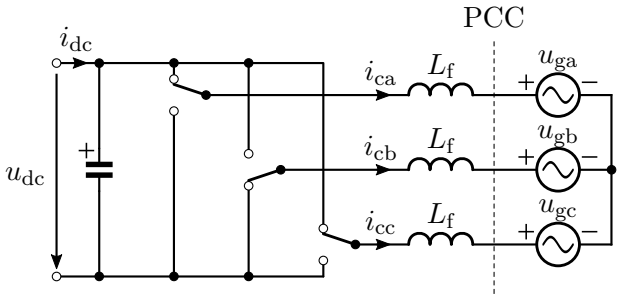
Problem 1: An operating point of a grid converter

The figure below shows a grid converter, whose DC voltage is $u_{\mathrm{dc}} = 600$ V, DC current is $i_{\mathrm{dc}} = 10$ A, and filter inductance is $L_{\mathrm{f}} = 10$ 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 $p_{\mathrm{c,ref}}$ is the reference of the converter output power, $W_{\mathrm{dc}} = (C/2)u_{\mathrm{dc}}^2$ is the energy of the DC-link capacitor, and $W_{\mathrm{dc,ref}} = (C/2)u_{\mathrm{dc,ref}}^2$ is its reference. Power control is assumed to be ideal, i.e. $p_{\mathrm{c}} = p_{\mathrm{c,ref}}$. The input power $p_{\mathrm{dc}} = u_{\mathrm{dc}} i_{\mathrm{dc}}$ is an unknown disturbance.

(a) Calculate the closed-loop transfer functions $W_{\mathrm{dc}}(s)/W_{\mathrm{dc,ref}}(s)$ and $W_{\mathrm{dc}}(s)/p_{\mathrm{dc}}(s)$.

(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.