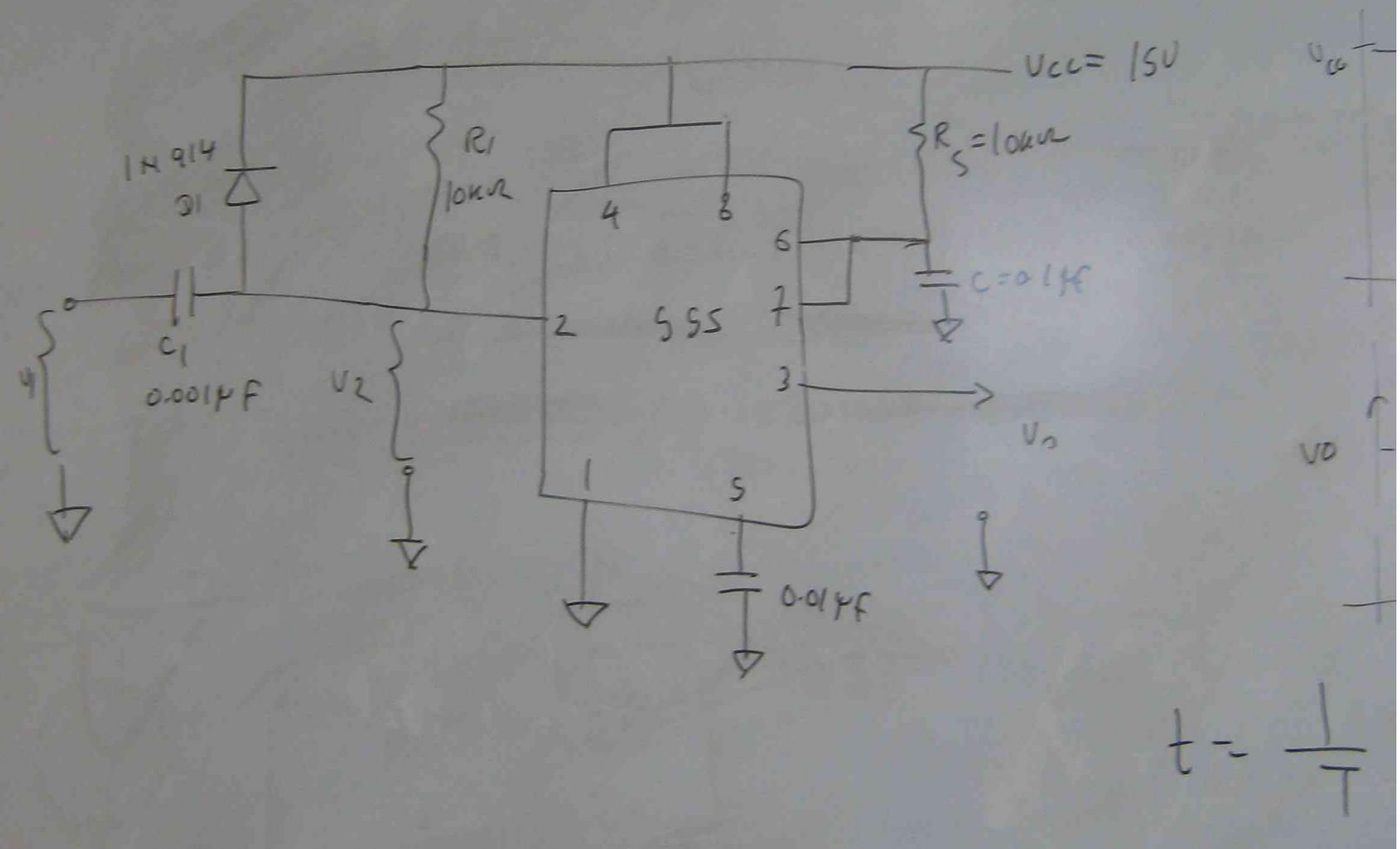
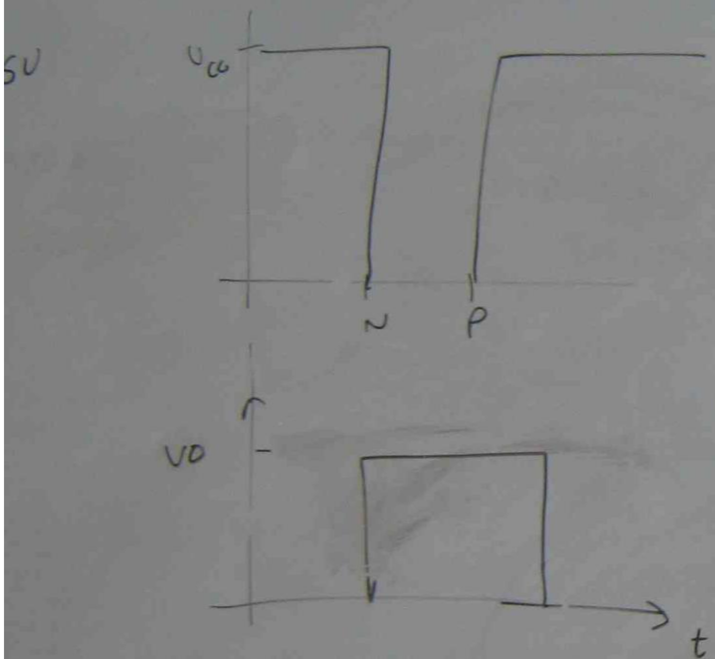
