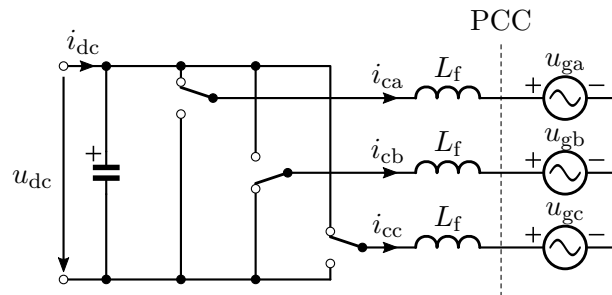


Problem 1: An operating point of a grid converter

The figure below shows a grid converter, whose DC voltage is $u_{dc} = 600$ V, DC current is $i_{dc} = 10$ A, and filter inductance is $L_f = 10$ mH. The electric grid is assumed to be a balanced three-phase voltage source with frequency of 50 Hz and phase-to-phase rms voltage of 400 V. The displacement power factor at the PCC is controlled to unity. The converter can be assumed to be lossless and switching-cycle-averaged quantities are considered.

- (a) Calculate the converter current vector in grid-voltage coordinates.
- (b) Calculate the magnitude of the converter output voltage vector.



Problem 2: DC-link voltage controller

A PI controller is used to regulate the DC-link voltage of a power converter,

$$p_{c,ref} = -k_p(W_{dc,ref} - W_{dc}) - k_i \int (W_{dc,ref} - W_{dc})dt$$

where $p_{c,ref}$ is the reference of the converter output power, $W_{dc} = (C/2)u_{dc}^2$ is the energy of the DC-link capacitor, and $W_{dc,ref} = (C/2)u_{dc,ref}^2$ is its reference. Power control is assumed to be ideal, i.e. $p_c = p_{c,ref}$. The input power $p_{dc} = u_{dc}i_{dc}$ is an unknown disturbance.

- (a) Calculate the closed-loop transfer functions $W_{dc}(s)/W_{dc,ref}(s)$ and $W_{dc}(s)/p_{dc}(s)$.
- (b) Express the controller gains k_p and k_i as functions of the damping ratio ζ and the undamped natural frequency ω_0 of the closed-loop characteristic polynomial.

