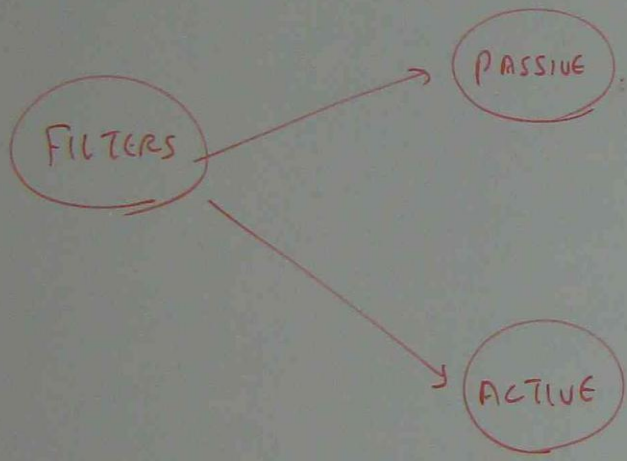
# ACTIVE FILTERS

A FILTER IS A CIRCUIT DESIGNED TO PASS A SPECIFIED BAND OF FREQUENCIES AND TO REJECT OTHERS OUTSIDE THE BAND.




PASSIVE : CONSISTS of RESISTOR, CAPACITOR & INDUCTORS

ACTIVE – THEY CAN INCORPORATE AN ACTIVE DEVICE SUCH AS OP-AMP IN CONJUNCTION WITH PASSIVE COMPONENTS.

PRECISION CONTROL IS PROVIDED BY ACTIVE DEVICES

## FREQUENCY RESPONSE OF FILTERS

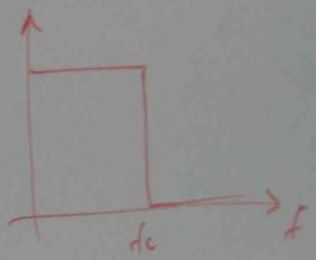
(a) LOW PASS

(b) HIGH PASS

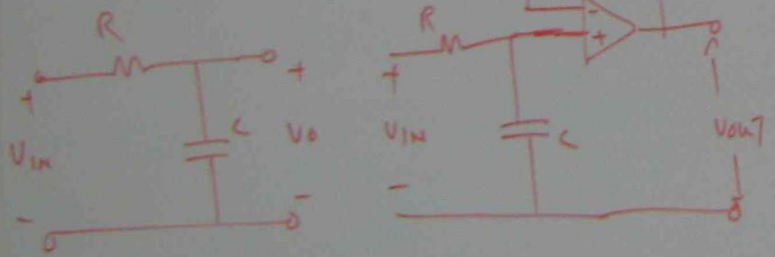
(c) BAND PASS

(d) BAND STOP NOTCH FILTER

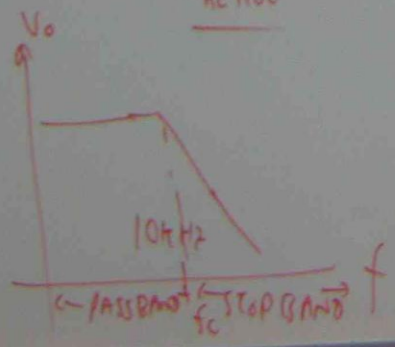
ACTIVE FILTER ATTENUATES THOSE FREQUENCIES OUTSIDE THE PASS BAND.