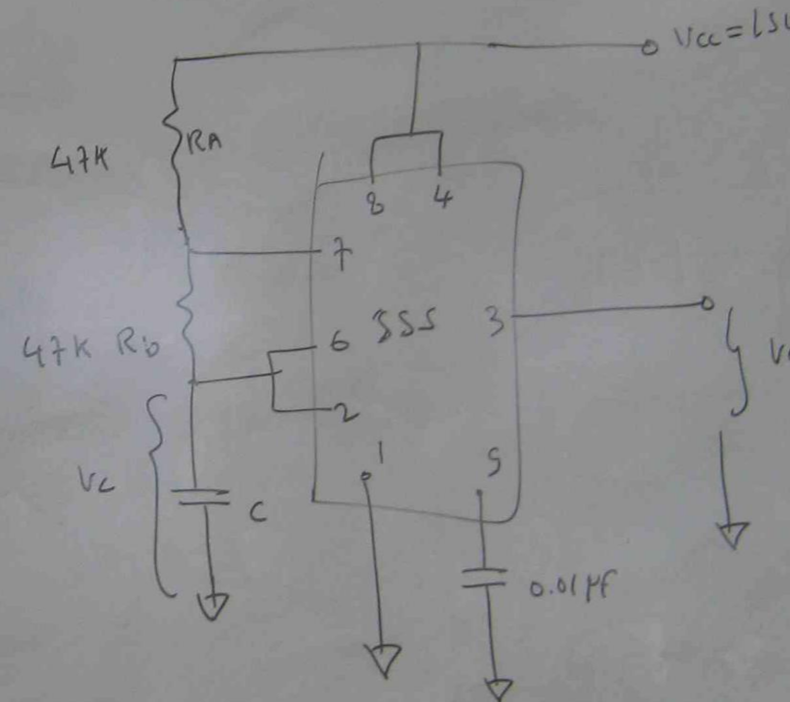
MONOSTABLE CIRCUIT







