Power Graph Analysis

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Goal:

Given a duration of charge and total energy distributed, generate a function of power with respect to time that models the one given by HECO.

Method

First, we examined the energy with respect to time plot given using the graphing tool Desmos. Using an Online Curve fitting tool, we generated a function that models the given plot.

The function that was found was:

$$f(x) = \frac{115.19042}{1 + 0.0786688810066\sqrt{x}} - 77.18642$$

Where x is in minutes. We can rewrite this function in a general form:

$$f(x) = \frac{a}{1 + b\sqrt{x}} + c$$

Note that the integral of this function from start time 0 to end time t will give us the total energy in $kW \cdot min$.

To generate our function, we will assume two things. One is that b is constant for any energy, time values. The reason for this is that the integral of $f(x)$ is very very ugly, and solving for b is much too difficult. So we assume that

$$b = 0.0786688810066.$$

The other assumption is that the $f(t) = 0$. That is, the charge always goes to zero upon completion. We have two unknowns and two equations.

$$f(t) = 0 \tag{1}$$

$$\int_0^t f(x)\,\mathrm{d}x = \text{total energy } E. \tag{2}$$

Using equation (1), We can solve for c:

$$\begin{aligned}
f(t) &= 0 \\
&= \frac{a}{1+b\sqrt{t}} + c \\
&= \frac{a}{1+0.0786688810066\sqrt{t}} + c \\
\rightarrow c &= -\frac{a}{1+0.0786688810066\sqrt{t}}
\end{aligned}$$

We can then use equation (2) to solve for a:

$$\int_0^t f(x)\,\mathrm{d}x = E$$

$$\frac{-2a\ln(b\sqrt{t}+1)}{b^2} + \frac{2a\sqrt{t}}{b} + ct = E$$

Solving for a:

$$\frac{b^2(E-ct)}{2(b\sqrt{t}-\ln(b\sqrt{t}+1)} = a$$

We have our 3 unknowns, and thus our generated function.