ECE581

State Plane Analysis of the Dual Active Half-Bridge Converter

The dual active half-bridge (DAHB) converter is shown in Fig. 1. All capacitors C_∞ are very large in value, such that their ripple can be neglected within one switching period. The converter operates with phase-shift modulation, as shown in the timing diagram in Fig. 1. Consider the following design of the converter:

- L_l = 10 µH
- V_g = 200 V
- V = 200 V
- n_t = 1
- f_s = 200 kHz
- All devices Q_1-Q_4 have an effective output capacitance of C_{ds} = 100 pF
- All capacitors, C_∞, have the same voltage bias, $V_g/2 = V/2$

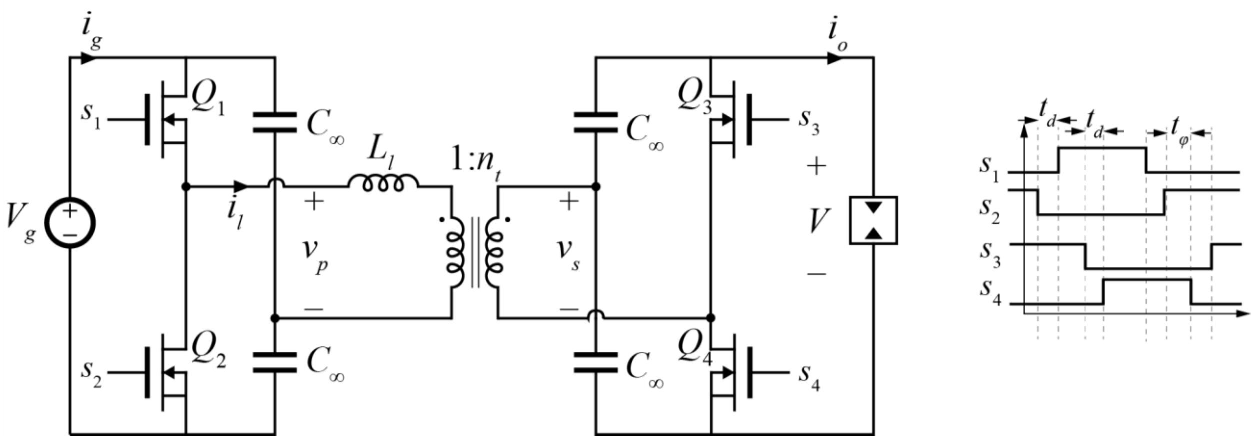

Figure 1: DAHB converter with phase shift modulation control

1. Sketch the j_l-m_p and j_l-m_s state planes for operation at P_{out} large enough such that all devices obtain ZVS and the phase shift $t_\varphi > 0$. Label all salient features (angles, radii, J and M values) with appropriate variable names
2. Solve each state plane to determine the ZVS boundary of each bridge, as a function of the current at the start of the respective dead-time interval and any circuit parameters

For the 1:1 DAHB, with modulation timing as defined in Fig. 1, it is possible to operate with $t_\varphi = 0$, but $t_d > 0$, and maintain ZVS of all devices. Under this specific mode of operation

3. Sketch the j_l-m_p and j_l-m_s state planes, again labeling all salient features.
4. Sketch the time-domain v_p, vs, i_l, i_o, and i_g over one full switching period.
5. Solve for numerical values of the dead time t_d of each half-bridge, and the average output power P_{out} over one switching period.