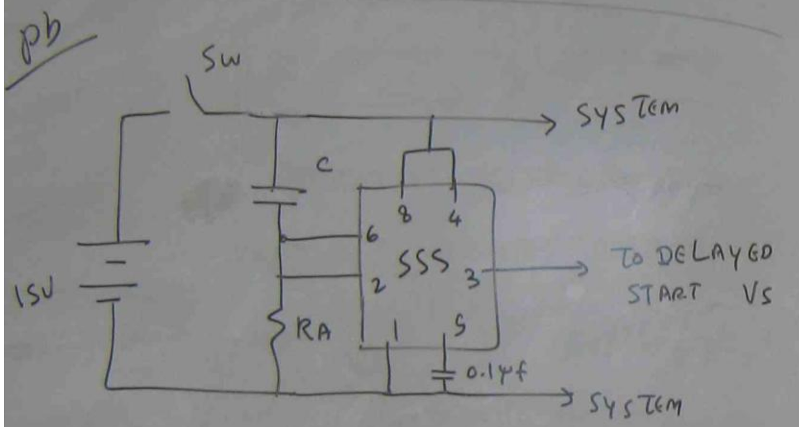
$$t = \frac{1}{T}$$

$$T = t_{High} + t_{Low}$$

$$t_{High} = 0.69\,(R_a + R_b)\,C$$

$$t_{Low} = 0.69\,R_b\,C$$

CALCULATION OF POWER ON TIME DELAY



FOR THE ABOVE TIMER CIRCUIT, CALCULATE ON TIME DELAY GIVEN $R_A = 820K$

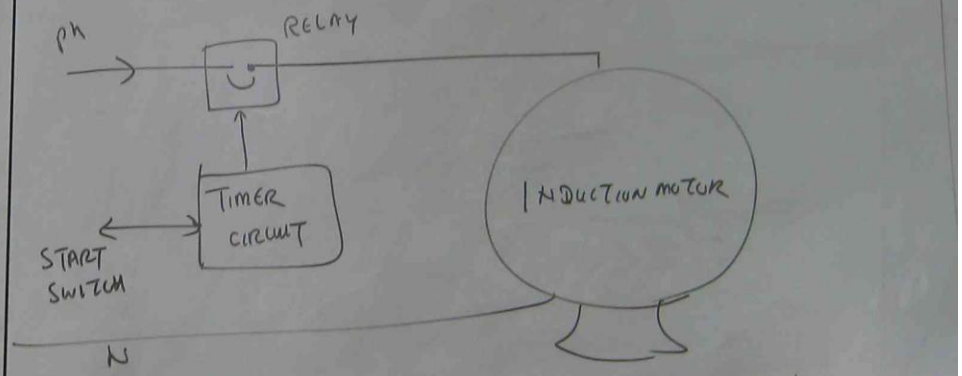
$C = 2.2\mu f$

SKETCH OUT PUT PULSE.

$$\boxed{T = 1.1 R_A C}$$

$$T = 1.1 \times 820 \times 10^{3} \times 2.2 \times 10^{-6}$$

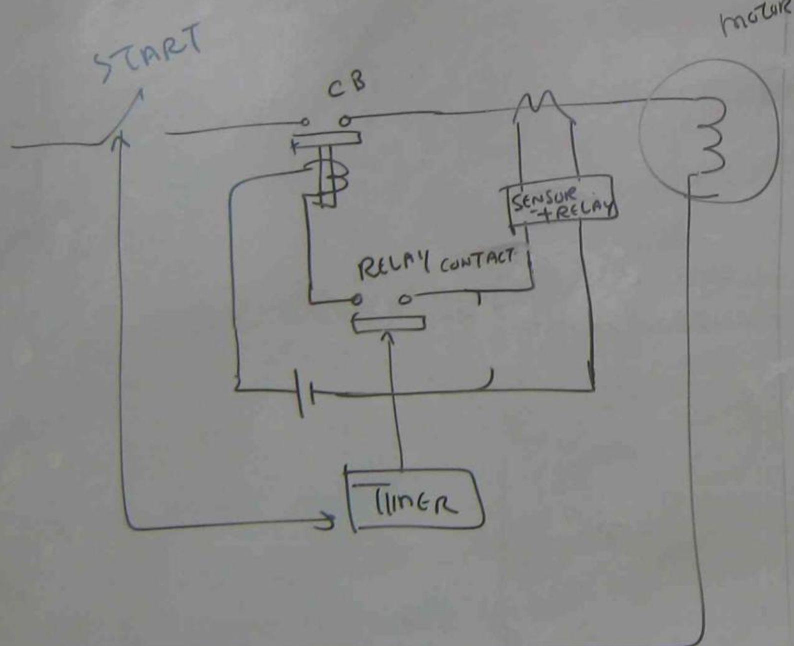
$$= 1.98 \text{ sec} \simeq \underline{\underline{2 \text{ sec}}}$$

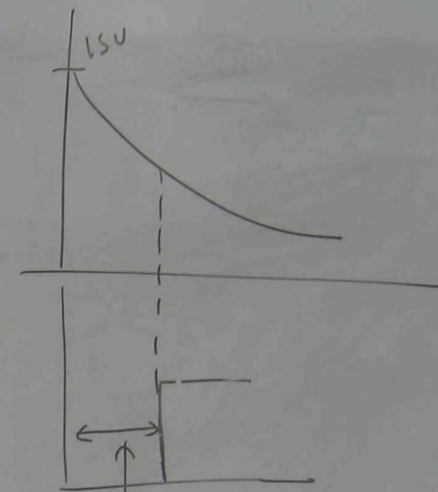


TIMER CIRCUIT IS APPLIED FOR MOTOR CONTROL RELAY. AT STARTING TIME, MOTOR CURRENT IS USUALLY HIGH. THE TIMER CIRCUIT CAUSES PROTECTIVE CIRCUIT TO IGNORE STARTING CURRENT WITH IN TIME SETTING.

