. Series resonant inverter schematic on OrCAD®.

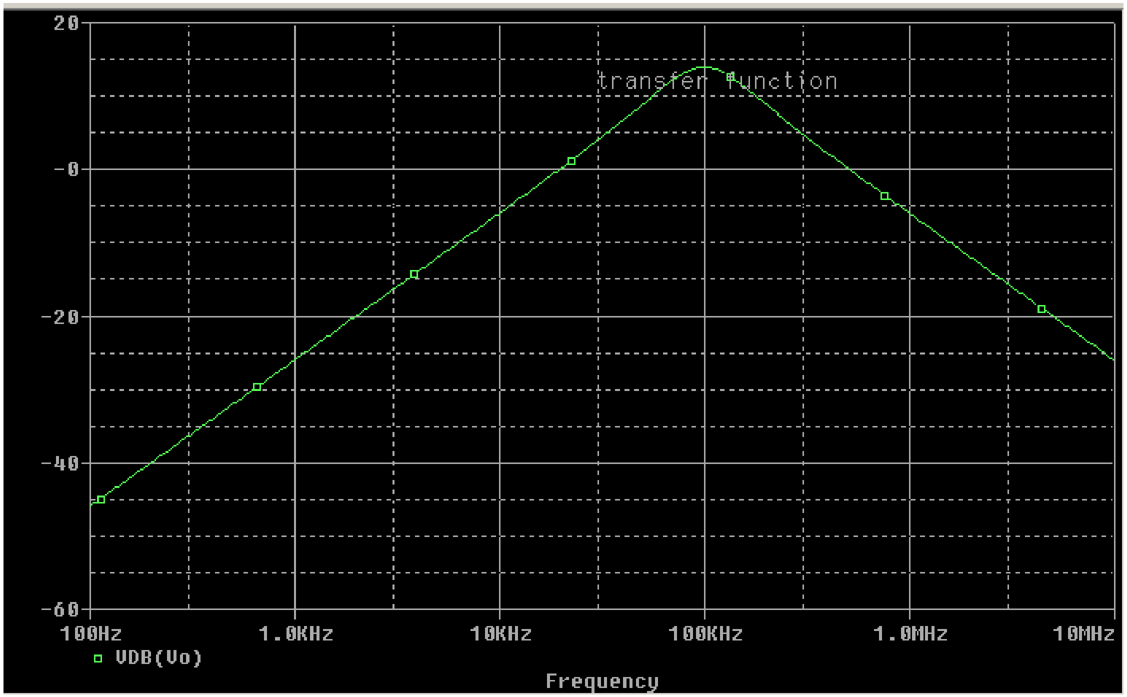
a. Once the above schematic is captured, the simulations can be run. First, the type of simulation will need to be specified. This simulation is an AC Sweep. The sweep needs to be a Logarithmic Decade, with a start frequency of 100 and end frequency of 10Meg. Points/decade will need to be 101.

Q1. What is the peak output voltage of a resonant inverter operation at 100KHz? Verify your results mathematically.



This shows the output voltage of a resonant inverter rising to 5V at the frequency is 100kHz.

Remove the voltage marker, and use a db magnitude of voltage to measure the voltage gain or transfer function of output/input voltage. Place the voltage marker in series next to R.



Q2. What can be said about the transfer function? Verify your results mathematically.

Now change VAC voltage source with Vsin as shown in figure 2. Set the VAMPL for 5V, Voff is 0, and Freq is 100k.

