Background

The objective of Experiment 5 is to design, construct, test, and demonstrate an inverter to interface the high-voltage (120 – 200 V) dc bus to a 120 V_{rms} ac load.

Laboratory Procedure

Part 1: Modified Sine Wave Inverter

The goal of part 1 is to construct and demonstrate a "modified sine wave" inverter that is fed by the dc-dc boost converter of Exp. 4, and produces a 60 Hz ac rectangular waveform having an rms value of 120 V.

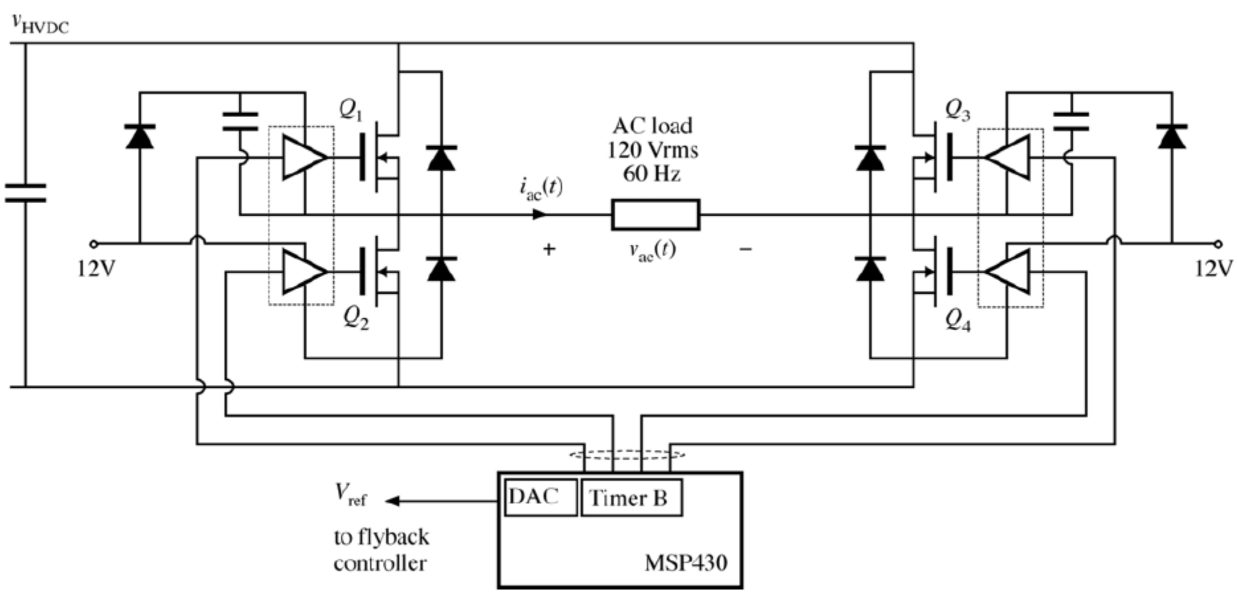

Fig. 1: Inverter H-bridge schematic.

1. Generation of Gate Drive Signals

Implement your pre-lab assignment C code that generates the gate drive control signals illustrated in Fig. 2. Obtain oscilloscope waveforms that show that the frequency is 60 Hz, and that the dead times of the Q1/Q2 and the Q3/Q4 signals are at least 200 nsec (500 nsec or more would be an even safer choice).

In addition, add code to your C program that allows you to set a variable to a desired value of HVDC (boost output) voltage, and then the code will output the appropriate value to the D/A converter to set the reference input V_{ref} of the boost converter feedback loop. Obtain data comparing the programmed and measured values of HVDC at 150 V and at a lower voltage, with the boost converter operating with a resistive load.