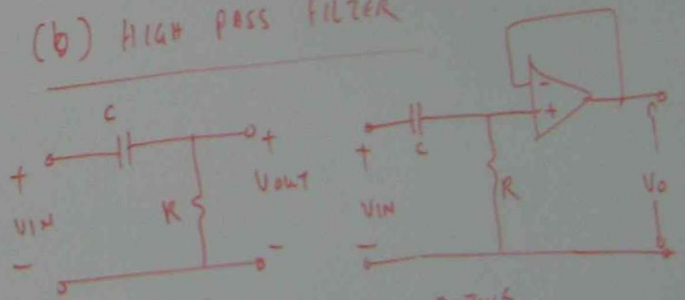

### (a) LOW PASS FILTER



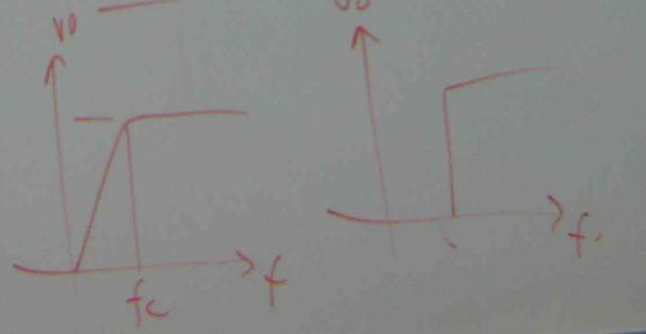

PASSIVE ACTIVE




### (b) HIGH PASS FILTER



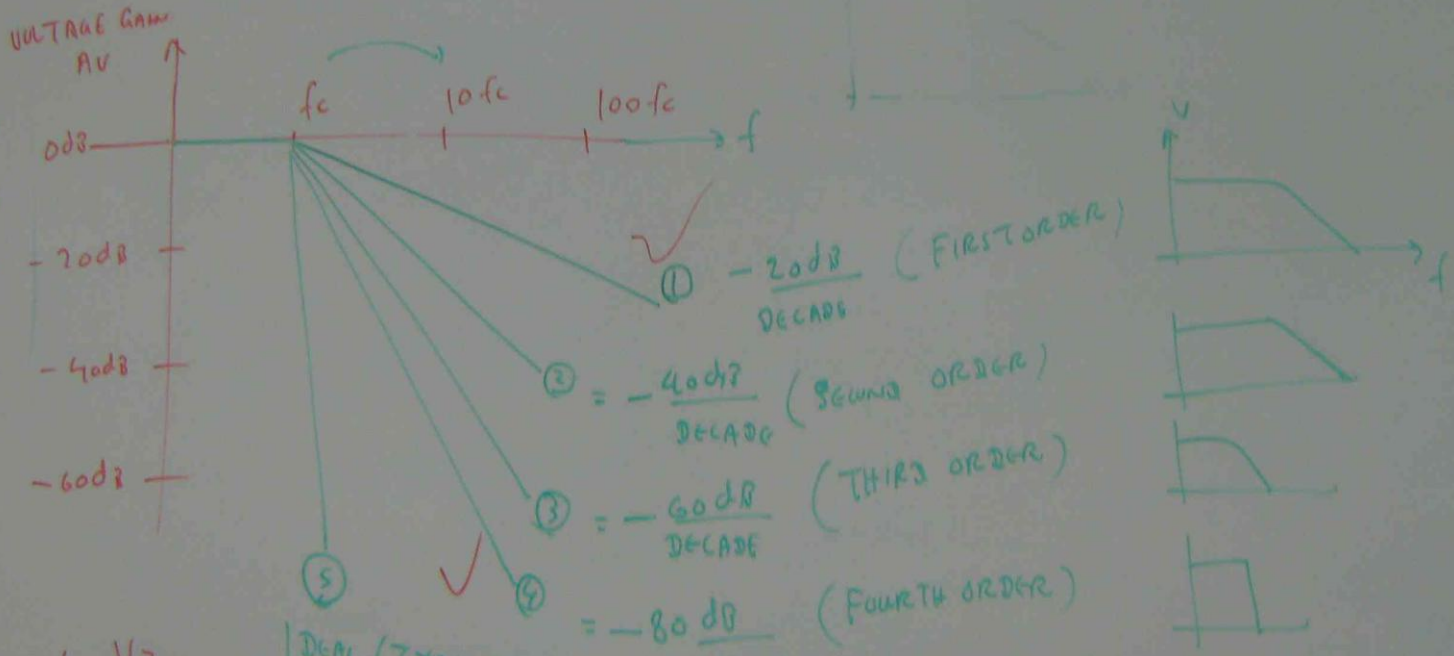

PASSIVE ACTIVE



Cut off frequency $f_c = \frac{1}{2\pi\sqrt{RC}}$

$-40\ \frac{dB}{DECADE}$

## FILTER CLASSIFICATION



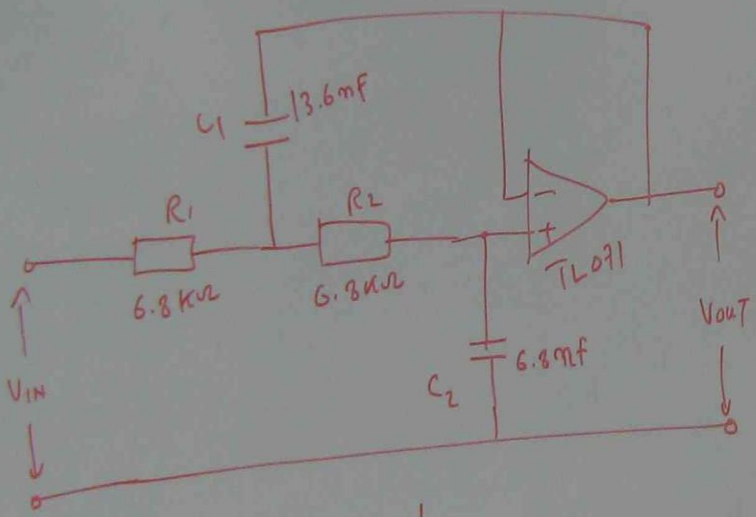

$dB = 20\log\frac{V_2}{V_1}$

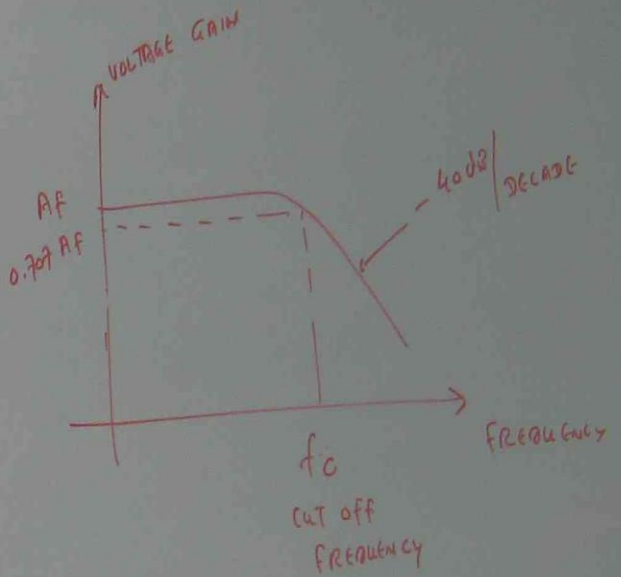
$= 20\log A_V$

$A_V = \frac{V_2}{V_1}$

— 40 dB / DECADE