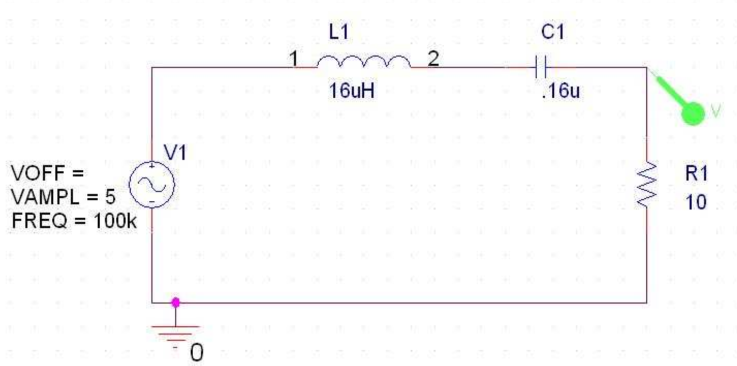
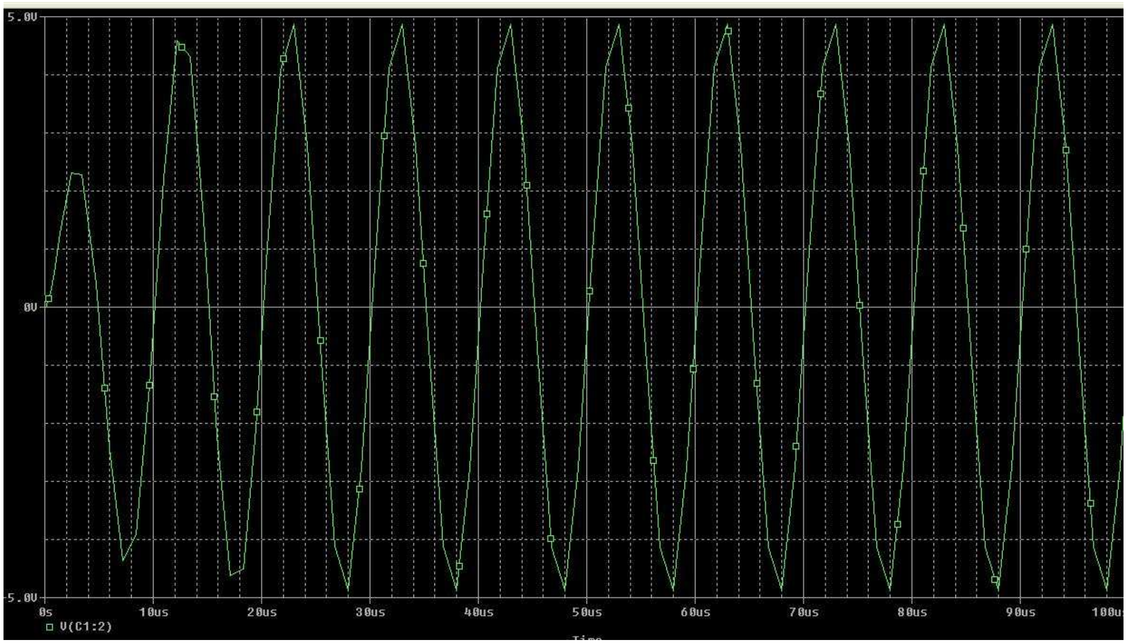


Figure 2. The schematic of Series resonant inverter with Vsin in OrCAD.

When the above schematic is captured, the simulations can be run. First, the type of simulation will need to be specified. This is a (Time Domain) transient simulations. The Run to time will need to be changed to 100µsec. The Start Saving data after should be set to zero.

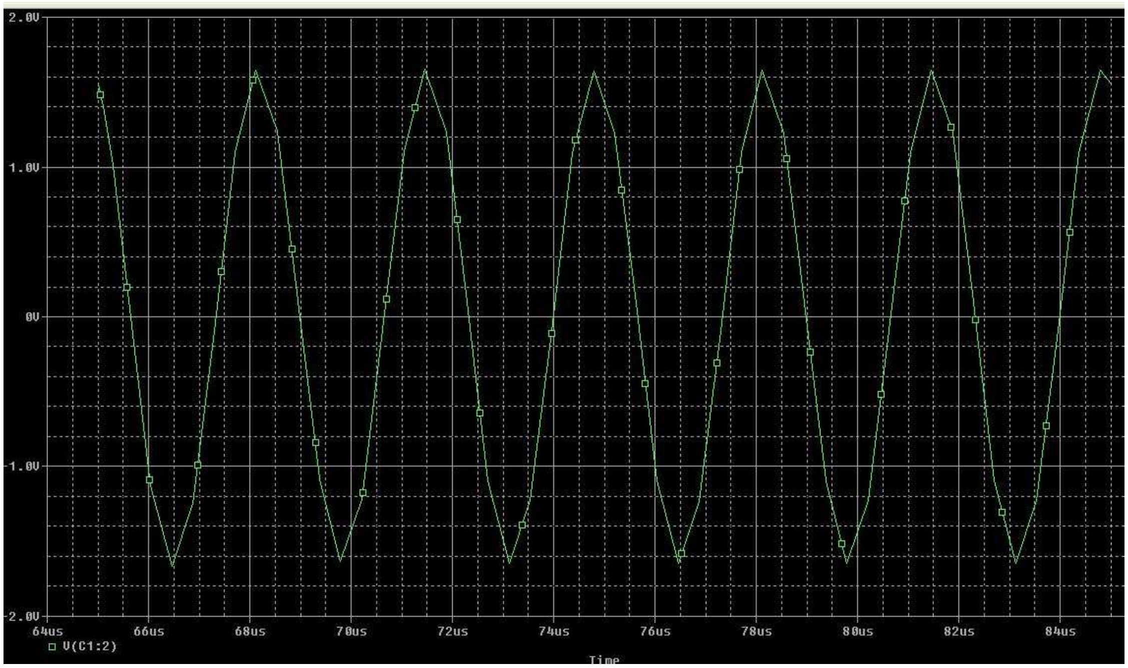
Q3. What is the peak-to-peak output voltage?



