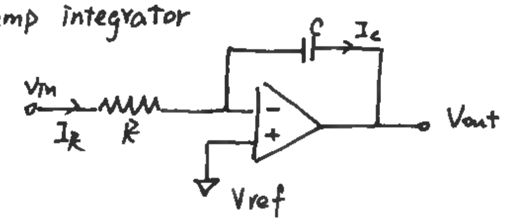
op-amp integrator

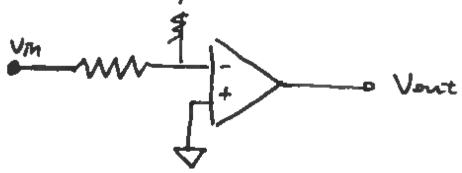


$I_c = C \cdot \frac{dV_c}{dt} \rightarrow Q = C \cdot V_c$

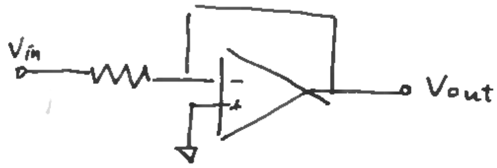
DC : Capacitor – short circuit

High freq : Capacitor – open circuit

⇒ set → Low freq at Vin : Vout & Ishunt remain the same (no oscillation)



⇒ High freq at Vin : Vout has ripple (the buck converter case)



Response time : RC. (short $\underline{T_{RC}}$ — response quicker)

$\underline{T_{on}} < RC$

charge time

$$\frac{V_{out}(s)}{V_{in}(s)} = -\frac{1}{RCS}$$

$$\frac{V_i(s)}{V_o(s)} = -RCS$$

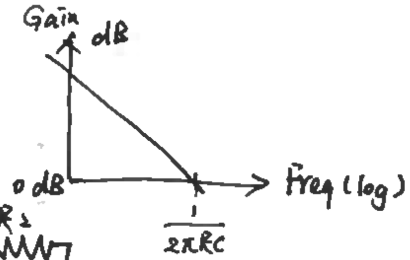
Apply Millman's theorem at negative input :

$$V_- = \frac{\frac{V_{in}}{R} + jC\omega V_{out}}{\frac{1}{R} + jC\omega}$$

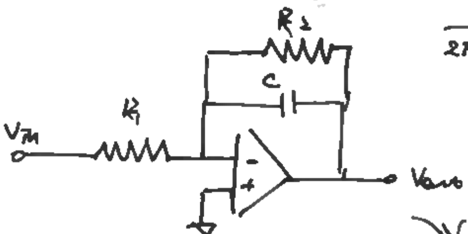
→ Transfer function : $V_{in} = -jRC\omega V_{out}$, ⇒ $\frac{V_{in}}{V_{out}} = -jRC\omega$

$(V_- = 0)$

$$T = \frac{-1}{jx} \quad \left(x = \frac{\omega}{\omega_0} ,\ \omega_0 = \frac{1}{RC} \right)$$



$$\left\{ \begin{array}{l} C \cdot \frac{dV_c}{dt} = -\frac{V_{in}}{R} \\ C \cdot \frac{dV_{out}}{dt} = -\frac{V_{in}}{R} \\ C \cdot S \cdot V_o(s) = -\frac{V_{in}(s)}{R} \\ \frac{V_o(s)}{V_{in}(s)} = -\frac{1}{CS\,R} = -\frac{1}{CRS} \end{array} \right.$$



$I_R = I_c$

↘ (close loop gain. $-R_2/R_1$ when DC input.)

(Limitation : DC component in Vin easy to be saturate (offset voltage)

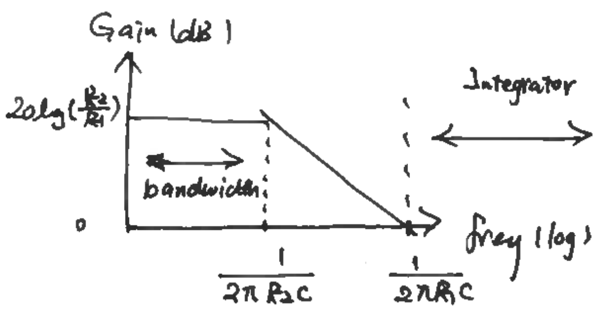
$$C \cdot \frac{dV_c}{dt} + \frac{V_c}{R_2} = -\frac{V_{in}}{R_1}$$

$$C \cdot S \cdot V_{out}(s) + \frac{V_{out}(s)}{R_2} = -\frac{V_{in}(s)}{R_1}$$

$$\left(CS + \frac{1}{R_2} \right) \times V_{out}(s) = -\frac{V_{in}(s)}{R_1}$$

$$\frac{V_{out}(s)}{V_{in}(s)} = -\frac{1}{R_1} \times \frac{1}{CS + \frac{1}{R_2}}$$

$$= -\frac{\frac{R_2}{R_1}}{R_2 CS + 1}$$



Now input signal → $I_D \cdot 10m\Omega$

$I_D \cdot 0.01\Omega$

0.9mV reference voltage → $0.9A \cdot 0.01\Omega$

→ 9mV

$R_2/R_1 = 1$ or smaller

$\frac{1}{R_2 C}$ → Bandwidth for R_2/R_1 gain

~~330k~~ 330k ~ 1200k.

