GridCal

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HVDC MODELLING

Research oriented power systems software.

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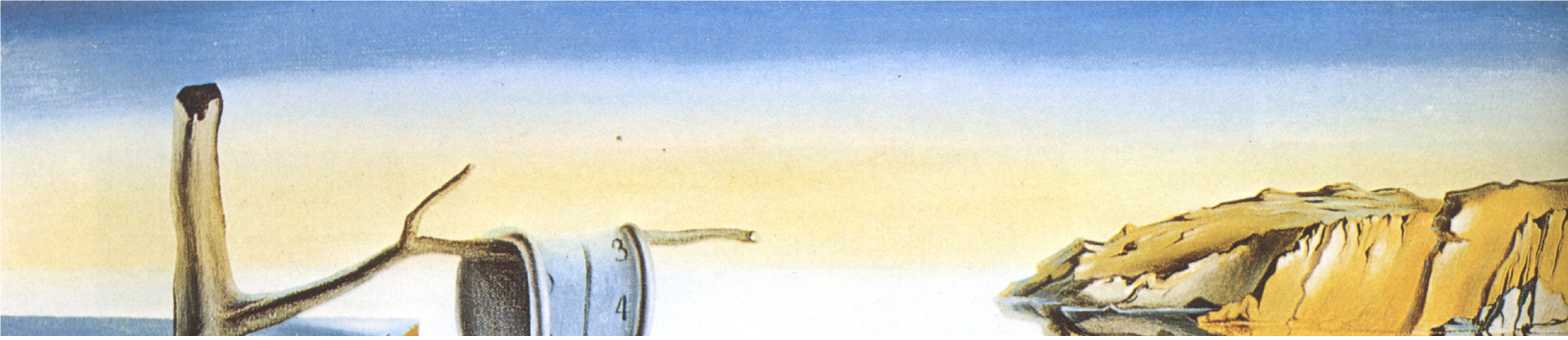

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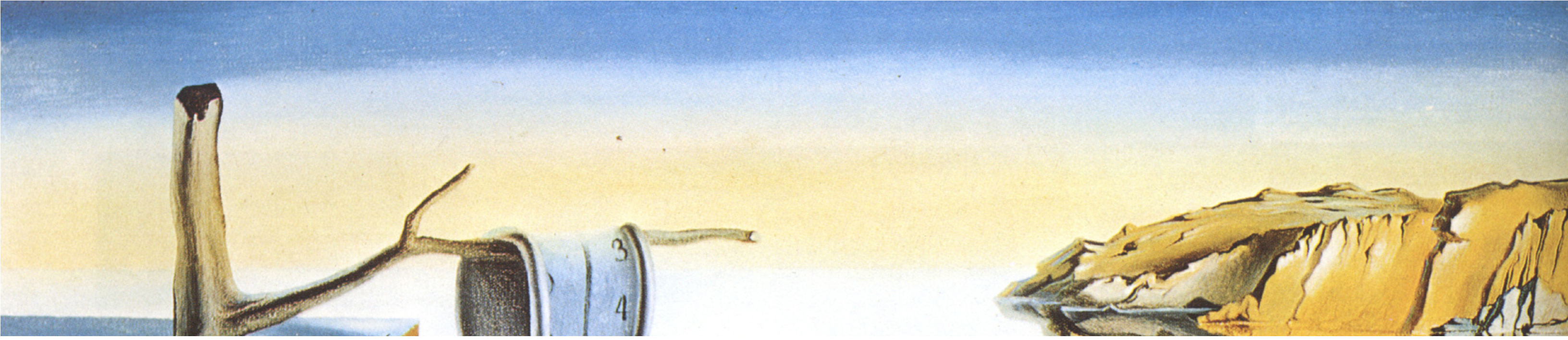

1. HVDC modelling

In this section a general HVDC converter model is presented along with the power flow equations to simulate HVDC grids.