This figure is shown the result of the output voltage at resonant frequency is approx 5v.

Next, change FREQ from 100k to 300k and rerun the simulation. Also change the "Run to Time" to 85µsec, "Maximum Step Size" to 25µsec and "Start Saving data after" to 65µsec in the Transient Analysis setup.

Q4. What is the peak-to-peak output voltage?



The LCC inverter

PROCEDURE:

Part 2: Build the schematic shown in Figure 3.

V1 is an AC voltage source (VAC) from the source library. It needs to be set for 5 volts.

L1 is an ideal inductor from the Analog Library. Set for16μH.

R1 is an ideal resistor from the Analog Library. Set for10Ω.

C1 is an ideal capacitor from the Analog library. Change the value to 0.16μ F.

C2 is an ideal capacitor from the Analog library. Change the value to 0.16μ F.

Where k= Cp/Cs = C2/C1=1

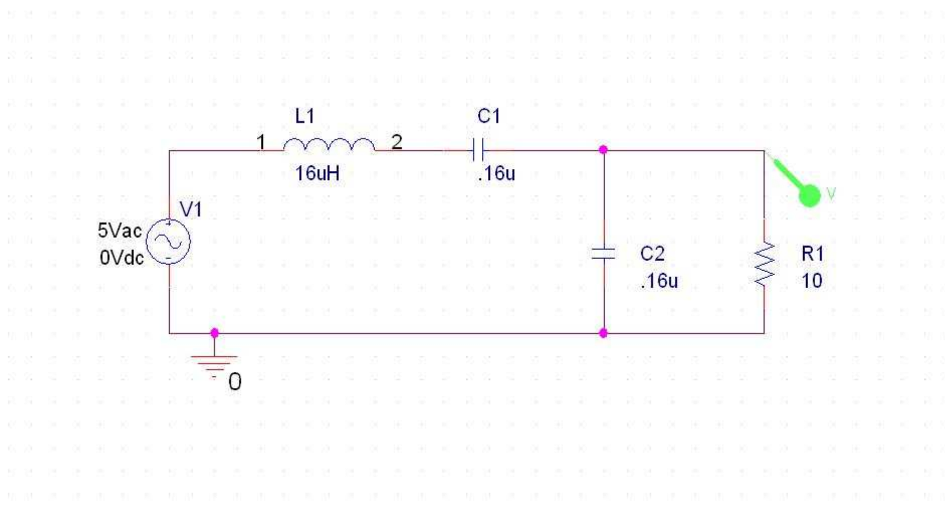
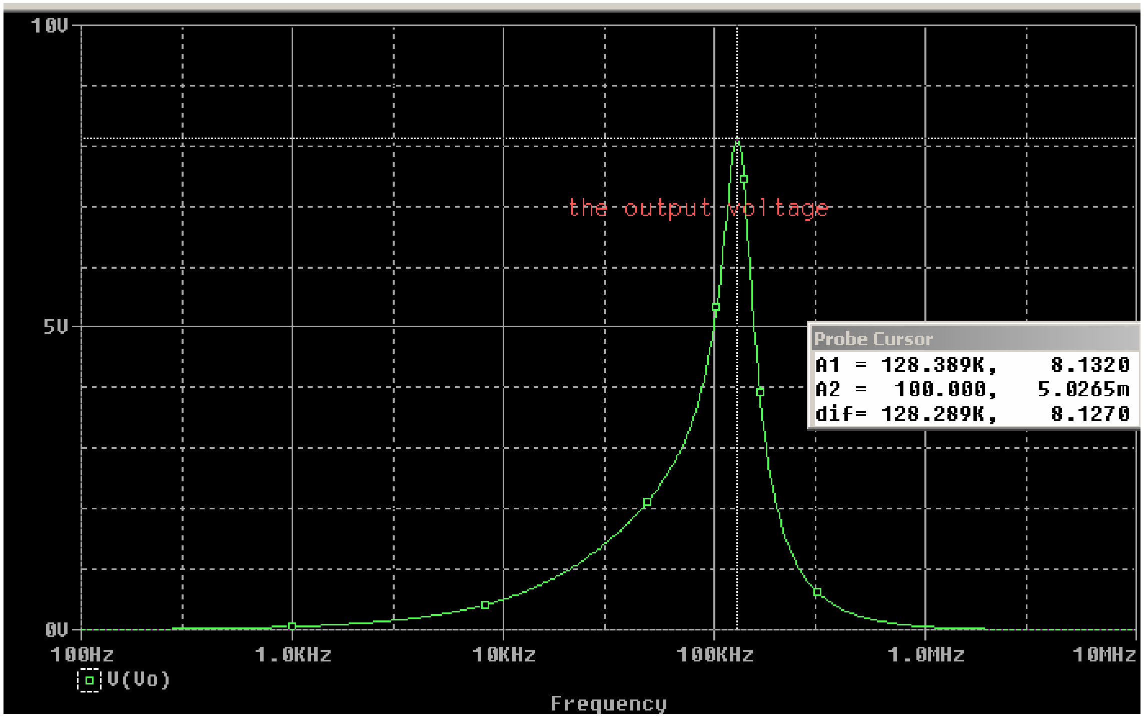


Figure 3. LCC resonant inverter schematic in OrCAD®.

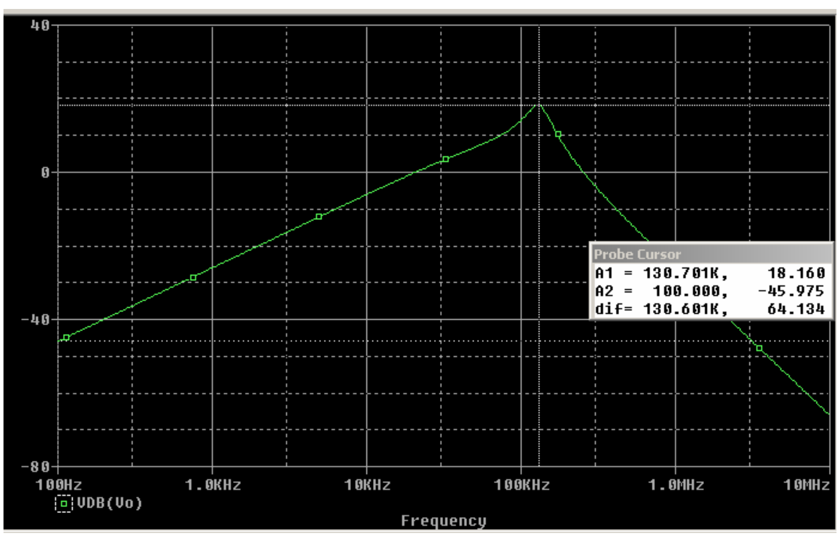
Once the above schematic is captured, the simulations can be run. First, the type of simulation will need to be specified. Most of these simulations are AC Sweep, Logarithmic decade. The end frequency will need to be changed to 10Meg. Running the simulation will result in the following output (Pts/Decade and Start freq should be set to 101 and 100 unless otherwise specified).

Q5. What is the peak output voltage of a resonant inverter operation at 100KHz? Verify your results mathematically.