# THE SECOND ORDER LOW PASS BUTTERWORTH FILTER



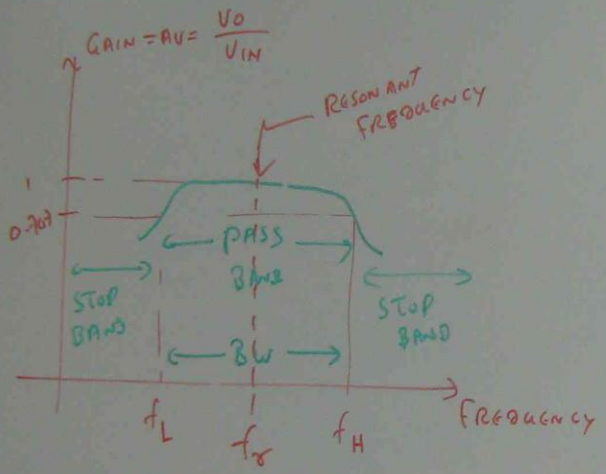




$$f_c = \frac{1}{2\pi\sqrt{R_1 R_2 C_1 C_2}}$$

FOR CORRECT OPERATION

$R_1 = R_2$ AND $C_1 = 2C_2$

## ③ BAND PASS FILTER

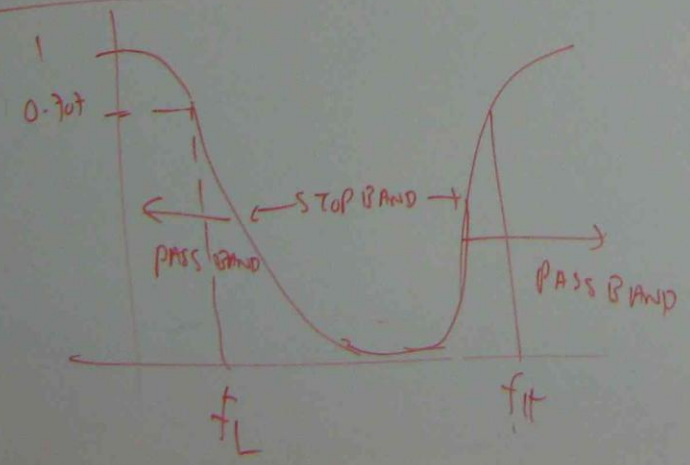



BAND WIDTH (BW) = $f_H - f_L$

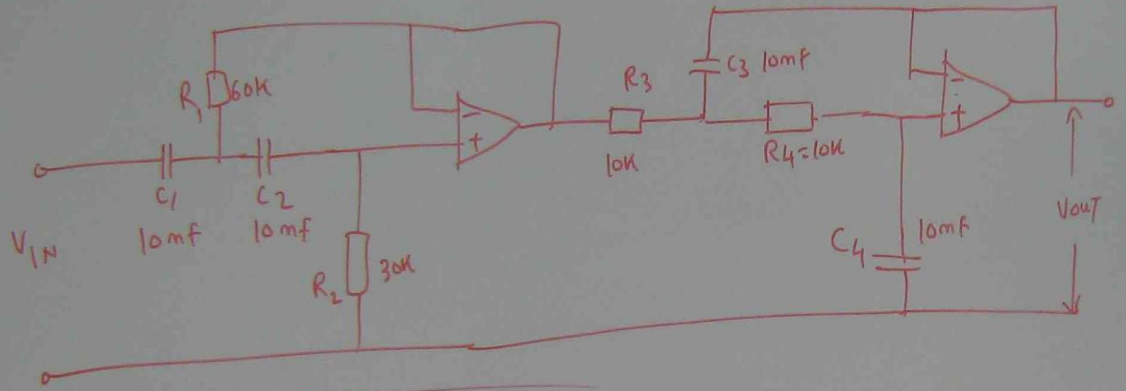
Q FACTOR = QUALITY FACTOR = RESONANT FREQUENCY / BAND WIDTH

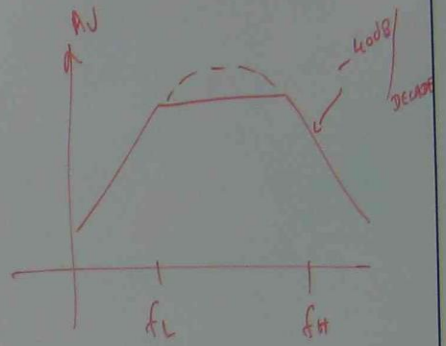
$Q = \frac{f_r}{BW}$

## ④ BAND STOP FILTER



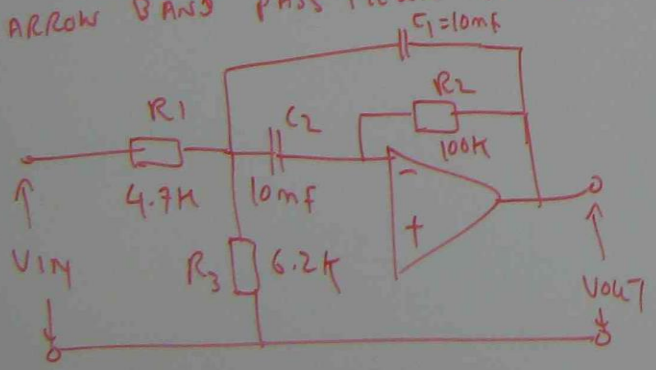
## SECOND ORDER BAND PASS FILTER

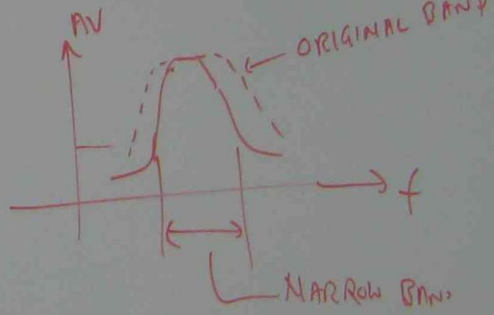


