Name:
Time:

Lab 4: Single-Phase Inverters & Filtering

Pre Lab

Voltage source inverters: An AC-to-DC converter is called an inverter. They are widely used in applications such as motor drives, HVDC transmission systems, wind energy systems, and solar energy systems, just to name a few. Generally when we talk about inverters in this class we mean voltage source inverters (VSI). The output voltage is set and the output current is allowed to vary for a voltage source inverter…hence the name.

1. Draw the schematic for the most commonly used single phase voltage source inverter: The H-bridge. It's also known as a full bridge inverter.

2. Briefly describe the operation of a full bridge single phase inverter.

3. Draw the output voltage waveform for a full bridge single phase inverter if each transistor pair conducts for half of the cycle (180^0 conduction).

Name:
Time:

4. Draw the output current waveform if a purely resistive load of 0.4 Ω was attached to the inverter and the input voltage was 100 V_{dc}.

5. How would the current waveform change if the load were inductive?

6. The control of inverters must be very precise in order to keep from damaging the DC source. In terms of the switching of the IGBTs (or other power switching device), what must be avoided in order to ensure the source isn't shorted?

Name:
Time:

Grid connection requirements: IEEE 1547-2003 standard provides rules for connecting distributed resources to the grid, such as if one wanted to put solar panels on one's roof. The standard can be downloaded from IEEE Xplore.

1. List 3 requirements for connecting distributed resources to the grid.

Filtering: The equation for instantaneous output voltage of a single phase full bridge inverter (VSI) is:

$$v_o = \sum_{n=1,3,5\ldots}^{\infty} \frac{4V_s}{n\pi} \sin(n\omega t)$$

v_o is an infinite sum of sinusoids of whose frequencies are integer multiples of the fundamental, *w. We* say that the voltage contribution from the n=1 sinusoid is the fundamental. All other voltage contributions we collectively refer to as harmonics. For example, the 3rd harmonic is described as: $\frac{4V_s}{3\pi}\sin(3\omega t)$. If the fundamental is 60 Hz, as in the US, the 3rd harmonic will be 180 Hz and so on.

Generally, harmonics are a bad thing in an electric power system; they lead to problems with equipment and increased losses. Therefore, we want to minimize them as much as possible. As you might have seen when doing the previous problem, IEEE 1547 provides rules for the amount of TDD allowed when connecting distributed resources to the grid. Total harmonic distortion is defined as $= \frac{1}{I_1}\left(\sum_{n=2,3\ldots}^{\infty} {I_n}^2\right)^{1/2}$. $TDD = total\ demand\ distortion = THD\ \frac{fundamental\ load\ current}{circuit\ rating}$. We'll deal with THD only in this lab. One way to reduce the THD of an inverter is to use a filter.

1. What type of filter would be best to use?

Name:
Time:

Lab Exercises

Voltage source inverters

1. Implement a single-phase, 180^0 modulation, full-bridge VSI. Use a DC source as the input; you choose the voltage. Use any resistive load you like, just be sure not to exceed its ratings. Be sure the toggle switches on the IGBT Chopper/Inverter module are in their correct positions.
2. Take screenshots of the output voltage and current waveforms. Note when each transistor is on.

3. Do the diodes ever conduct? Why or why not?

Filtering

1. Run the inverter with a 20 V DC source as the input and a 17 Ω resistor as a load. Take a screenshot of the harmonic analyzer for the output current and note the THD (the Labvolt software calls it merely “distortion”).

2. Take a screenshot of the input voltage, input current, output voltage, and output current all on the same screen. What is the input power, the power delivered to the load, and the inverter's efficiency?

3. Design and implement a passive output filter for the full bridge inverter so that no current harmonic is more than 15% of the fundamental and THD is below 13%. **Do not use polarized capacitors,** including the 210 uF one in the Labvolt "Filtering Inductors/Capacitors" module. Make sure that whatever components you choose can handle the voltages and currents present in your circuit.
    a. Why won't electrolytic (polarized) capacitors work here?

b. Describe your design process and make a schematic of your final filter with component values.

4. Take a screenshot of the harmonic analyzer for the output current and note the THD.

Name:
Time:

5. What is the input power, the power delivered to the load, and the inverter's efficiency?

6. Why did the input power decrease so much? Hint: look at the input current on the scope.

7. Write down any opinions or conclusions you've come to about filtering for single phase inverters.