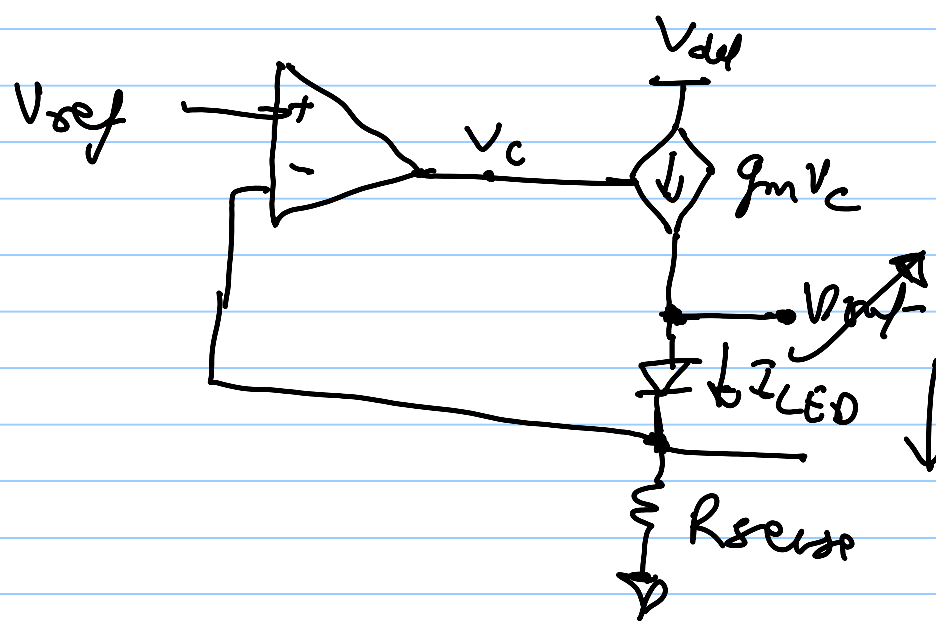
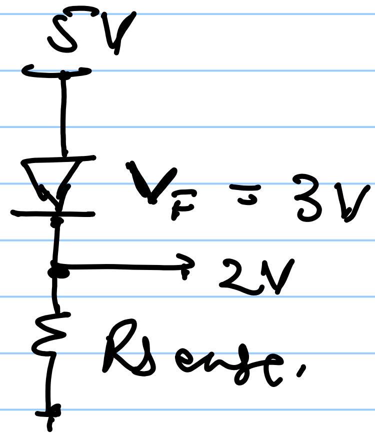
EE 2019

\# Linear Regulators are also known as Low drop-out (LDO) Regulators when operated at low ($V_{in} - V_{out}$)

\# Linear Regulators can also be used as current Regulators.



$$I_{load} = \frac{V_{ref}}{V_{sense}}$$



$$I_{LED} = \frac{3}{R_{sense}}$$

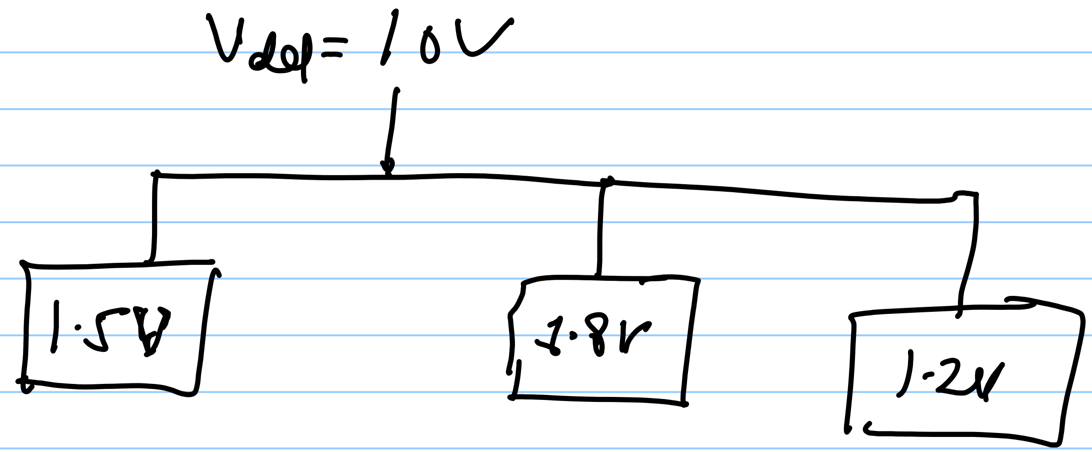
I_{LED} does not remain constant if V_{dd} is varying.