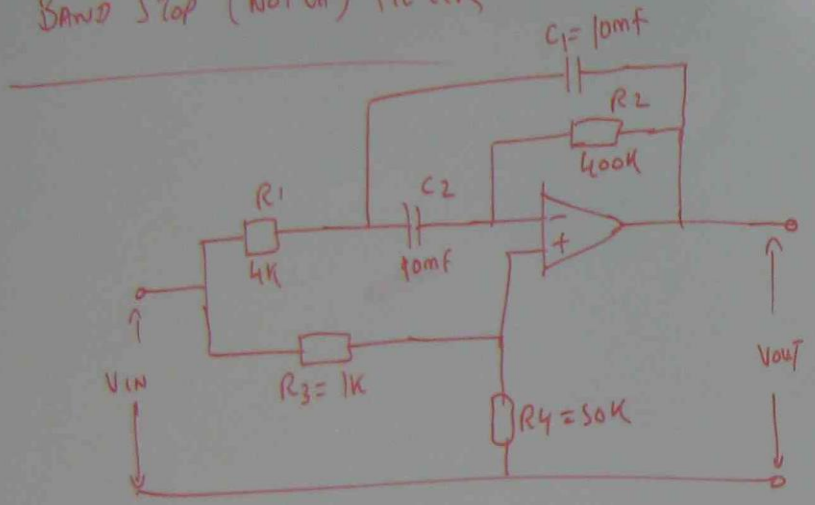

$$f_r = \sqrt{f_L \times f_H}$$

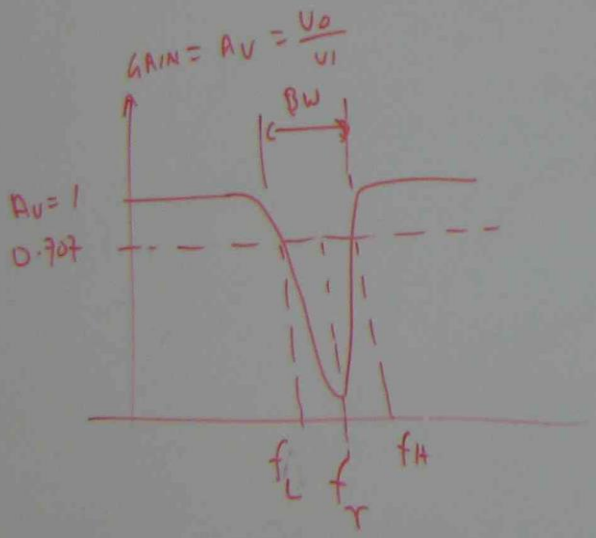
IN PRECISION CONTROL SYSTEM, IT NEEDS TO NARROW THE PASS BAND. MULTIPLE FEED BACK NARROW BAND PASS FILTER IS REQUIRED.



# BAND STOP (NOTCH) FILTER

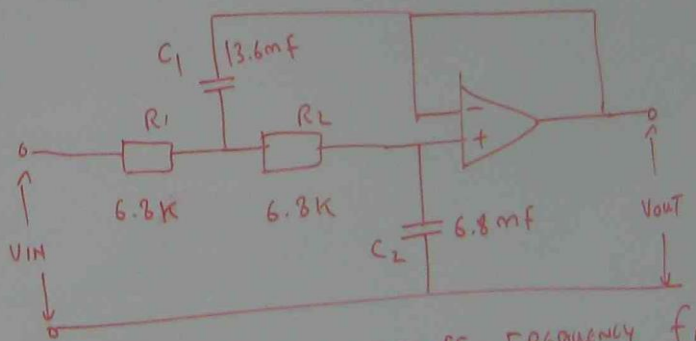



THE BAND STOP FILTER ALSO CALLED NOTCH FILTER IS USED TO REJECT AN UNWANTED FREQUENCY.

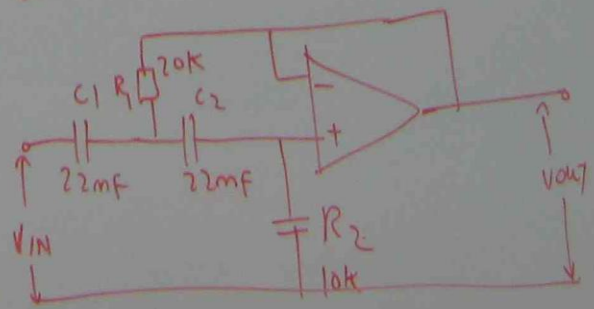
**Pb ①** (a) CALCULATE THE CUT-OFF FREQUENCY $f_H$

