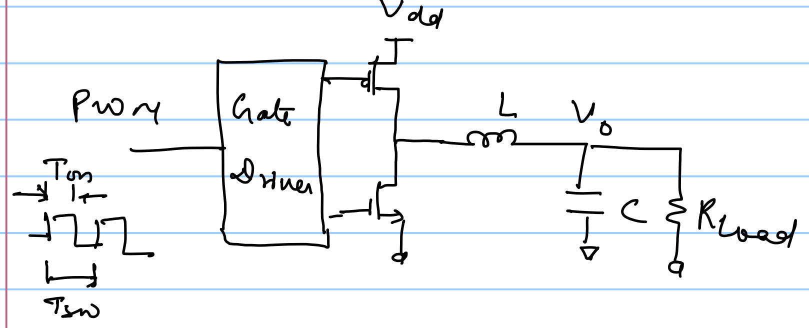
Linear Vs. Switching Regulators

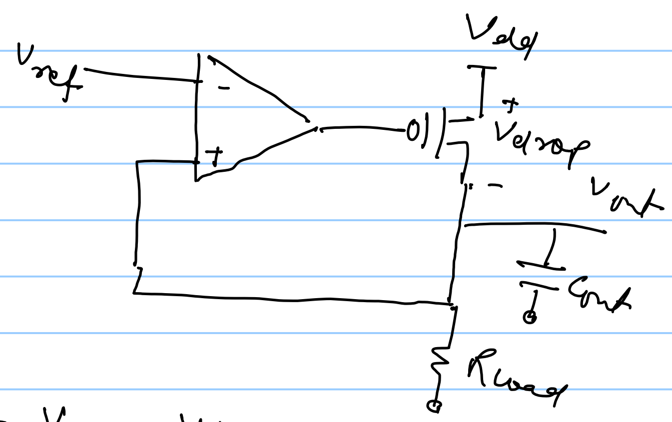
Switching Regulator



$V_o = D \cdot V_{dd}$

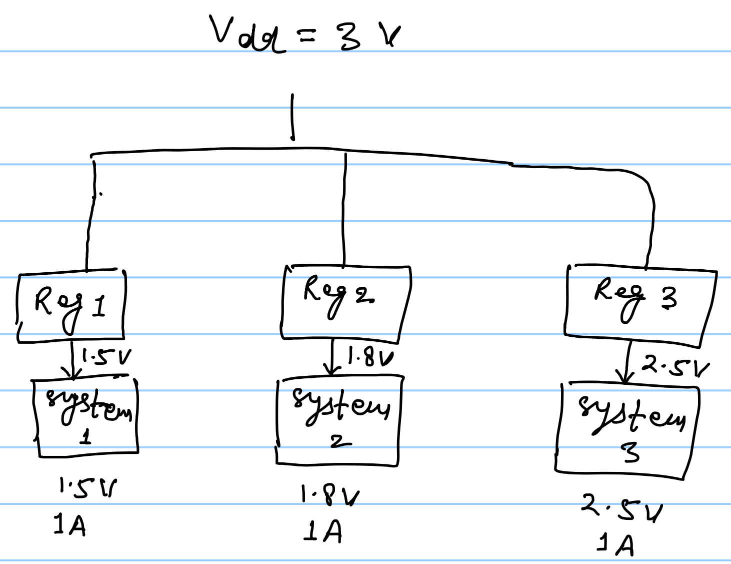
$D = \frac{T_{on}}{T_{sw}}$

Linear Regulator



$V_{out} = V_{dd} - V_{drop}$

	Switching	Linear
1	More efficient across V_o/V_{in}	Less efficient if $V_{in} >> V_o$, $V_{drop} >>$
2	Expensive due to inductor	Cheaper
3	Switching is noisy, not preferred for noise sensitive applications – Analog & RF	Quiet



Case-1 Reg 1, 2 & 3 are switching

$\eta = 90\%$

$\eta_{total} = 90\%$

Case-2 Reg 1, 2 & 3 are linear

$$\eta_{total} = \frac{P_{out\_total}}{P_{in}}$$

$$= \frac{P_{out\_total}}{P_{out\_total} + P_{loss}}$$

$P_{out\_total} = 1.5W + 1.8W + 2.5W$

$= 5.8W$

$P_{loss1} = 1.5W$

$P_{loss2} = 1.2W$

$P_{loss3} = 0.5W$

$P_{loss} = 3.2W$

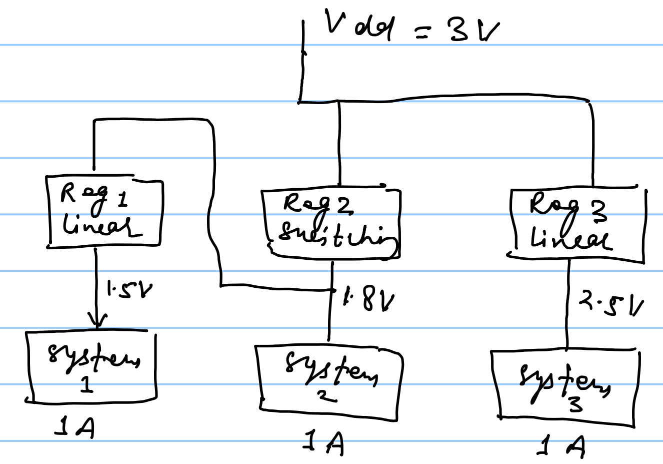
$P_{in} = P_{out\_total} + P_{loss} = 9W$

