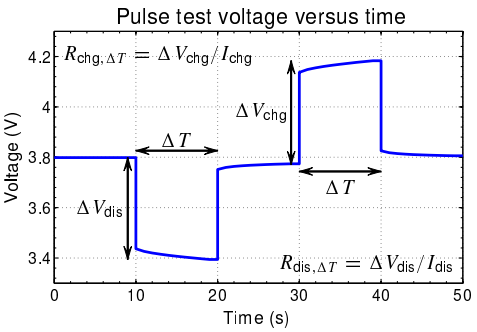
Voltage-based rate limits, using simple cell model

- As previewed in course 1, standard "Hybrid Pulse Power Characterization" (HPPC) method specified by the Partnership for New Generation Vehicles (PNGV)
- Power is calculated to enforce limits on cell terminal voltage, predictive over the next ΔT s , updating at a faster rate than once every ΔT s
- Must run cell tests: compute, store resistances at different SOCs and temperatures



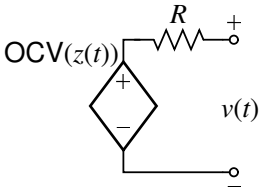
HPPC: discharge power

- Assume a simplified cell model $v(t) = \text{OCV}(z(t)) - i(t)R$, or

$$i(t) = (\text{OCV}(z(t)) - v(t))/R$$

- To compute power limit, assume we are concerned only with keeping terminal voltage between $v_{\min}$ and $v_{\max}$
- For discharge power, set $R = R_{\text{dis},\Delta T}$ and clamp $v(t) = v_{\min}$
- Then, calculate maximum discharge current as constrained by voltage as

$$i_{\max,n}^{\text{dis,volt}} = (\text{OCV}(z_n(t)) - v_{\min})/R_{\text{dis},\Delta T}$$



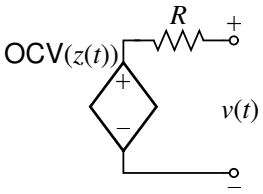
- Pack discharge power is then calculated as

$$P_{\max}^{\text{dis}} = N_s N_p v_{\min} \min_n \left(i_{\max,n}^{\text{dis,volt}}\right)$$

HPPC: charge power

- Again assume $i(t) = (\text{OCV}(z(t)) - v(t))/R$
- For charge power, set $R = R_{\text{chg},\Delta T}$ and clamp $v(t) = v_{\max}$
- Note, however, that charge current is assumed negative in sign by convention, so that maximum-magnitude current is a minimum in the signed sense:

$$i_{\min,n}^{\text{chg,volt}} = (\text{OCV}(z_n(t)) - v_{\max})/R_{\text{chg},\Delta T}$$



- Pack charge power is then calculated as

$$P_{\min}^{\text{chg}} = N_s N_p v_{\max} \max_n \left(i_{\min,n}^{\text{chg,volt}}\right)$$

Summary

- HPPC power-limit-estimation method first collects current–voltage pulse data from cells in laboratory
- Then, calculates dis/charge resistances $R_{\text{dis},\Delta T}$ and $R_{\text{chg},\Delta T}$
- Using simplified cell model, clamps terminal voltage to either $v_{\max}$ or $v_{\min}$ and uses pulse resistances to compute maximum-magnitude current
- Multiplies current by voltage to make estimate of power limits