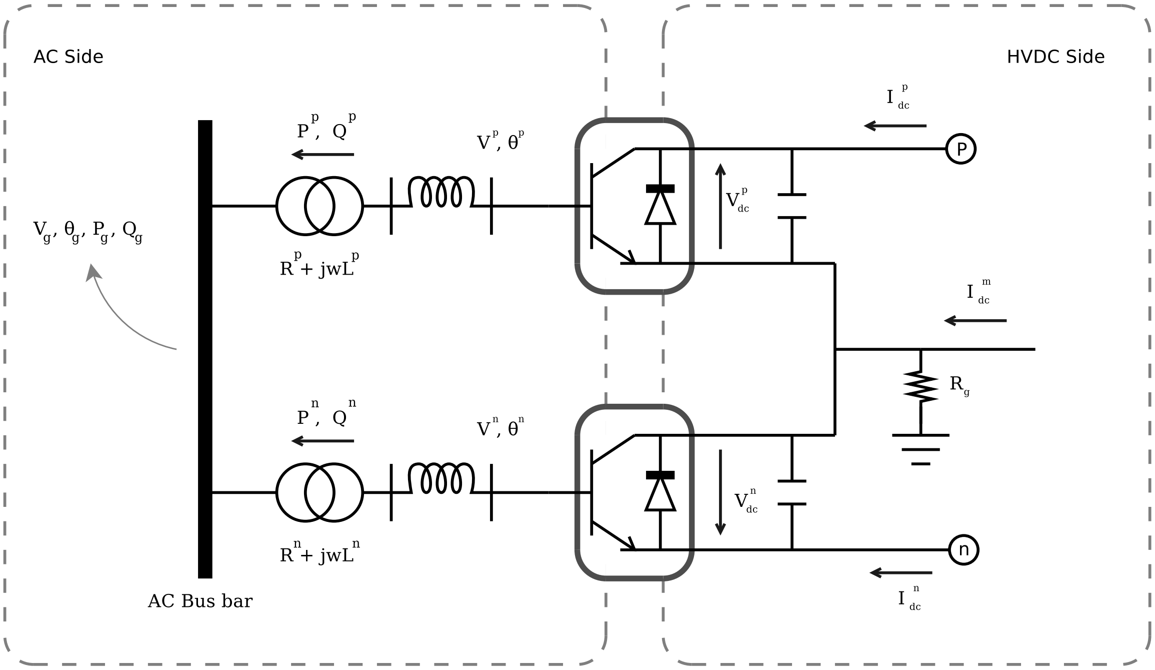

Figure 1.1: HVDC general converter model

Newton-Raphson system of equations to solve the HVDC grid power flow.

$$
\begin{bmatrix}
\frac{\partial f_3}{\partial V_g} & \frac{\partial f_3}{\partial \theta_g} & 0 & 0 & 0 & 0 & -1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
\frac{\partial f_4}{\partial V_g} & \frac{\partial f_4}{\partial \theta_g} & 0 & 0 & 0 & 0 & 0 & -1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & -1 & 0 & -1 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & -1 & 0 & -1 & 0 & 0 & 0 & 0 & 0 \\
\frac{\partial f_7}{\partial V_g} & \frac{\partial f_7}{\partial \theta_g} & \frac{\partial f_7}{\partial V^p} & \frac{\partial f_7}{\partial \theta^p} & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
\frac{\partial f_8}{\partial V_g} & \frac{\partial f_8}{\partial \theta_g} & \frac{\partial f_8}{\partial V^p} & \frac{\partial f_8}{\partial \theta^p} & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
\frac{\partial f_9}{\partial V_g} & \frac{\partial f_9}{\partial \theta_g} & 0 & 0 & \frac{\partial f_9}{\partial V^n} & \frac{\partial f_9}{\partial \theta^n} & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
\frac{\partial f_{10}}{\partial V_g} & \frac{\partial f_{10}}{\partial \theta_g} & 0 & 0 & \frac{\partial f_{10}}{\partial V^n} & \frac{\partial f_{10}}{\partial \theta^n} & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
\frac{\partial f_{11}}{\partial V_g} & \frac{\partial f_{11}}{\partial \theta_g} & \frac{\partial f_{11}}{\partial V^p} & \frac{\partial f_{11}}{\partial \theta^p} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \frac{\partial f_{11}}{\partial V_{dc}^p} & 0 & \frac{\partial f_{11}}{\partial I_{dc}^p} & 0 \\
\frac{\partial f_{12}}{\partial V_g} & \frac{\partial f_{12}}{\partial \theta_g} & 0 & 0 & \frac{\partial f_{12}}{\partial V^n} & \frac{\partial f_{12}}{\partial \theta^n} & 0 & 1 & 0 & 0 & 0 & 0 & 0 & \frac{\partial f_{12}}{\partial V_{dc}^n} & 0 & \frac{\partial f_{12}}{\partial I_{dc}^n} \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \frac{\partial f_{13}}{\partial V_{dc}^p} & \frac{\partial f_{13}}{\partial V_{dc}^n} & 1 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \frac{\partial f_{14}}{\partial V_{dc}^p} & \frac{\partial f_{14}}{\partial V_{dc}^n} & 0 & 1 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & A & 0 & 0 & 0 & B & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & C & 0 & 0 & D & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & E & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & F & 0 & 0 & 0 & 0
\end{bmatrix}^{(k}
\times
\begin{bmatrix} V_g \\ \theta_g \\ V^p \\ \theta^p \\ V^n \\ \theta^n \\ P_g \\ Q_g \\ P^p \\ Q^p \\ P^n \\ Q^n \\ V_{dc}^p \\ V_{dc}^n \\ I_{dc}^p \\ I_{dc}^n \end{bmatrix}^{(k}
=
\begin{bmatrix} \Delta f_3 \\ \Delta f_4 \\ \Delta f_5 \\ \Delta f_6 \\ \Delta f_7 \\ \Delta f_8 \\ \Delta f_9 \\ \Delta f_{10} \\ \Delta f_{11} \\ \Delta f_{12} \\ \Delta f_{13} \\ \Delta f_{14} \\ \Delta f_{15} \\ \Delta f_{16} \\ \Delta f_{17} \\ \Delta f_{18} \end{bmatrix}^{(k}
\tag{1.1}
$$

Each element of the matrix is a $N \times N$ matrix, where N is the number of converters in the HVDC grid. The sub-matrices A, B, C, D, E and F depend of the converter control mode.