Ballparking SOC parameters

- If the model uses a single parallel R–C branch, it's quite simple to get a ballpark idea of model's parameter values
  - We will improve on these methods later in the course

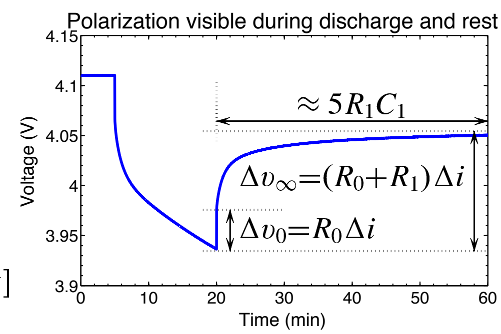
$$
\begin{aligned}
z[k+1] &= z[k] - \frac{\eta[k]\Delta t}{Q} i[k] \\
i_{R_1}[k+1] &= \exp\left(-\frac{\Delta t}{R_1 C_1}\right) i_{R_1}[k] \\
&\quad + \left(1 - \exp\left(-\frac{\Delta t}{R_1 C_1}\right)\right) i[k] \\
v[k] &= \mathrm{OCV}(z[k]) - R_1 i_{R_1}[k] - R_0 i[k]
\end{aligned}
$$

- Can compute Q by discharging cell slowly from 100 % to 0 % SOC and recording ampere hours removed
- Can find η by charging from 0 % to 100 % SOC, computing discharge capacity divided by charge capacity
- Can average dis/charge voltages at every SOC to find $\mathrm{OCV}(z[k])$

Ballparking R_0 parameter

- Next, conduct pulse test; notice instantaneous voltage change

$$
\begin{aligned}
z[k+1] &= z[k] - \frac{\eta[k]\Delta t}{Q} i[k] \\
i_{R_1}[k+1] &= \exp\left(-\frac{\Delta t}{R_1 C_1}\right) i_{R_1}[k] \\
&\quad + \left(1 - \exp\left(-\frac{\Delta t}{R_1 C_1}\right)\right) i[k] \\
v[k] &= \mathrm{OCV}(z[k]) - R_1 i_{R_1}[k] - R_0 i[k]
\end{aligned}
$$

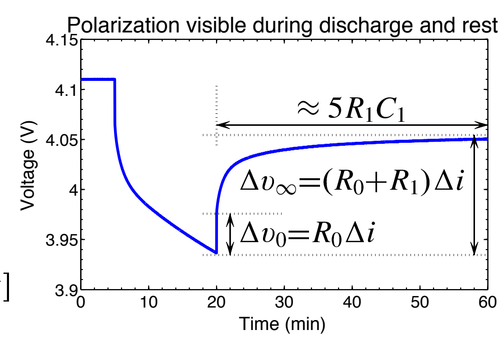


- Only $-R_0 i[k]$ changes instantly, so response to removal of pulse $|\Delta v_0| = R_0 |\Delta i|$

Ballparking R_1 parameter

- Next, consider steady-state voltage change after pulse

$$
\begin{aligned}
z[k+1] &= z[k] - \frac{\eta[k]\Delta t}{Q} i[k] \\
i_{R_1}[k+1] &= \exp\left(-\frac{\Delta t}{R_1 C_1}\right) i_{R_1}[k] \\
&\quad + \left(1 - \exp\left(-\frac{\Delta t}{R_1 C_1}\right)\right) i[k] \\
v[k] &= \mathrm{OCV}(z[k]) - R_1 i_{R_1}[k] - R_0 i[k]
\end{aligned}
$$



- $|\Delta v_\infty| = (R_0 + R_1)|\Delta i|$, from which we can deduce R_1

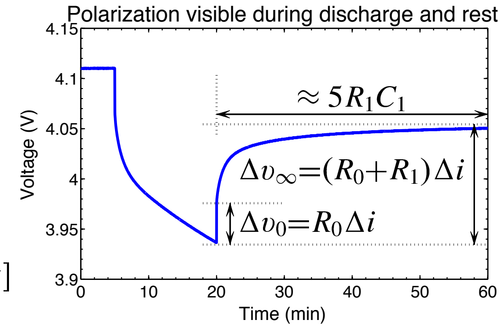
Ballparking C_1 parameter

- Finally, consider time to decay to steady-state

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

$$i_{R_1}[k+1] = \exp\left(-\frac{\Delta t}{R_1 C_1}\right) i_{R_1}[k] + \left(1 - \exp\left(-\frac{\Delta t}{R_1 C_1}\right)\right) i[k]$$

$$v[k] = \mathrm{OCV}(z[k]) - R_1 i_{R_1}[k] - R_0 i[k]$$



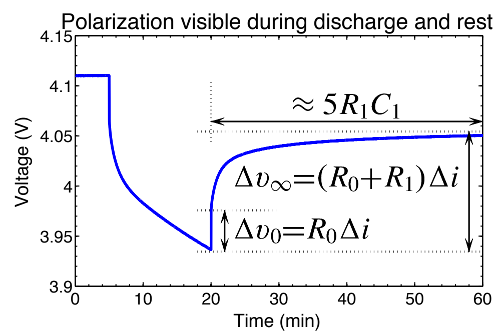
- Pulse response converges to steady state in about five time constants, $\Delta t = 5R_1C_1$, from which we can deduce C_1

Example with values

- For cell test conducted to gather plotted data, $|\Delta i| = 5$ A, $|\Delta v_0| = 41$ mV, and $|\Delta v_\infty| = 120$ mV
- We then compute $R_0 \approx 8.2\,\mathrm{m}\Omega$ and $R_1 \approx 15.8\,\mathrm{m}\Omega$
- Time to steady-state is about 60 min − 20 min = 40 min = 2400 s
- So,

$$5R_1C_1 \approx 2400\,\mathrm{s} \quad \text{and} \quad C_1 \approx 480/R_1$$

- Using R_1 from above, $C_1 \approx 30$ kF



Summary

- Have seen simple procedure to approximate parameter values for model having a single R–C branch
- Simple dis/charge test used to determine values for Q, η, OCV
- Pulse discharge finds R_0, R_1, C_1
- If model uses multiple parallel R–C branches in series, this simple approach will not work—we'll look at another approach later