IF MOTOR CURRENT IS STILL HIGH AFTER HAVING

PASSED THE TIME DELAY, THEN THE PROTECTIVE RELAY EXECUTES TO PROTECT THE MOTOR FROM OVER CURRENT.



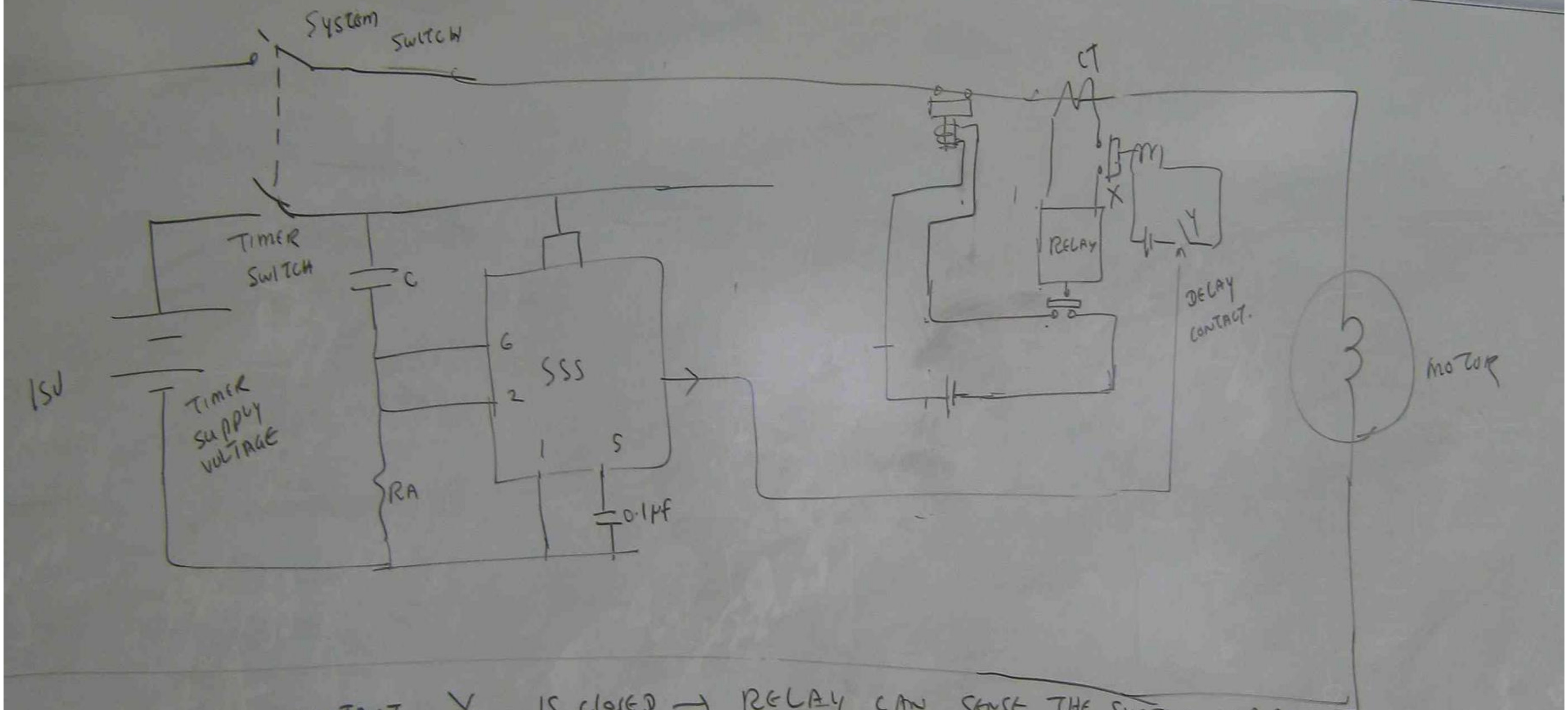


TIME DELAY $T = 1.1 R_A C$

BY THIS WAY, THE RELAY CAN IGNORE MOTOR STARTING CURRENT RISE.

TIMER PREVENT THE RELAY CONTACT TO CLOSE WHEN THE MOTOR START SWITCH IS CLOSED.