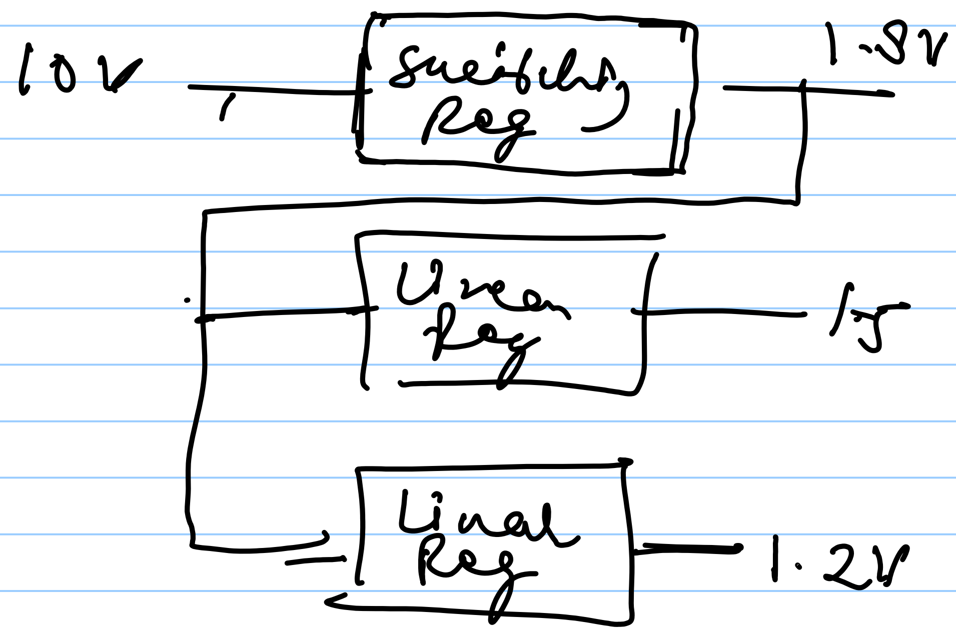
$R_{sense} = 20\,\Omega$

Switching Regulator

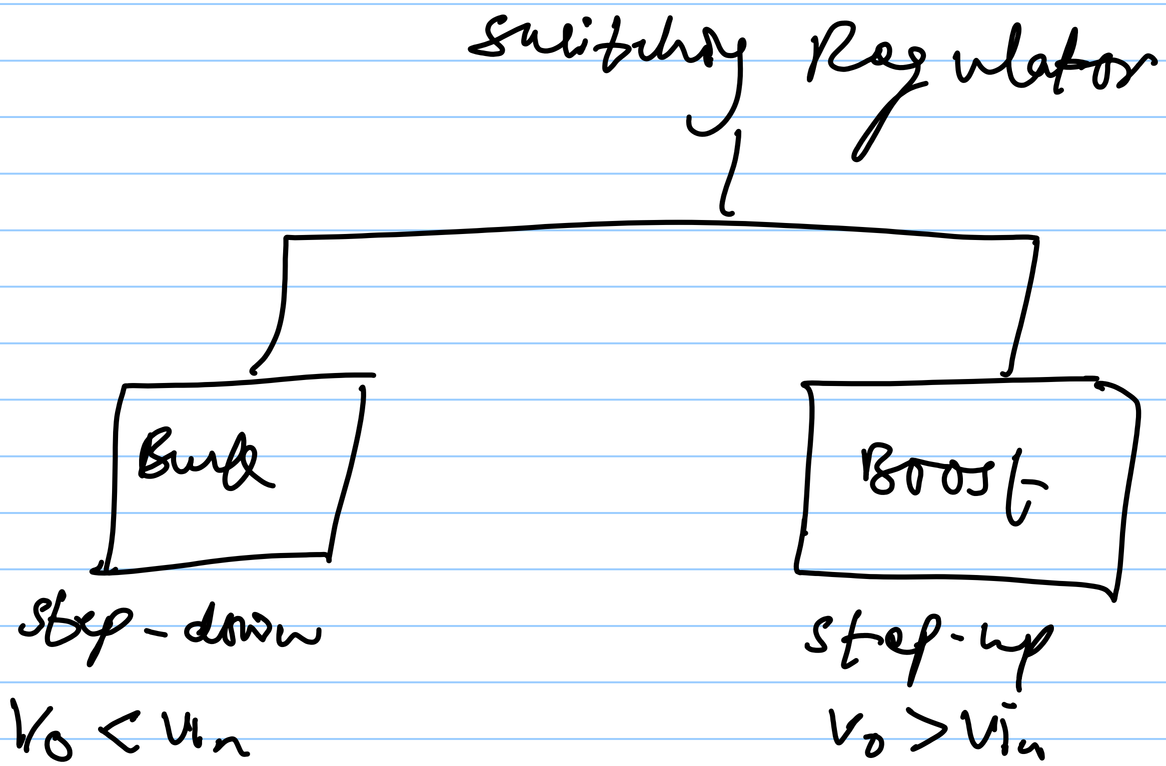
10V → 1V

η = 10% with linear Reg

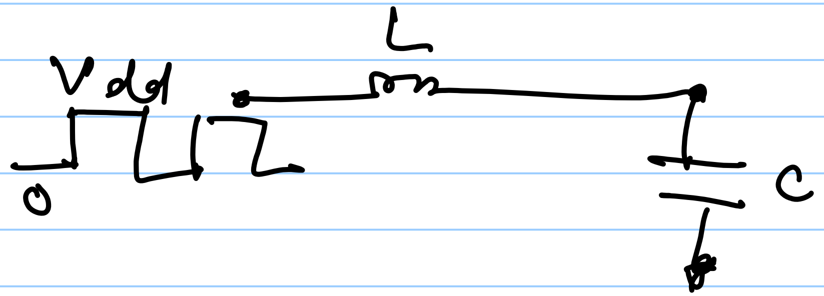




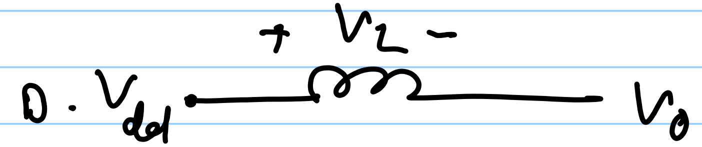
Switching Regulator can be of two types.


