EN 313 - Power Electronics

Assignment-6

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1. A single-phase MOSFET-based two-level voltage source inverter operates from a DC source of 400V and delivers the maximum possible AC voltage at its output. What is the RMS value of the fundamental component of the AC voltage? What is the switching frequency of each MOSFET under this condition?

2. A single-phase two-level voltage source inverter (VSI) is operating from a DC source of 350V. The VSI is supplying an R-L load. Switching frequency of the VSI is 1kHz. The worst-case peak-to-peak ripple in the output current is 8.75A when *sine-triangle PWM (STPWM) with bipolar voltage switching* is used to generate the gate pulses for the switches of the VSI. Switches are ideal.

   (a) Determine the inductance of the load. (Hint: Use the principle of superposition to split the fundamental and ripple components of the output current; make suitable assumptions.)

   (b) What is the worst-case peak-to-peak ripple in the output current if *STPWM with unipolar voltage switching* is employed in the VSI?

   (c) RMS value of the fundamental component of output voltage is 198V. Assume the modulating signal to be constant over a carrier cycle. Determine the time instants (in the fundamental cycle) at which the worst-case peak-to-peak output current ripple occurs in both the PWM methods (STPWM with bipolar and unipolar voltage switching).

   (d) What is the total harmonic distortion (THD) in the output voltage for both the STPWM methods and how does it compare with the THD in square-wave operation? What is the reason for the current waveforms being more sinusoidal with STPWM than square-wave operation?
   (Hint: RMS value of the output voltage over a line-cycle $V_{AB,RMS} = \sqrt{\frac{1}{\pi}\int_0^{\pi} \left(V_{AB,RMS}^{T_s}\right)^2 \, d\omega t}$ where T_s is the time period of the carrier-wave.)

   (e) Simulate the single-phase inverter in SEQUEL (Choose a load resistance of 10Ω). Verify the peak-to-peak ripple in output current and the THD of output voltage with both the STPWM methods. Carry out the simulation in square-wave operation as well. Determine the THD in line current in each case, from the simulated waveforms. Comment on the relative values of THD (in current) with square-wave opereation and both the STPWM methods.

3. Refer to the single-phase two-level voltage source inverter (VSI) connected to an AC source shown in Fig. 1. The switches (can be considered ideal) in the VSI are turned ON and OFF appropriately to produce a quasi-square wave output voltage v_o as shown in the figure. Average power delivered to the AC source is 10kW and the AC source operates at unity power factor.

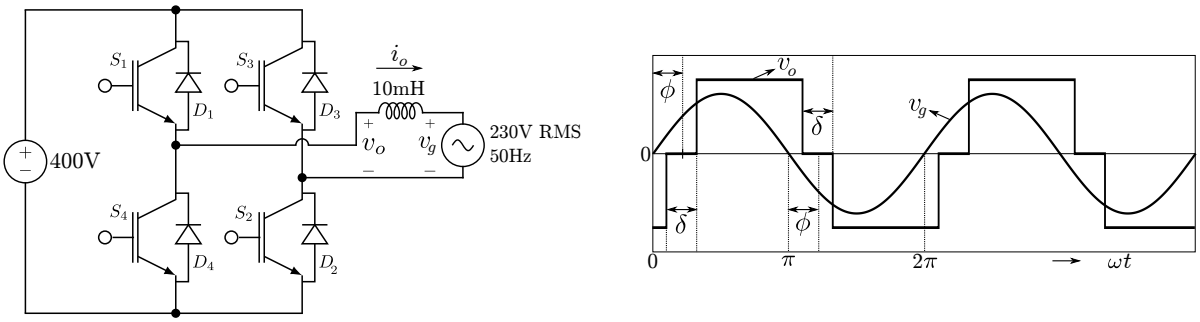

Figure 1: Single-phase two-level VSI connected to grid

(a) Determine the values of δ and ϕ.

(b) Sketch the waveform of the fundamental component of output current i_o. Indicate the switches conducting in the different intervals in a line cycle.

Answers:

1. 360.13V, switching frequency=fundamental frequency of the output AC voltage

2. (a) 10mH (b) 4.375A
   (c) $\omega t = 0°$ for bipolar PWM and $\omega t = 38.68°$ for unipolar PWM
   (d) 145.77% for bipolar PWM and 76.9% for unipolar PWM; 48% for square-wave operation

3. (a) $\delta = 82.08°$ and $\phi = -30.71°$