~~250k~~ ~ 2.25M

320k ~ 2.25M   2250k

$2.25\times10^6 Hz = \frac{1}{R_2C}$ $C = 1\mu$

m μ n p

$= \frac{1}{R_2 \times 1\times10^{-9}}$

$R_2 = \frac{1}{2.25\times10^6\times10^{-9}}$

$= \frac{10^3}{2.25}$

$= 444.4\Omega$

if $C = 10p = 1\times10^{-11}C$

$R_2 = \frac{1}{2.25\times10^6\times10^{-11}}$

$= 0.444\times10^5$

$= 444k\Omega$

$R_1 = 9.7\Omega$

if $C = 1p = 1\times10^{-12}$ $C = 0.1p$

4.4MHz

$R_2 = 444k\Omega$ ⇒ 440k

$R_1 = 97\Omega = 100\Omega$ ⇒ 100Ω

if $R_1 = 10k\Omega$

$R_2 = 45560k$

$= 45M\Omega$

$C = \frac{1}{R_2\times2.25\times10^6}$

$= \frac{1}{45560\times10^3\times2.25\times10^6}$

$= 10^{-9}$

$= 9.76\times10^{-9}\times10^{-5}$

$= 0.976\times10^{-15}$

0 ~ 0.9mV ⇒ 4.1V output.

$\frac{4.1}{0.9mV} = 4556$ gain

output 4.1V

~~gain = 4.1V/0.9mV = 4.56×10^3~~

gain = 120dB

$20\log(x) = 120$

$\log(x) = 6$

$x = 10^6$ 5×10^4

1M   1Ω

100M ↔ 100Ω

10M ↔ 10Ω.

⇒ 0.1V ripple → 10mΩ

$\frac{0.1}{10m\Omega} = \frac{0.1}{0.01\Omega} = 10A$

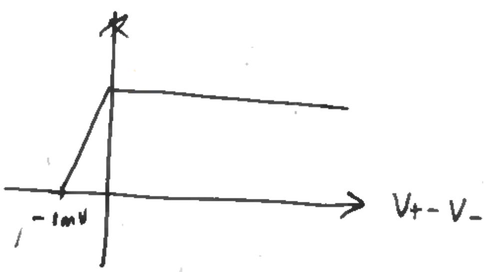
9.1V → 1.044 ~ 0.954A

ripple. 0.09A

$V = 0.09\times0.01\Omega$

$= \frac{9\times10^{-4}}{2}V$

$= 4.5\times10^{-4}V$

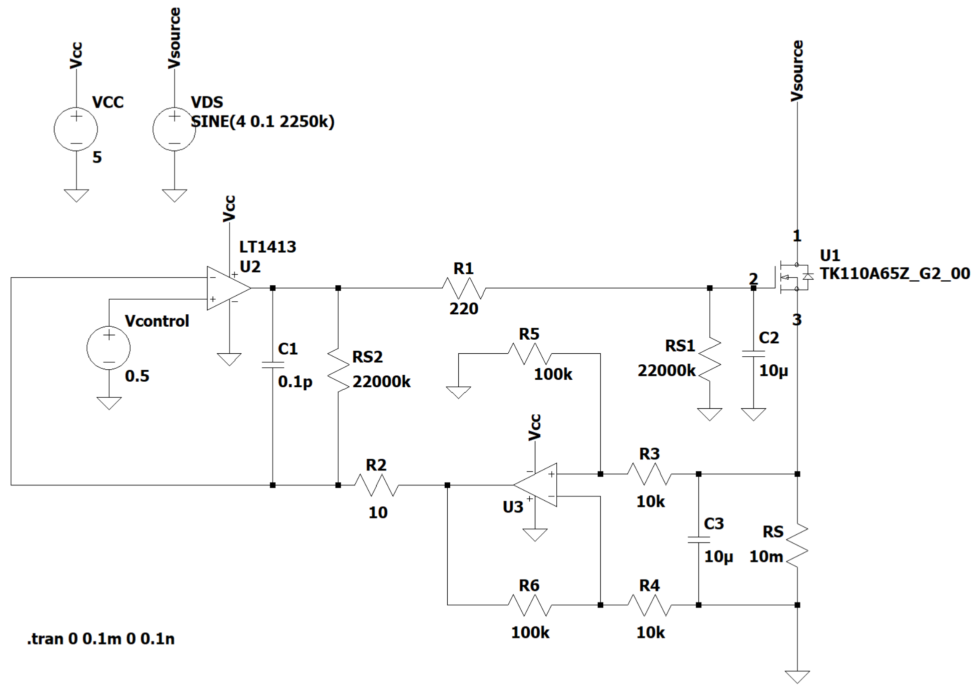


~~Vo = Vc~~

$V_{cc} = 5V$ $5/0.1mV$

$= \frac{5000}{0.1} = 50000$ gain

105mV →


Vcc
Vsource
VCC
5
VDS
SINE(4 0.1 2250k)
Vsource
Vcc
LT1413
U2
Vcontrol
0.5
C1
0.1p
RS2
22000k
R1
220
R5
100k
1
U1
TK110A65Z_G2_00
2
3
RS1
22000k
C2
10µ
Vcc
R2
10
U3
R3
10k
C3
10µ
RS
10m
R6
100k
R4
10k
.tran 0 0.1m 0 0.1n