This shows the output voltage of a LLC resonant inverter rising to 8.13V at frequency approx.128kHz

Again, remove the voltage marker, and use a db magnitude of voltage to measure the voltage gain or transfer function of output/input voltage. Place the voltage marker in series next to R.



This shows the transfer voltage of a LLC resonant inverter rising to 18V at the resonant frequency.

Q6. What can we say about the transfer function for a LLC resonant inverter? Verify your results mathematically?

Now change VAC voltage source with Vsin as shown in figure 4 simulation time domain at resonant frequency. Set the VAMPL for 5V, Voff to zero, and FREQ to 100KHz.

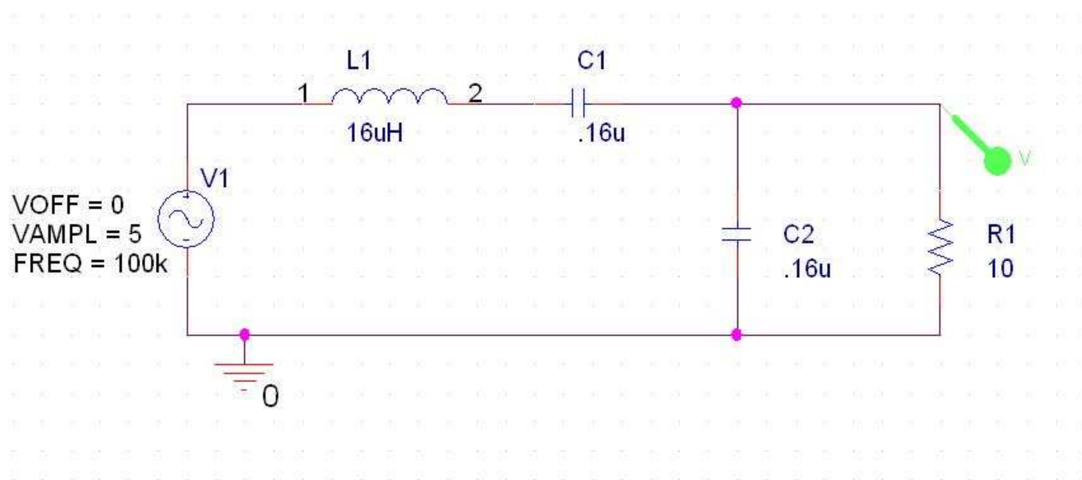
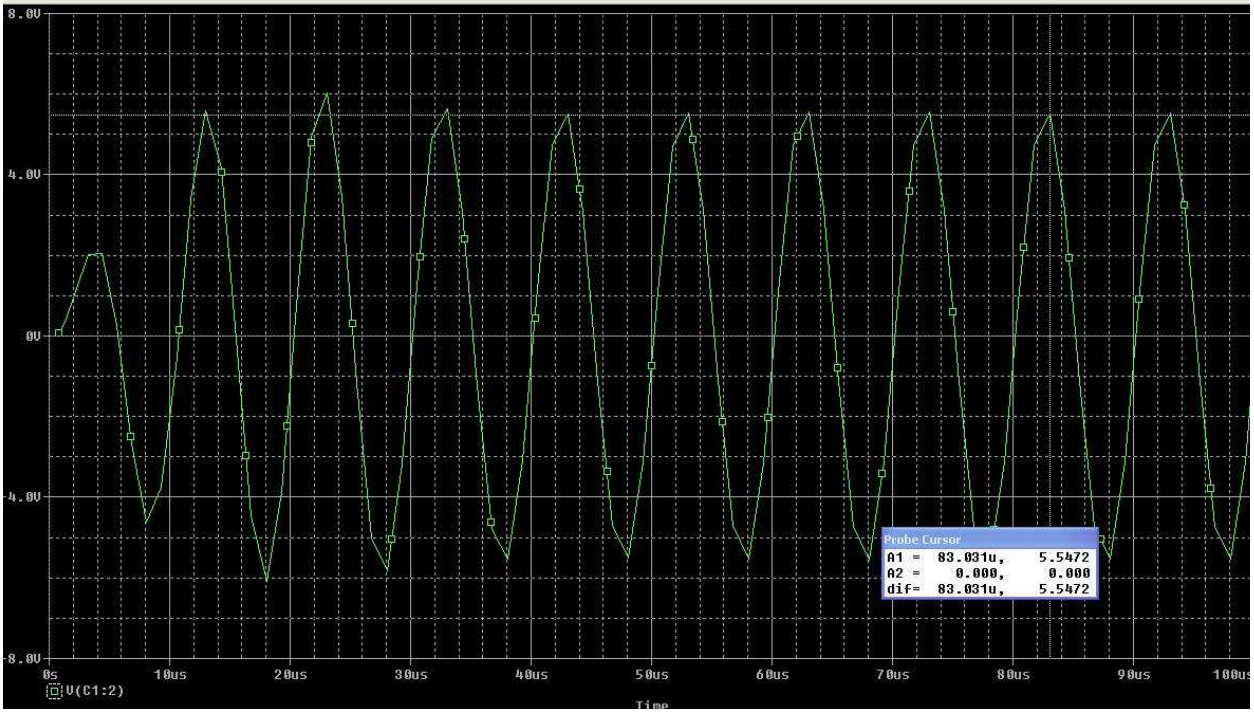


