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1. Control of Half Bridge Inverter

A. If $K(s) = (k_p s + k_I) / s$, determine the control system loop gain found in Figure 1.

B. Derive the closed-loop transfer function, $i(s) / i_{ref}(s)$

C. Build Figure 1 in Simulink. Use the following parameters in the simulator:

$L = 1000\mu H$ $R = 5m\Omega$ $r_{ON} = 0\ m\Omega$ $V_{DC} = 1200V$ $V_s = 400V$ $f_s = 2000$ Hz

Here is a 6 minute tutorial on Simulink that is all one needs to complete this exercise: https://www.youtube.com/watch?v=KUa1MWm8bvk

The current command, i_{ref}, should be first changed from 0 to 1000 A at t = 0.6secs (see Step block). Once the model is built, vary the controller gains until the output current reaches the reference value within 5 milliseconds. What values of k_I and k_p did you select?

Plot the output current, i, and modulation index, m for 5 sets of k_I and k_p values. Plot the reference current, i_{ref}, on the same scale as i.

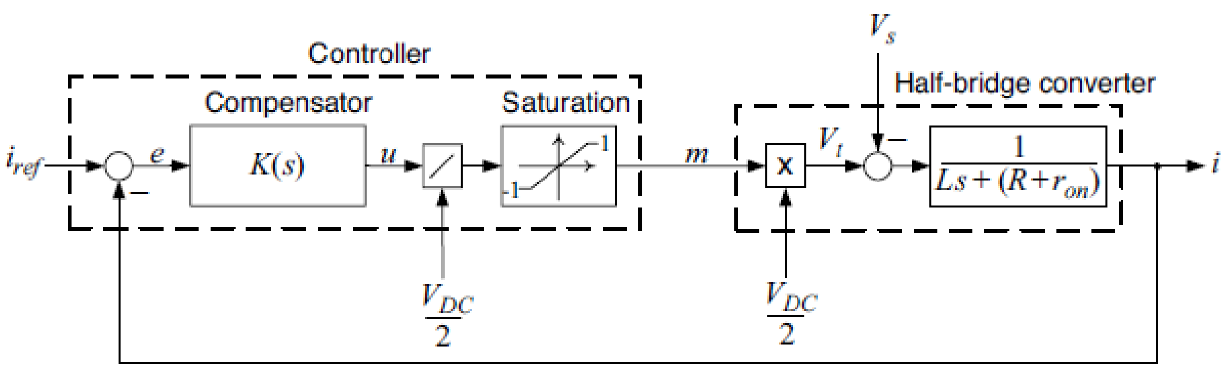
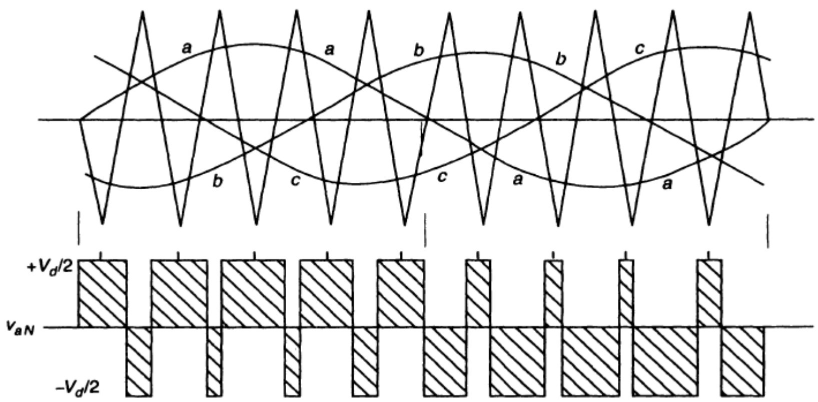


Figure 1: Half Bridge Converter Block Diagram Model

2. Half Bridge / Full Bridge Inverter Operating with Pulse Width Modulation.

In class, the gate signals to the semiconductors had a fixed width. In practice, pulse width modulation (PWM) is typically used (and more advanced routines such as space vector modulation) to control when the devices turn ON or OFF. The triangular waveform in the figure below is referred to as the carrier waveform (fixed frequency) and the three phase signals are referred to as the reference waveform (amplitude adjusted by the control system). The line to neutral voltage for signal A is plotted below the carrier and reference waveforms. If the carrier waveform is greater than the reference signal, a positive pulse is observed. If the carrier waveform is less than the reference signal, a negative pulse is observed in the output voltage. In this exercise, we are going to explore a few of the benefits of PWM and will be explained in more detail next week.



Run the half bridge simulink inverter model by hitting the button that looks like a "play" button at the top of the screen. Click on the block that contains the sample time, T_s at the bottom of the model once the simulation has completed. Within the GUI that appears, click on "FFT Analysis". With the "Input" set to "I load", compute the FFT spectrum by clicking on the word "Display".

A. Record the spectrum and the total harmonic distortion, THD, for carrier frequencies 1000 Hz, 2000 Hz, 3000 Hz, and 5000 Hz. The carrier frequency can be adjusted in the "Discrete PWM Generator" block within the half bridge inverter model.

B. What can be observed as the frequency is increased for: 1. Load Current 2. THD 3. Harmonics Spectrum. Take appropriate screenshots to support your answer.

C. Build a Full-Bridge Inverter model.

   Note: Replace <u>both</u> Vdc/2 voltage sources from the Half-Bridge inverter model with <u>one</u> voltage source equivalent to Vdc. Place the ground at the midpoint between one set of IGBT components.

   To validate your model, the fundamental component of the full-bridge inverter should be twice the size of the half-bridge inverter. Check with the FFT analysis tool explained earlier.

   Provide a screenshot of the output voltage and current seen by the load.