Switching Regulator
Buck
step-down
Vo < Vin
Boost
step-up
Vo > Vin

works on PWM principle.



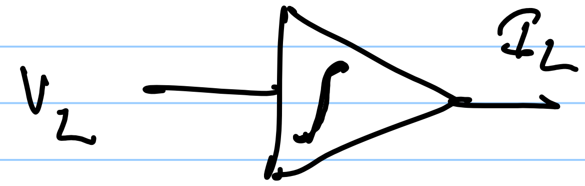
$V_o = D \cdot V_{dd}$.



$$V_L = L \frac{di_L}{dt}$$

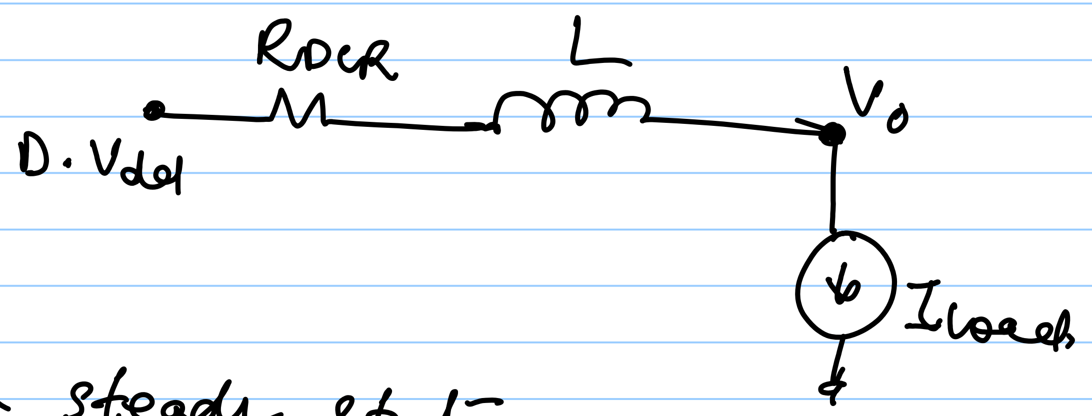
$$I_L = \frac{1}{L} \int_0^T V_L(t)\, dt + I_L(0)$$