MOTOR START SWITCH IS ALSO ATTACHED TO TIMER



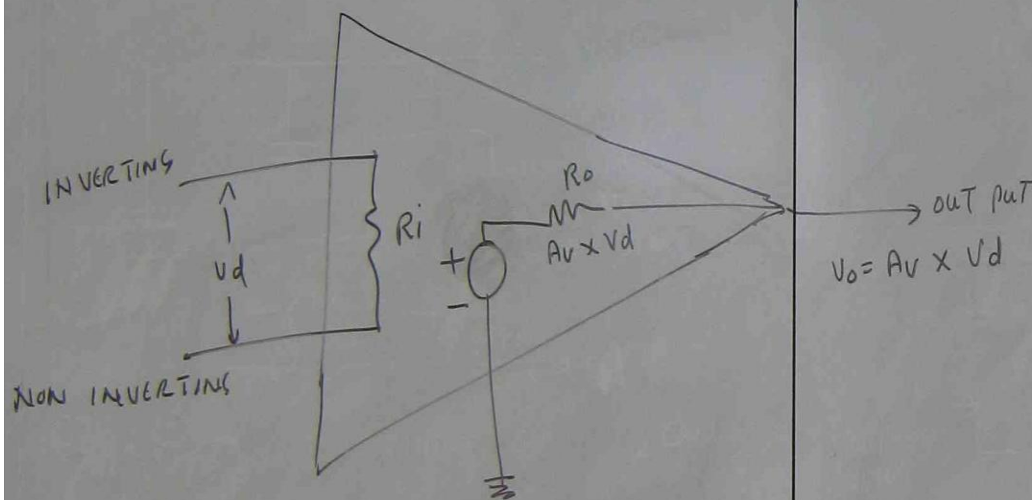
CONTACT X IS CLOSED → RELAY CAN SENSE THE SYSTEM CURRENT

BUT CONTACT X IS INSTANTLY NOT CLOSED BECAUSE TIME DELAY

CONTACT Y OPERATED BY SSS TIMER PREVENTS IT TO DO SO.

SSS TIMER WAITS FOR SOME TIME UNTIL SYSTEM STARTING CURRENT FALLS TO NORMAL.

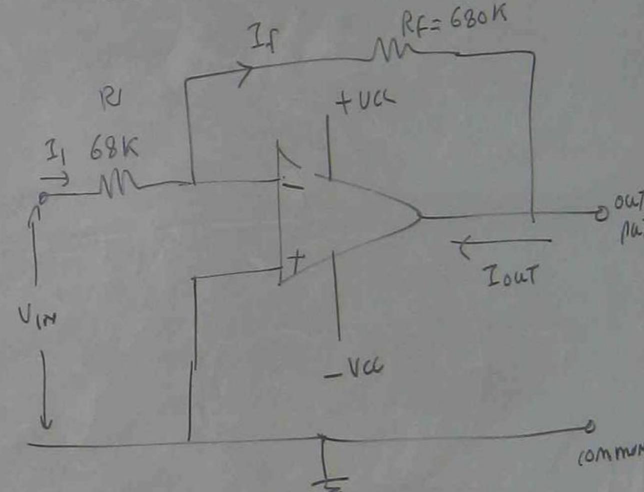
OPERATIONAL AMPLIFIER CIRCUIT (1)



