Modeling exponential decay in maximum capacitance across specified flight patterns in small aircraft

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motivation

to explore possibilities in the rates of maximum capacitance decay,

- computational approaches are studied to identify the choice of parameters for the steepness of capacitance decay is in good agreement with past recordings,
- algorithmic approaches were formulated to ensure that flight data can be appropriately represented with a polynomial basis,
- novel formulas for the change in state of charge for different parasitic loads are introduced

$$\mathrm{SOC}_1 = 1 - \frac{q_{\mathrm{max}} - q_b}{e^{\sum_i -\beta_i |t^{(i)}_{\mathrm{initial}} - t^{(i)}_{\mathrm{final}}|} C_{\mathrm{max}}}$$

$$\mathrm{SOC}_2 = 1 - \frac{q_{\max} - q_b}{\left(e^{\sum_i -\beta_i |t^{(i)}_{\mathrm{initial}} - t^{(i)}_{\mathrm{final}}|} \times e^{\beta^{\mathrm{PL},\tau^{(i)}}_{\tau^{(i)}_{\mathrm{PL}}} |t^{PL}{}_{\mathrm{final}} - t^{PL}{}_{\mathrm{initial}}|} \right) C_{\max}}$$

$$\mathrm{SOC}_3 = 1 - \frac{q_{\max} - q_b}{\left(1 + (\beta^{\mathrm{PL},\mathcal{T}^{(i)}}_{\mathcal{T}^{(i)}_{\mathrm{PL}}} |t^{PL}{}_{\mathrm{final}} - t^{PL}{}_{\mathrm{initial}})t^{PL}{}_{\mathrm{final}} + (\beta^{\mathrm{PL},\mathcal{T}^{(i)}}_{\mathcal{T}^{(i)}_{\mathrm{PL}}} |t^{PL}{}_{\mathrm{final}} - t^{PL}{}_{\mathrm{initial}}) \right. \\ \left. \frac{(t^{PL}{}_{\mathrm{final}})^2}{2} + \cdots \right) C_{\max}} \ ,$$

novelty of our approach

from previous works in the literature, room for new results lies in our approach which focuses on

- the development of computational approaches for modeling capacitance degradation which involve the choice of free parameters that we have specified,
- assessing the reliability of polynomials which are used to approximate flight data through computations of the MSE from the relevant Fourier sine and/or cosine coefficients used in the approximation,
- applying our approach to other flight patterns with an arbitrary number of stages to generate an expansive combinatorial space of predictions

key findings

in our work, we discovered the utility of the novel approach through our ability to

- specify parameter families which predict the decay in capacitance, with the iteratively defined formula

$$\mathcal{C}_{\mathrm{max}_{i+1}} = e^{-\sum_i \beta_i |t^{(i)}_{\mathrm{final}} - t^{(i)}_{\mathrm{initial}}|} \mathcal{C}_{\mathrm{max}_i} \ ,$$

- adjusting the rate of degradation in $\mathcal{C}_{\mathrm{max}}$ which allows for applications of the model to other aircraft and more complicated flight patterns,
- connections between temporal and frequency domains