$\eta_{total} = \frac{5.8}{9} = 64\%$

Case-3

Reg 1 & Reg 3 are Linear

Reg 2 is switching



$P_{loss\,1} = 0.3\,W$

$P_{loss\,2} \simeq 0.4\,W$

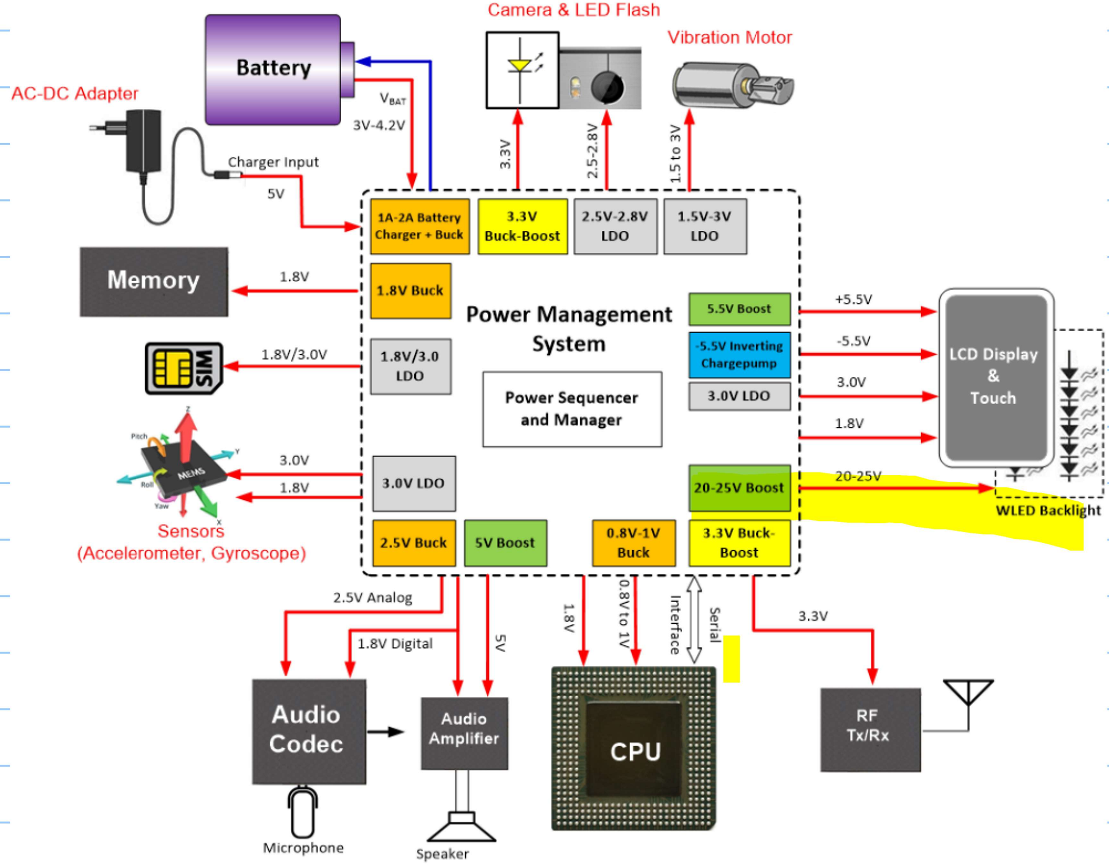
$P_{loss\,3} = 0.5\,W$

$P_{loss} = 1.2\,W$

$P_{in} = 7\,W$

$$\eta = \frac{5.8}{7} \simeq 82.8\%$$

Power Management in a Smartphone



Switching Regulator → 4–5
Linear Regulators → 25-30
Switching supplies ≃ 90% of the power

Performance Parameters of a Regulator

1. Efficiency $= \dfrac{P_{out}}{P_{in}}$

   $P_{in} = P_{out} + P_{loss}$

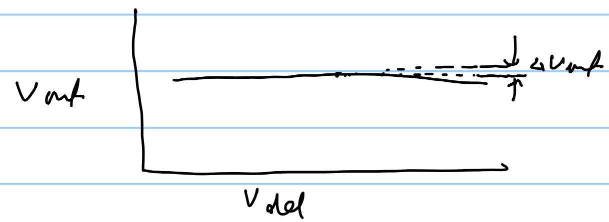
   $$\eta = \frac{P_{out}}{P_{out} + P_{loss}}$$

2. Accuracy: drift in V_{out} w.r.t. varying conditions.
   (→ dynamic)

   static accuracy is mostly caused by offset

3. Line Regulation

   $$\text{Line Regulation} = \frac{\Delta V_{out}\,(dc)}{\Delta V_{dd}\,(dc)}$$



④ Load Regulation

$$= \frac{\Delta V_{out}\,(dc)}{\Delta I_{load}\,(dc)} = \text{Ohms}$$

⑤ Line Transient

Drift in V_{out} w.r.t. step change in V_{dd}.