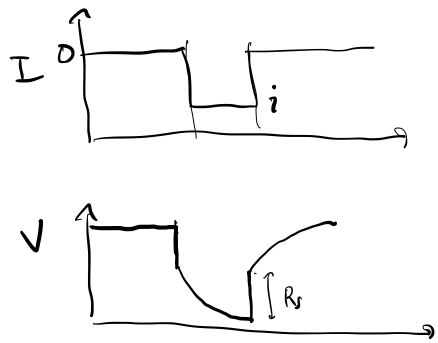
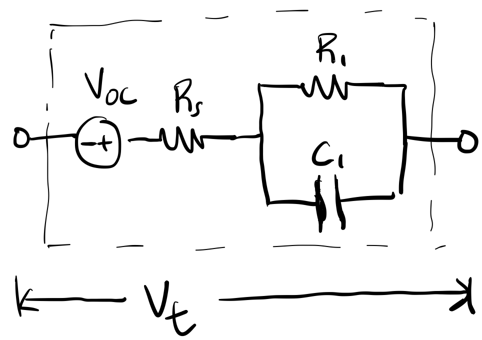
Nov 29, 2021

Topics: 1) OCV – R – RC model (DC analysis)

2) Introduction to EIS (AC analysis)

OCV-R-RC





$$\boxed{\text{KVL:} \quad V_t(t) = V_{oc}(z(t)) - i(t)R_s - i_{R_1}(t)R_1}$$

Solve for i_{R_1}.

KCL: $i = i_{R_1} + i_{C_1}$

$$= i_{R_1} + C_1 \frac{dV_1}{dt}, \quad V_1 = i_{R_1} \cdot R_1$$

$$i = i_{R_1} + C_1 R_1 \frac{di_{R_1}(t)}{dt}$$

$$\frac{di_{R_1}(t)}{dt} = -\frac{1}{R_1C_1} i_{R_1}(t) + \frac{1}{R_1C_1} i(t)$$

$$\dot{x}(t) = ax(t) + bu(t)$$

$$\Rightarrow x(t) = e^{at}x(0) + \int_0^t e^{a(t-\tau)} bu(\tau)d\tau$$

evaluate the integral: $(t \to k\Delta t)$

current update:

$$i_{R_1}[k+1] = \exp\left(\frac{-\Delta t}{R_1C_1}\right) i_{R_1}[k] + \left(1 - \exp\left(-\frac{\Delta t}{R_1C_1}\right)\right) i[k] \quad (1)$$

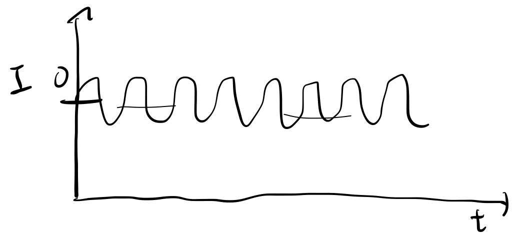
SOC update:

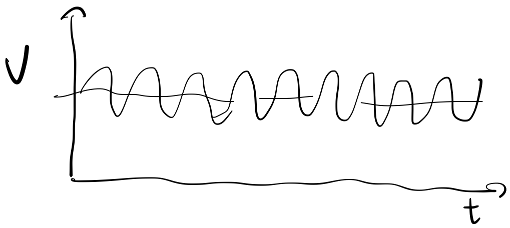
$z \in (0,1)$

$$z[k+1] = z[k] - \frac{i[k]\Delta t}{Q_{max}}$$

(+ve current means discharging the cell)

Impedance (To be continued...)





$$I(\omega) = \underset{\uparrow \text{ amplitude}}{I_0} \sin(\underset{\uparrow \text{ frequency}}{\omega} t) = I_0 \exp(j\omega t)$$

$$V(\omega) = V_0 \sin(\omega t + \overset{\text{phase shift}}{\phi}) = V_0 \exp(j(\omega t + \phi))$$

$$Z(\omega) = V(\omega) / I(\omega) \qquad \text{(Ohm's Law)}$$

$$= \frac{V_0 \exp(j(\omega t + \phi))}{I_0 \exp(j\omega t)}$$

$$= \frac{V_0}{I_0} \exp(\cancel{j\omega t}) \exp(j\phi) \exp(\cancel{-j\omega t})$$

$$Z(\omega) = Z_0 \exp(j\phi) \qquad , \qquad Z_0 \triangleq V_0 / I_0$$

$$Z(\omega) = \underbrace{Z_0 \cos\phi}_{Re(Z)} + j \underbrace{Z_0 \sin\phi}_{Im(Z)}$$