⇓



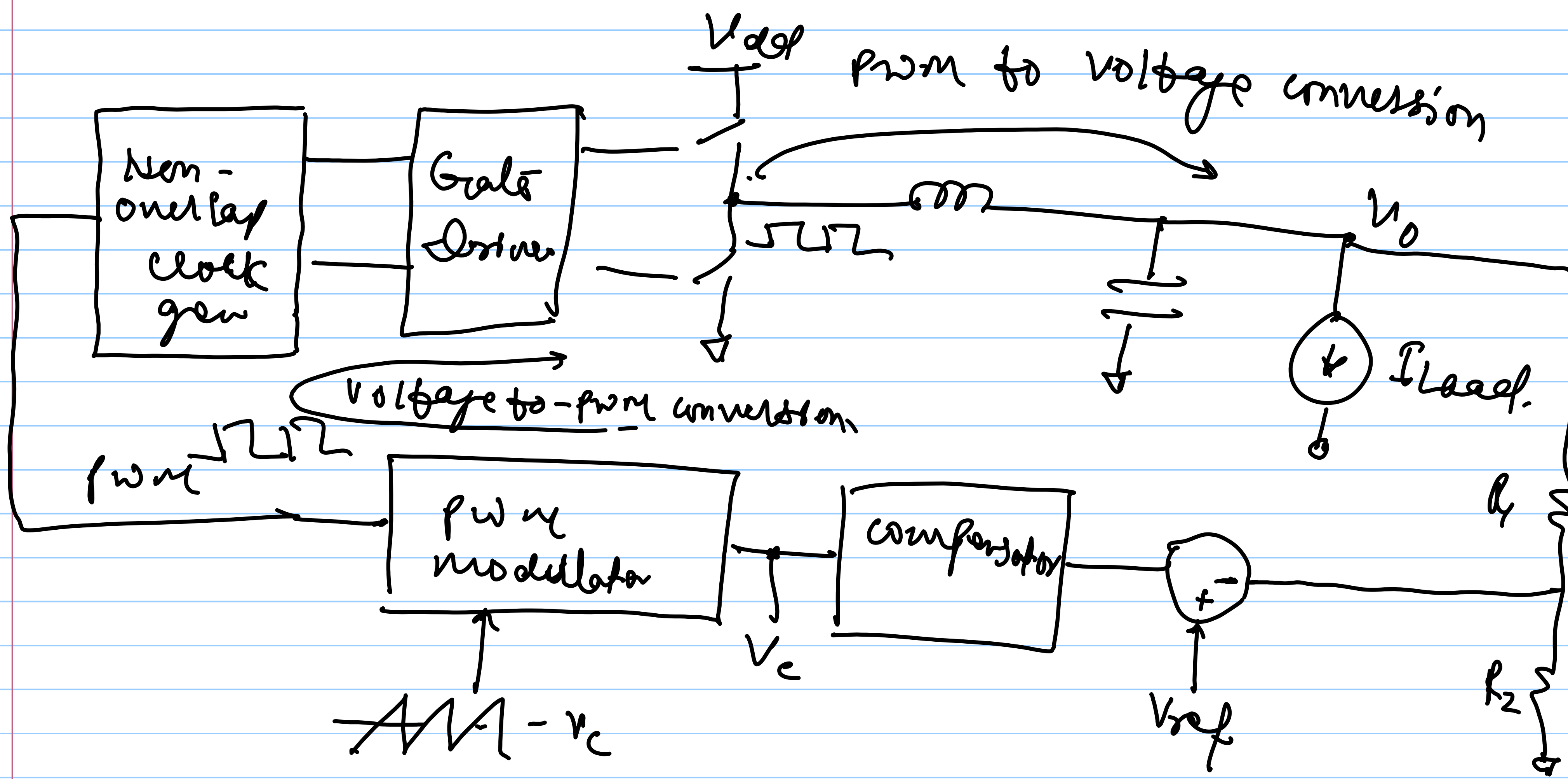
In steady state $\boxed{D \cdot V_{dd} = V_o}$

