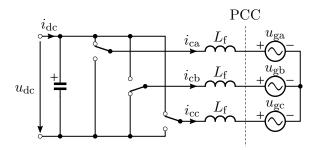
Problem 1: An operating point of a grid converter

The figure below shows a grid converter, whose DC voltage is $u_{\rm dc} = 600$ V, DC current is $i_{\rm dc} = 10$ A, and filter inductance is $L_{\rm f} = 10$ 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,

$$p_{\mathrm{c,ref}} = -k_{\mathrm{p}}(W_{\mathrm{dc,ref}} - W_{\mathrm{dc}}) - k_{\mathrm{i}} \int (W_{\mathrm{dc,ref}} - W_{\mathrm{dc}}) \mathrm{d}t$$

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

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