Figure 4. The schematic of LLC resonant inverter with Vsin in OrCAD.

When the above schematic is captured, the simulations can be run. First, the type of simulation will need to be specified. This is a (Time Domain) transient simulations. The Run to time will need to be changed to 100µsec. The Start Saving data after should be set to zero and the Max step size should be changed back to zero.

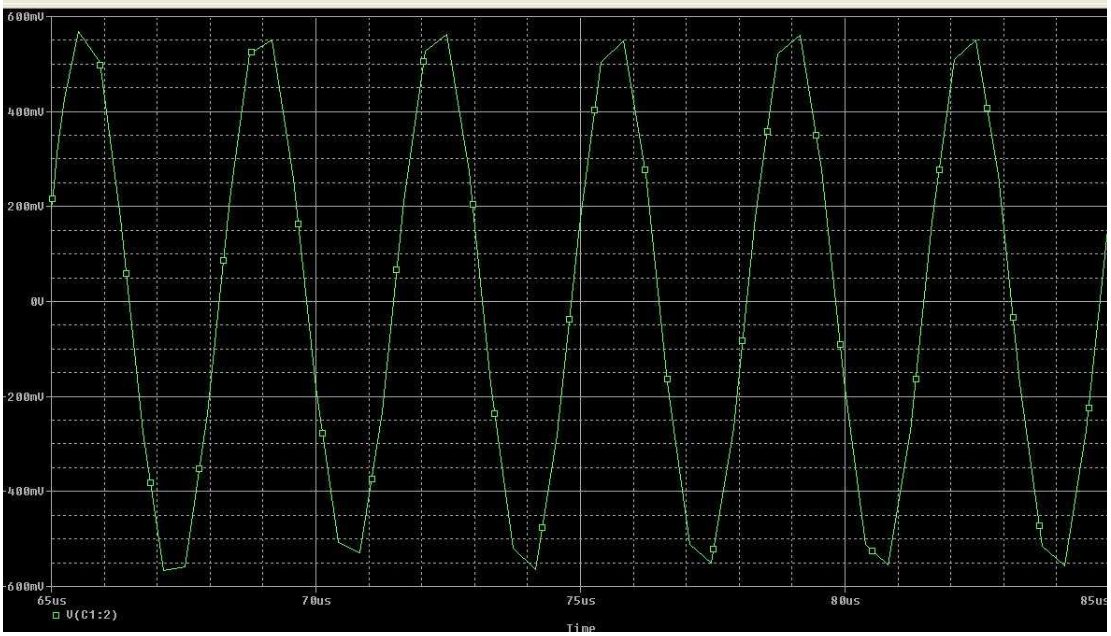
Q7. What is the peak-to-peak output voltage?



This figure is shown the result of output voltage at resonant frequency.