Practically inductors are not loss less

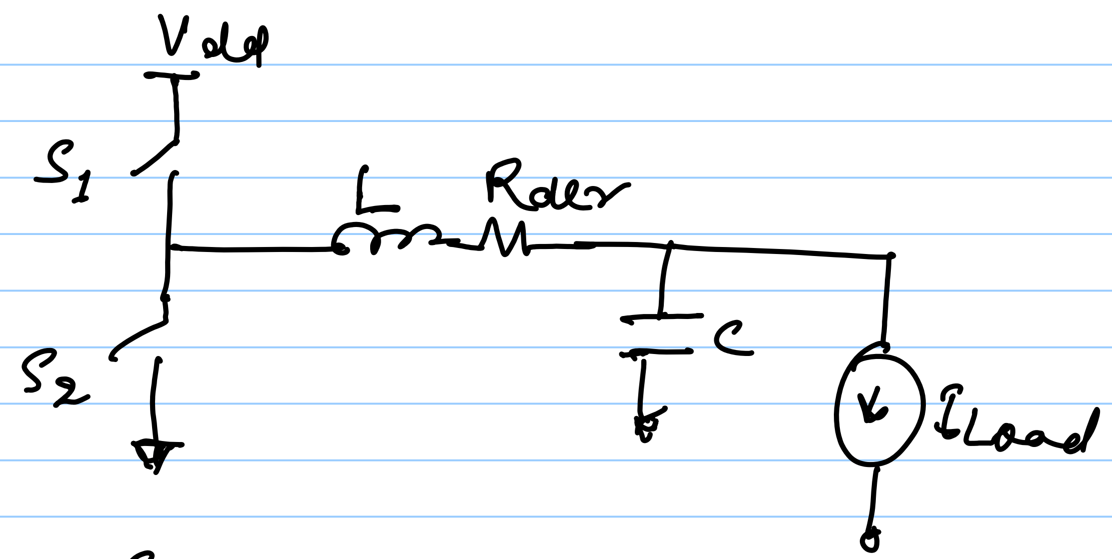


In steady state

$$D \cdot V_{dd} = V_o + I_{load} \cdot R_{DCR}$$

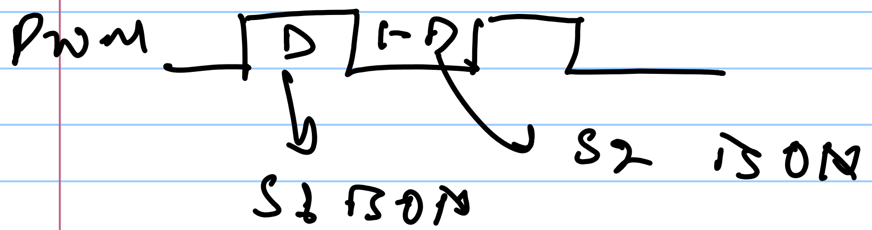


Vdd
PWM to voltage conversion
Non-overlap clock gen
Gate Driver
vo
Iload.
voltage-to-pwm conversion
pwm
pwm modulator
compensator
Ve
- vc
+
-
Vref
R1
R2



when S_1 and S_2 are ON they have some finite resistance → order of 10s of mΩ

ON resistance of S_1 is R_{on1}
and ON resistance of S_2 is R_{on2}



Total loss is $I_{load}^2 \times R_{total}$

$$R_{total} = D \cdot R_{on1} + (1-D) R_{on2} + R_{dcr}$$

$$\text{Total loss} = I_{Load}^2 \times (D R_{on1} + (1-D) R_{on2} + R_{dcr})$$

$R_{on1} = R_{on2} = 50 m\Omega$

$R_{der} = 200 m\Omega$

$I_{Load} = 100 mA$

$\text{Total Loss} = (50 m\Omega + 200 m\Omega) \times (100 mA)^2$

$= 2.5 mW$

$V_{out} = 4V, \quad V_{in} = 10V$

$P_{out} = 4V \times 100 mA = 400 mW$

$$P_{in} = P_{out} + P_{loss}$$
$$= 402.5\ mW$$

$$\eta = \frac{P_{out}}{P_{in}} = \frac{400\ mW}{402\ mW} =$$