(b) SKETCH THE FREQUENCY RESPONSE, INDICATING THE RELATIVE OUTPUT LEVELS




**Pb ②** (a) CALCULATE THE CUT OFF FREQUENCY $f_L$

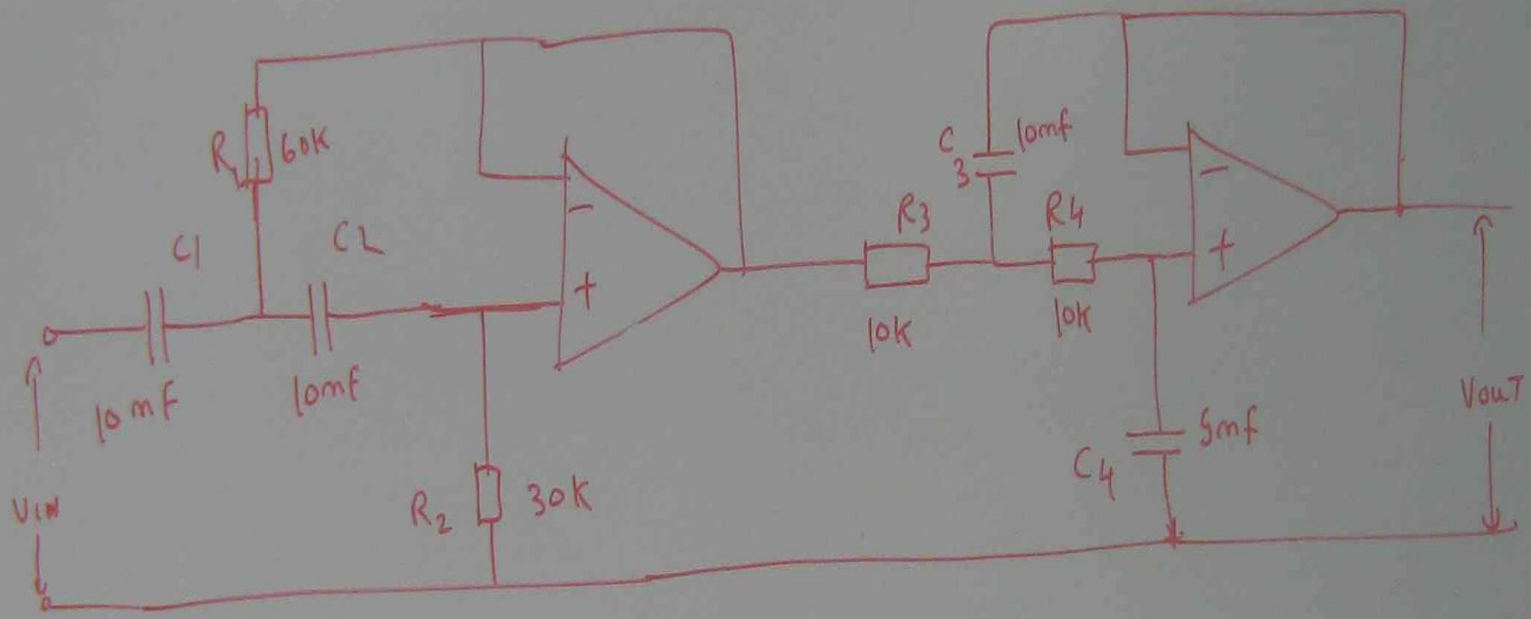
(b) SKETCH THE FREQUENCY RESPONSE



Pb ②

(a) CALCULATE THE CUT OFF FREQUENCIES $f_L$ AND $f_H$

(b) SKETCH THE FREQUENCY RESPONSE, INDICATING THE RELATIVE OUTPUT LEVELS $f_L$, $f_H$



Pb① 2nd ORDER LOW PASS BUTTERWORTH FILTER

$$f_c = \frac{1}{2\pi\sqrt{R_1 R_2 C_1 C_2}}$$

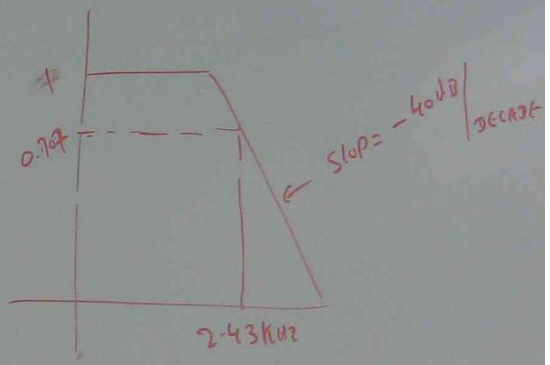
$$= \frac{1}{2 \times 3.14 \sqrt{6.8\times10^{3} \times 6.8\times10^{3} \times 13.6\times10^{-9} \times 6.8\times10^{-9}}}$$

$$= \frac{1}{6.28\sqrt{4276.27 \times 10^{-12}}}$$

$$= \frac{1}{6.28 \times 65.39 \times 10^{-6}}$$

$$= \frac{1}{410} \times 10^{6} = \frac{1000\times10^{3}}{410}$$

$$= 2.43\,KHz$$



pb ②

2nd ORDER HIGH PASS BUTTERWORTH FILTER

$$f_c = \frac{1}{2\pi\sqrt{R_1 R_2 C_1 C_2}}$$

$$= \frac{1}{6.28\sqrt{20\times10^3 \times 10\times10^3 \times 22\times10^{-9} \times 22\times10^{-9}}}$$

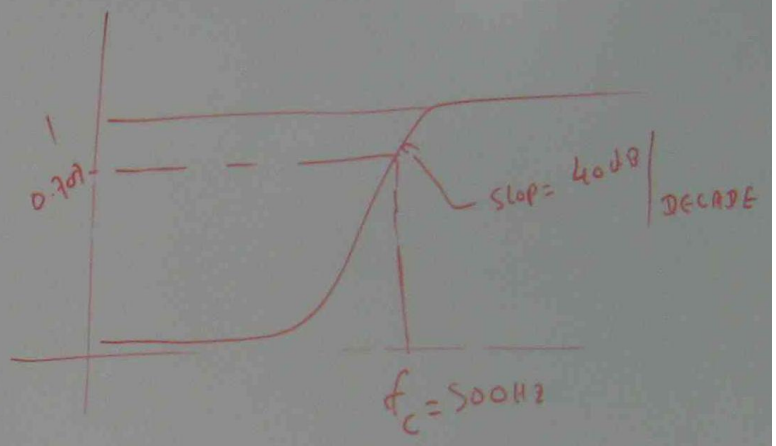
$$= \frac{1}{6.28\sqrt{96800\times10^{-12}}}$$

$$= \frac{1}{6.28\times311\times10^{-6}}$$

$$= \frac{10^6}{1953} = \frac{1000\times10^3}{1953}$$

$$= 0.5\ KHz$$

$$= 500\ Hz$$



Pb(3)

