Power Model:

$$\boxed{P_{total} = P_{dyn} + P_{leak}}$$

P_{dyn}:

$$P_{dyn} = C_{eff} \cdot V^2 \cdot f \, \boxed{\alpha(w)}$$

C_{eff} → 1nF, V → Vdd, $\alpha(w)$ → Switching Activity

$$\boxed{\alpha(w) = 0.5 + 0.5 \cdot w}$$

$\alpha(w) = 1 \Rightarrow$ compute

$\alpha(w) = 0.5 \Rightarrow$ Memory

$w \in \{0, 1\}$

w → workload mix; 0 → memory bound; 1 → compute bound

P_{leak}:

$$P_{leak} = P_{leak0} \cdot \underbrace{e^{a(V-0.8)}}_{\text{Sensitive to Volt. } (a=2)} \cdot \underbrace{e^{b(T-25)}}_{\text{Sensitive to temp. } (b=0.04)}$$

P_{leak0} → 0.6 W @ 25°C

$$\boxed{P_{total} = P_{dyn} + P_{leak}}$$

Thermal Model:

$$T_{ss} = T_{amb} + (P_{total} \cdot R_{th})$$

Thermal RC Model: (1st Order RC Model)

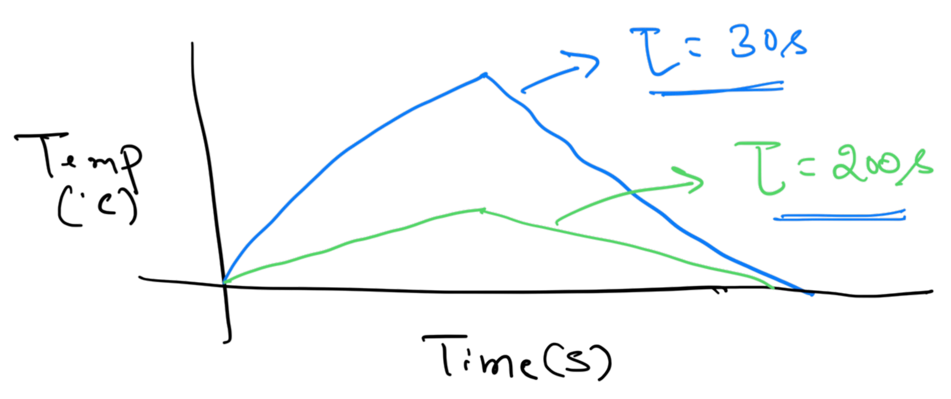
$$T(t+dt) = T(t) + (T_{ss} - T(t))(1 - e^{-dt/RC})$$

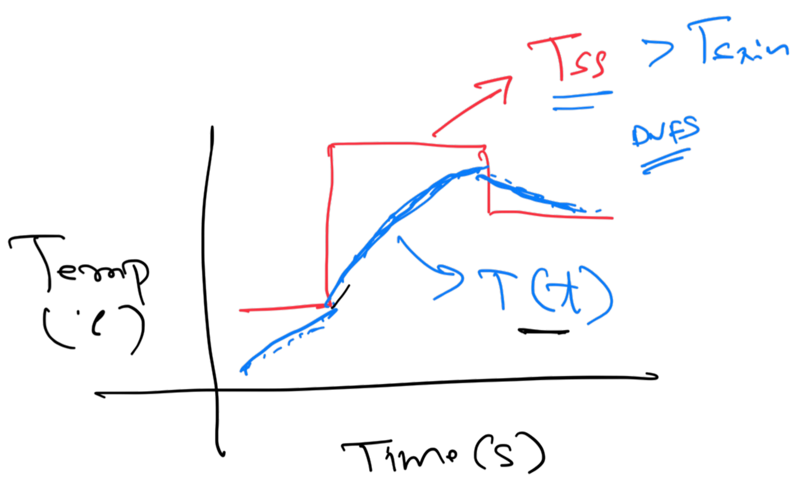
⇓ Simplify

$$T_{new} = T_{old} + (T_{ss} - T_{old}) \cdot (1 - e^{-t/RC})$$

$\tau = R_{th} \cdot C_{th}$ → Large ⇒ slow temp. change; → Small ⇒ fast temp. changes

$T(t) \to T_{ss}$ as $t \to \infty$ but will be capped by DVFS





Performance Model:

$$\underset{(\text{MIPS})}{Perf} = IPC(w) \times \underset{(\text{GHz})}{freq.}$$

$$IPC(w) = IPC_{min} + (IPC_{max} - IPC_{min}) \cdot w$$

IPC_{min} → (0.5) → (memory bound, $w=0$)

IPC_{max} → (2) → (compute bound, $w=1$)

w → workload mix

Energy:

$$E = P \cdot t \quad (J)$$

$$E = \frac{P \cdot t}{3600} \quad (Wh) \rightarrow \text{watt-hour}$$

$$E(t) \leftarrow E(t) + dE$$

→ Energy curve is cumulative; never goes down

→ Battery drops as energy accumulates

→ $\underset{(Wh)}{\text{Battery \%}} = \left[\dfrac{\text{Battery} - \text{Energy}}{\text{Battery}}\right] \times 100$