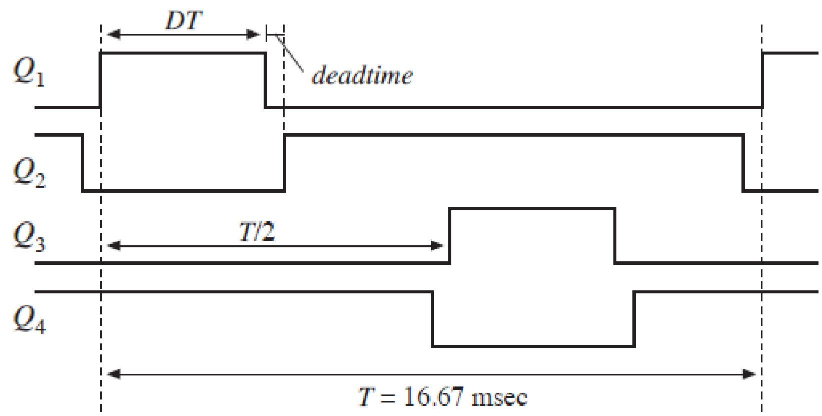

Fig. 2: Gate drive control timing.

2. Inverter Circuitry

Construct the power stage circuitry that you designed in your pre-lab assignment (Fig. 1), being sure to have bypass capacitors near each half of the H-bridge. You may power the gate drivers either from +12 V or +15 V. Connect a resistive load to the ac output of the H-bridge. Connect meters to measure the ac load voltage and current.

Note: As in Exp. 4, high voltages will be present in your circuit! Use caution in testing the circuit, do not touch the components, and be sure to turn off V_g before making changes to the circuit. Use x10 or x100 voltage probes when connecting the oscilloscope to the circuit.

Note: the ground leads of the oscilloscope probes are connected to earth ground. You cannot connect these leads to your half bridge outputs!

Use the oscilloscope to monitor the outputs of both half-bridge circuits, and use the oscilloscope subtract function to display the ac differential load voltage. Command the boost converter to produce a low output voltage, and observe oscilloscope waveforms to verify that the H-bridge is functioning properly. What is the measured system efficiency? Are the deadtimes sufficient? If so, proceed to the next step.

Command the boost converter to produce at least 150 V. Repeat the above paragraph.

3. Inverter Testing

Turn off the dc power, and disconnect the ac load resistor. Connect your inverter output to the isolated ac power outlet on your PV cart. Plug the cart power strip into this outlet, and plug a 25 W incandescent light bulb (provided by your TA) into the power strip. Measure the rms ac voltage using a battery-powered multimeter.

Start with a low inverter duty cycle. Command the boost converter to produce at least 150 V, and apply dc power to the boost converter. Read the voltage indicated by the meter. Without changing the boost converter voltage reference, increase the inverter duty cycle as necessary to get the ac voltmeter to read 120 V_{rms} (it will be necessary to turn the power off each time you change your C code). Capture the oscilloscope waveform and note the commanded inverter duty cycle and boost converter voltage at this point.

Part 2: True Sine Wave Inverter (Optional, Extra Credit)

The goal of part 2 is to construct and demonstrate a "true sine wave" inverter, that is fed by the dc-dc boost converter of Exp. 4, and produces a 60 Hz ac sinusoidal waveform having an rms value of 120 V.

4. Inverter Development

Design filter inductors to be connected to the output of your inverter. Fabricate and test your inductors to obtain the desired inductance. Connect your inductors between the H-bridge output and the ac load.

Modify your C code to produce a pulse-width modulated sinusoid as needed to drive the H-bridge gates. Test and debug your code.

5. Inverter Testing and Demonstration

Turn off the dc power, and disconnect the ac load resistor. Connect your inverter output to the isolated ac power outlet on your PV cart. Plug the cart power strip into this outlet, and plug a 25 W incandescent light bulb (provided by your TA) into the power strip. Measure this voltage using an ac voltmeter.

Command the boost converter to produce at least 180 V, and apply dc power to the boost converter. Read the voltage indicated by the meter. Without changing the boost converter voltage reference, increase the inverter duty cycle as necessary to get the meter to read 120V_{rms} (it will be necessary to turn the power off each time you change your C code). Capture the oscilloscope waveforms of the ac load current and the voltage of each half-bridge output.

Capture the oscilloscope waveform of the ac output (load) voltage (you must again subtract channels). Verify that the high-frequency switching ripple is less than 2 V peak-to-peak at all points on the sine wave. If so, then turn off the system and insert the "Kill-a-Watt" meter between the inverter output and the light bulb.

Check all readings of the "Kill-a-watt" meter at the 120 V_{rms} operating point: rms voltage, rms current, average power, and frequency. Do you believe them? How clean is the sine wave of the load current?