SECOND ORDER HIGH PASS FILTER + SECOND ORDER LOW PASS FILTER = SECOND ORDER BAND PASS FILTER

$$f_1 = \frac{1}{2\pi\sqrt{R_1 R_2 C_1 C_2}}$$

$$= \frac{1}{6.28\sqrt{60\times10^{3}\times30\times10^{3}\times10\times10^{-9}\times10\times10^{-9}}}$$

$$= \frac{1}{6.28\sqrt{180000\times10^{-12}}}$$

$$= \frac{10^{6}}{6.28\times424.26}$$

$$= \frac{1000\times10^{3}}{2664} = 0.375\,KHz$$

$f_L = 375\,Hz$

$$f_2 = \frac{1}{2\pi\sqrt{R_3 R_4 C_3 C_4}}$$

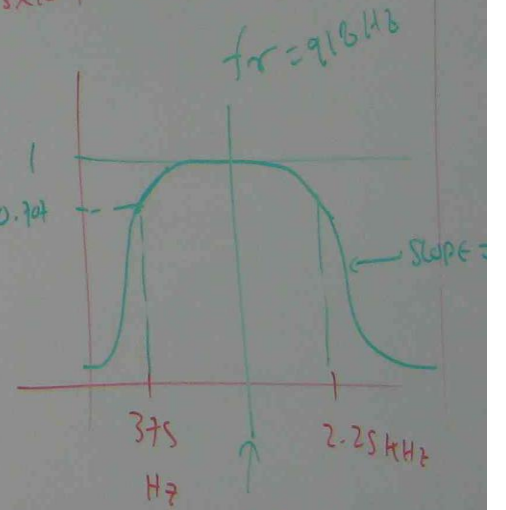
$$= \frac{1}{6.28\sqrt{10\times10^{3}\times10\times10^{3}\times10\times10^{-9}\times5\times10^{-9}}}$$