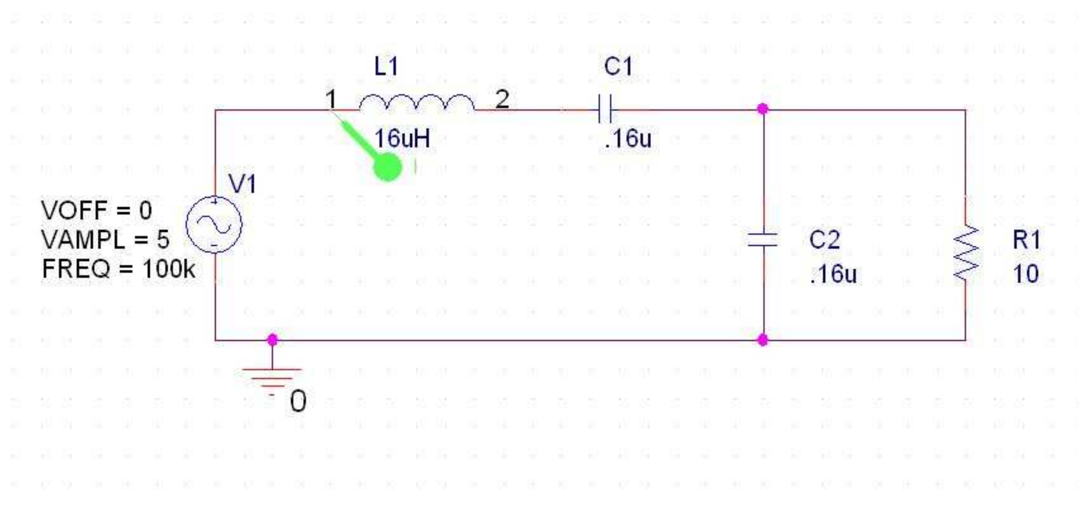
Next, change FREQ from 100k to 300k and rerun the simulation. Also change the "Run to Time" to 85μsec, "Maximum Step Size" to 25μsec and "Start Saving data after" to 65μsec in the Transient Analysis setup.

Q8. What is the peak-to-peak output voltage? Is the peak-to-peak voltage increasing or decreasing compare to the operation at 100Khz? Explain why?

