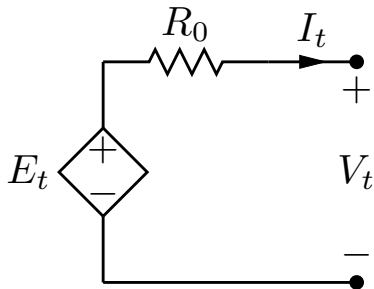


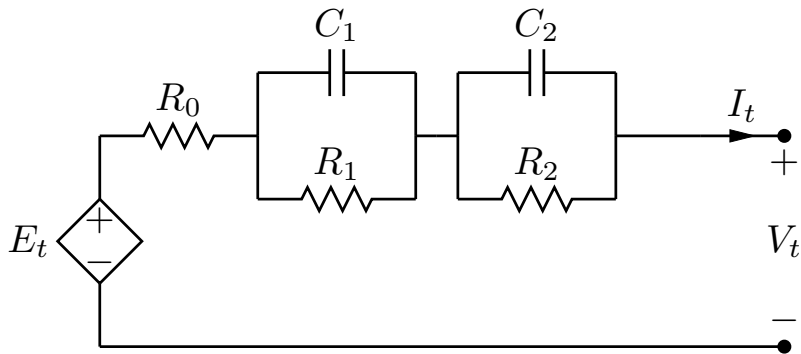
Equivalent circuit models

ECM of battery cell: internal resistance



- E_t : cell internal voltage
- V_t : cell terminal voltage
- I_t : cell current
- R_0 : cell resistance

Two-time-constant model



Two-time-constant model: derivation of equation

$$x = [v_{C_1} \ v_{C_2} \ v_{C_3}] , u_{tk} = [i_{tk} \ 1]^T \quad (1)$$

$$\mathcal{A}_c = \begin{bmatrix} \frac{-1}{R_1 C_1} & 0 & 0 \\ 0 & \frac{-1}{R_2 C_2} & 0 \\ 0 & 0 & \frac{-1}{R_3 C_3} \end{bmatrix}, \mathcal{B}_c = \begin{bmatrix} \frac{1}{C_1} & 0 \\ \frac{1}{C_2} & 0 \\ \frac{1}{C_3} & 0 \end{bmatrix} \quad (2)$$

$$\mathcal{K}_c = \text{diag}(k_1, k_2, k_3), \quad (3)$$

$$\mathcal{C} = [1 \ 1 \ 1], \mathcal{D} = [R_s \ E], \mathcal{G} = \sigma_g. \quad (4)$$