$$= \frac{1}{6.28\sqrt{5000\times10^{-12}}}$$

$$= \frac{10^{6}}{444}$$

$$= \frac{1000\times10^{3}}{444}$$

$f_H = 2.25\,KHz$



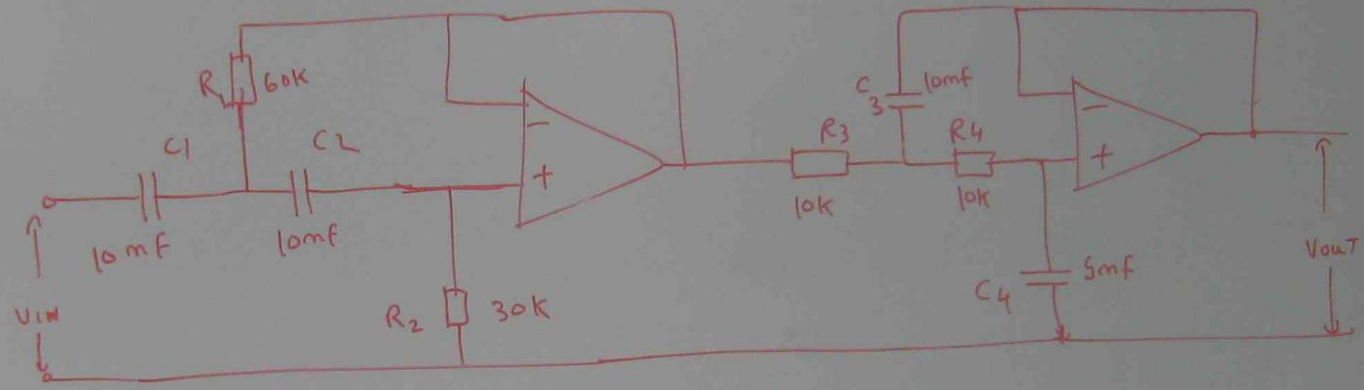

log375 =

log2250 =

Pb ①

(a) CALCULATE THE CUT OFF FREQUENCIES $f_L$ AND $f_H$

(b) SKETCH THE FREQUENCY RESPONSE, INDICATING THE RELATIVE OUTPUT LEVELS $f_L$, $f_H$




SLOPE = 40 dB / DECADE

$$f_r = \sqrt{f_L \times f_H}$$

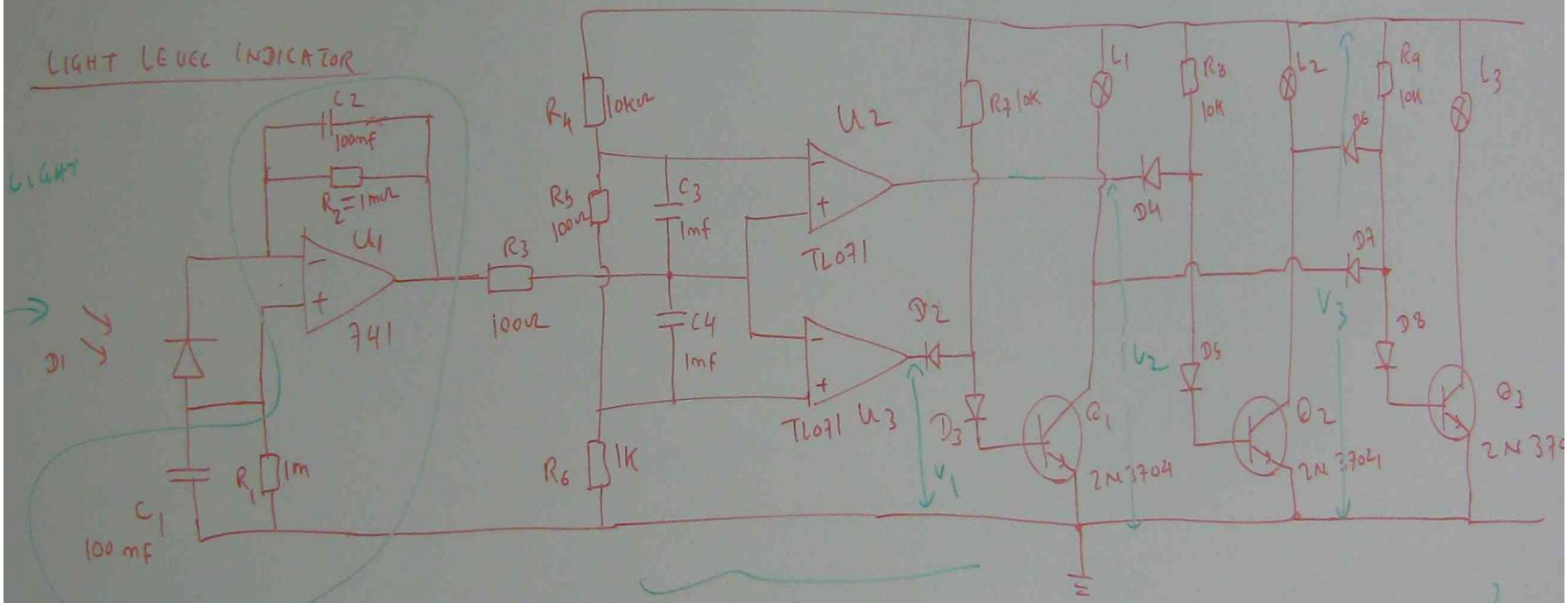
$$= \sqrt{375 \times 2250}$$

$$= 918\ Hz$$

Hz

# MULTI STAGE OP-AMP CIRCUITS

## LIGHT LEVEL INDICATOR




$U_1$ - LOW PASS FILTER

(2)

CURRENT → VOLTAGE CONVERTOR

COMPARATOR

(3)

(4) LIGHT DRIVERS.

SWITCHS FOR LAMPS.

(1) PHOTO DIODE $D_1$ CONVERTS THE LIGHT TO ELECTRICAL SIGNAL CURRENT

(2) LOW PASS FILTER $U_1$ PREVENTS THE HIGH FREQUENCIES. IT ACTS AS LOW PASS FILTER / CONVERST THE CURRENT TO VOLTAGE.

(3) OP-AMP $U_2$, $U_3$ ACT AS COMPARATOR. DEPENDING ON OUTPUT, $Q_1$, $Q_2$, $Q_3$ SWITCH ON THE LAMPS

(4) THE DRIVER TRANSISTORS
$L_1$, $L_2$ AND $L_3$

37021

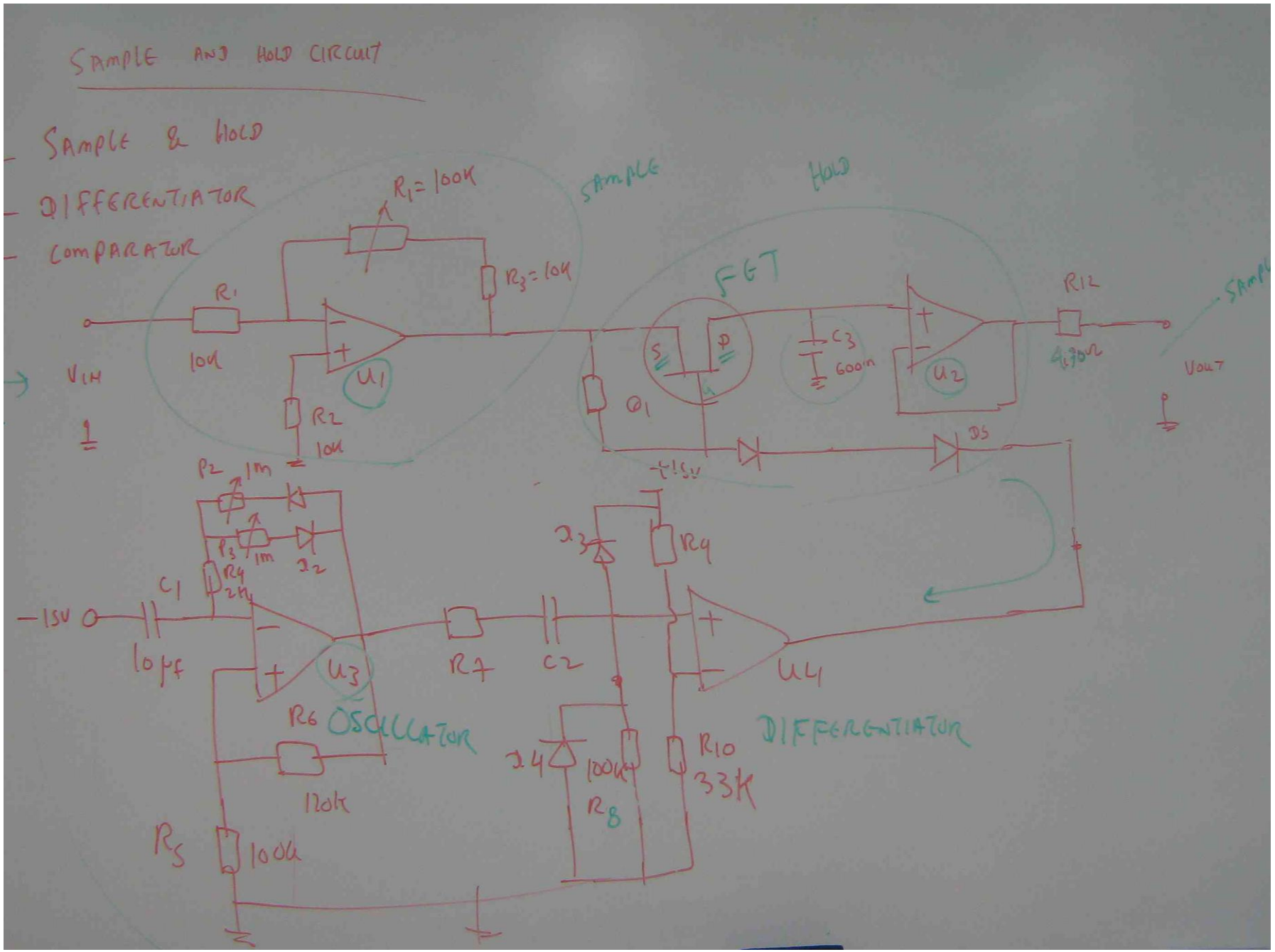
DIODES $D_4$, $D_6$, $D_7$ PREVENTS REVERSED CURRENT FLOWS.