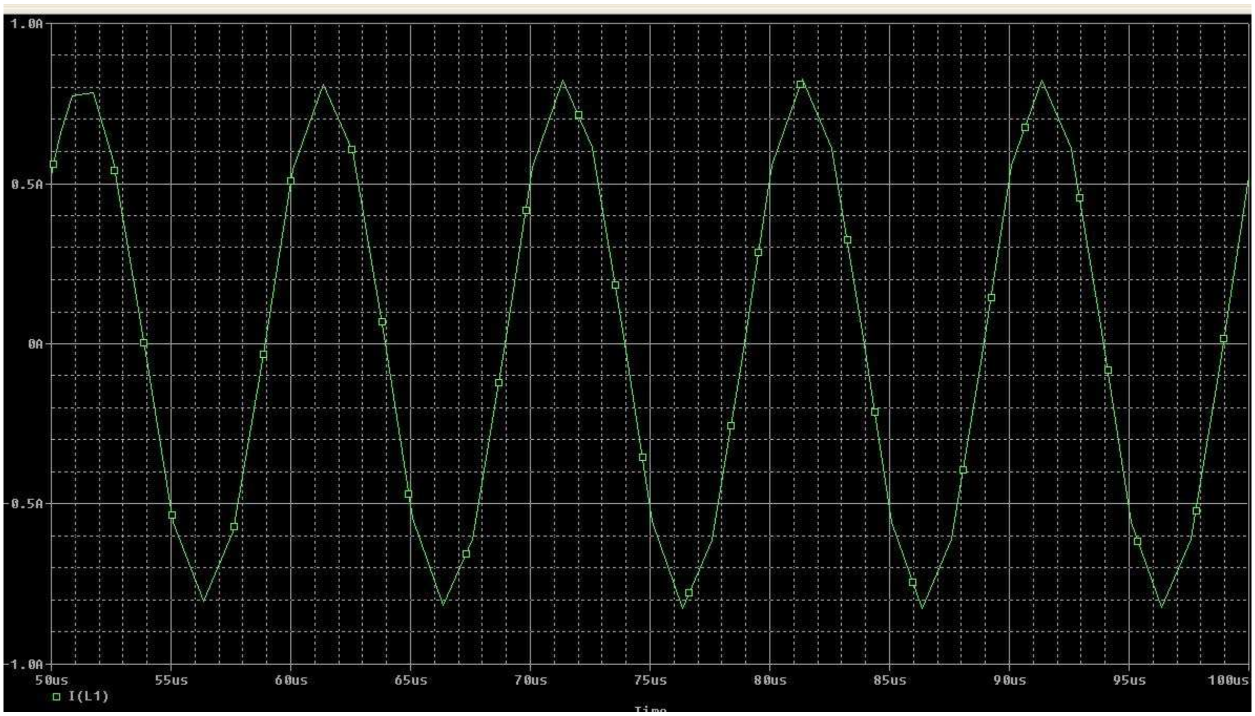


This figure is shown the result of output voltage operation at 300KHz.

Change the frequency of V1 back to 100k. Remove the voltage markers, and use a **current marker** to measure the inductor L1 current. Place the marker in series next to L1. Also change the "Run to Time" to 85µsec, "Maximum Step Size" to 25µsec and "Start Saving data after" to 50µsec in the Transient Analysis setup.

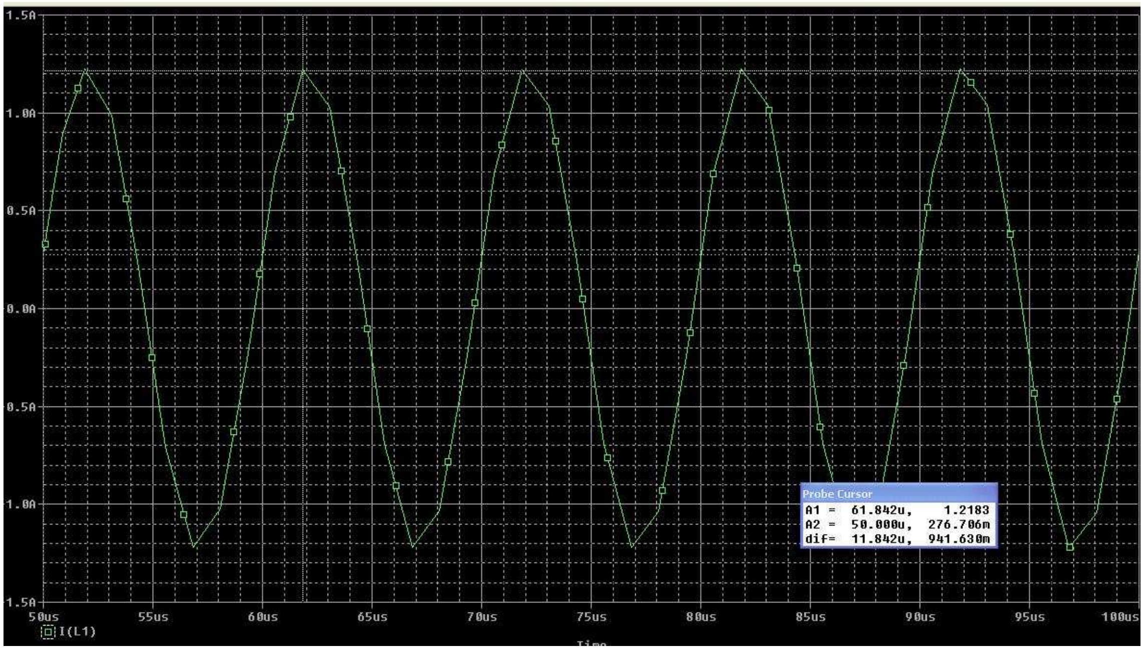


Q9. What is the peak inductor current during steady state? Verify peak current result mathematically.



The picture above shows that the peak steady state current is approximately 0.8A

Q10. Now change the load resistor to 5Ω and rerun the simulation.   What is the peak inductor current during steady state? Verify peak current result mathematically.



The picture above shows that the peak steady state current is approximately 1.2A

In the parallel resonant or parallel loaded inverter, the load voltage is equal to the resonant tank capacitor voltage. The LCC inverter employs tank capacitors both in series and parallel with the load. If the tank network is purely reactive, then its input impedance Zi is a monotonic function of the load resistance R. The terminal impedances are simple functions of the tank elements and the body diagram is easily constructed. Since the impedances do not depend on the load it is purely reactive.