DIODES $D_3$, $D_5$, $D_8$ DIRECT THE BIASING CURRENTS INTO TRANSISTORS

LIGHT LEVEL TOO LOW OR HIGH ARE INDICATED BY $L_1$ $L_2$ $L_3$

# SAMPLE AND HOLD CIRCUIT

- SAMPLE & HOLD
- DIFFERENTIATOR
- COMPARATOR



OP-Amp $U_1$ AND $U_2$ PROCESS THE DC INPUT VOLTAGE AND PRESENT THE SAMPLE LEVEL AT THE OUTPUT OF $U_2$

OP-Amp $U_3$ IS OSCILLATOR. IT'S OUTPUT IS APPLIED TO DIFFERENTIATOR $U_4$.

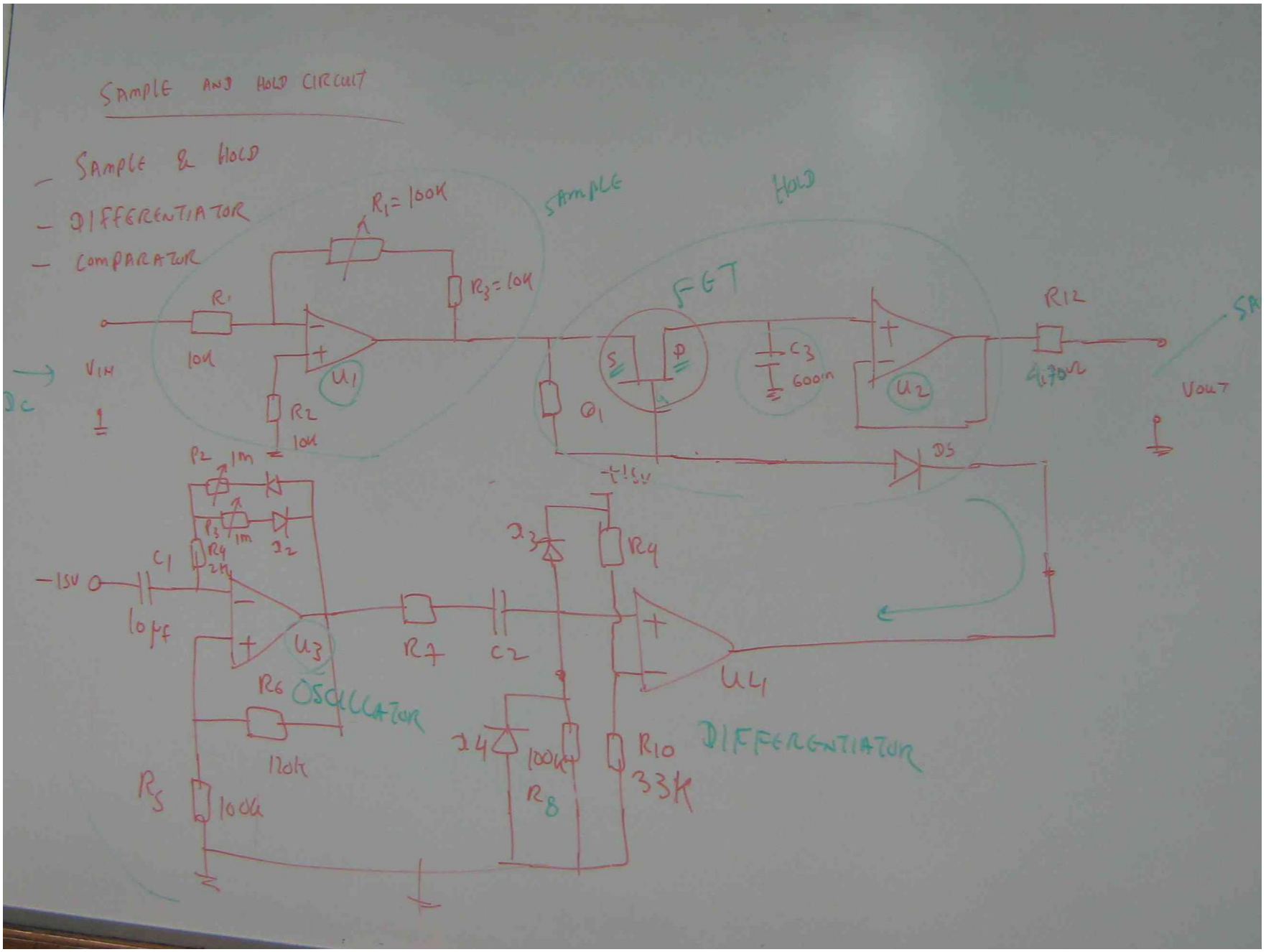
OP-Amp $U_4$ IS WIRED AS COMPARATOR

THE OUTPUT of COMPARATOR SWITCHES THE REVERSING DIODE $D_5$.

UNDER THESE CONDITION, THE GATE/SOURCE VOLTAGE of FET $Q_1$ WILL EQUAL 0V.

CAUSING $C_3$ TO CHARGE TO OUTPUT LEVEL of $Q_1$.

THE OUTPUT of $U_4$ QUICKLY SWITCHES NEGATIVE AGAIN, FORWARD-BIASING $D_5$ & TURN OF FET


SAMPLE AND HOLD CIRCUIT
- SAMPLE & HOLD
- DIFFERENTIATOR
- COMPARATOR
SAMPLE
HOLD
FET
$R_1$= 100K
$R_3$= 10K
R1
10K
$V_{IN}$
U1
R2
10K
P2 1m
R3 1m
D2
R4 2K
C1
10μf
-15V
U3
R6 OSCILLATOR
120K
R5
100K
R7
C2
D3
+15V
R4
U4
DIFFERENTIATOR
D4
100K
R8
R10
33K
Q1
S
D
C3
600n
U2
R12
470Ω
D5
VOUT