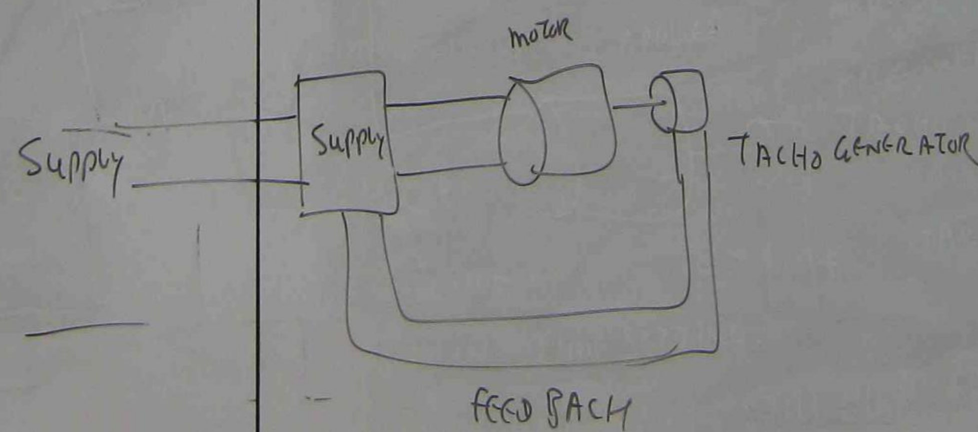
$V_o = A_V \times V_d$

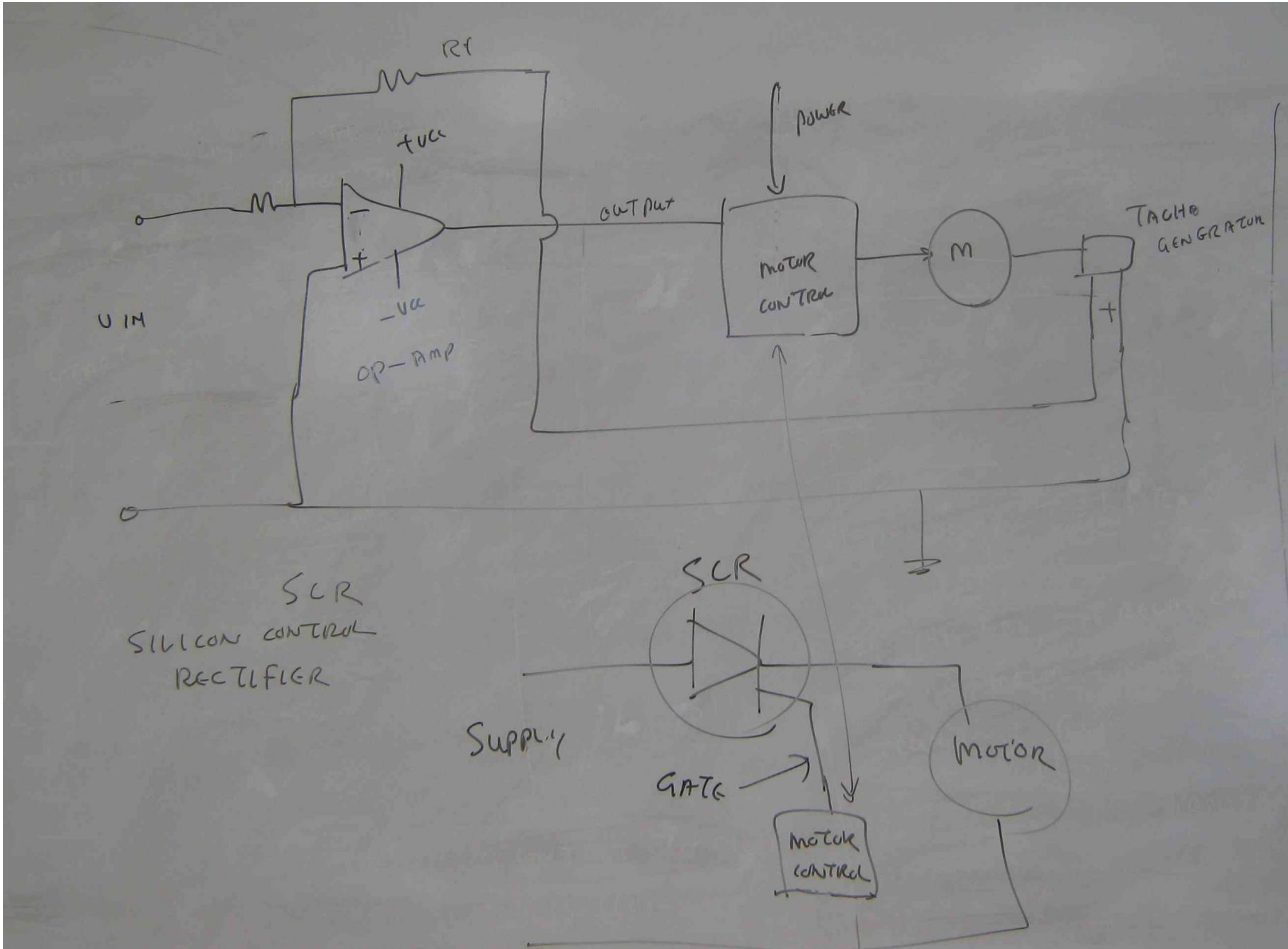
EQUIVALENT CIRCUIT OF OP-AMP

IDEAL INVERTING AMPLIFIER



FEED BACK FACTOR $B = \dfrac{R_1}{R_1 + R_F}$





Rf
+Vcc
-Vcc
OP-AMP
VIN
OUTPUT
POWER
MOTOR CONTROL
M
TACHO GENERATOR
SCR
SILICON CONTROL RECTIFIER
SCR
SUPPLY
GATE
MOTOR
MOTOR CONTROL

OP- AMP CIRCUIT CONTROL THE MOTOR CONTROL MODULE WHICH INCLUDES SCR (ELECTRONIC SWITCHING DEVICE).

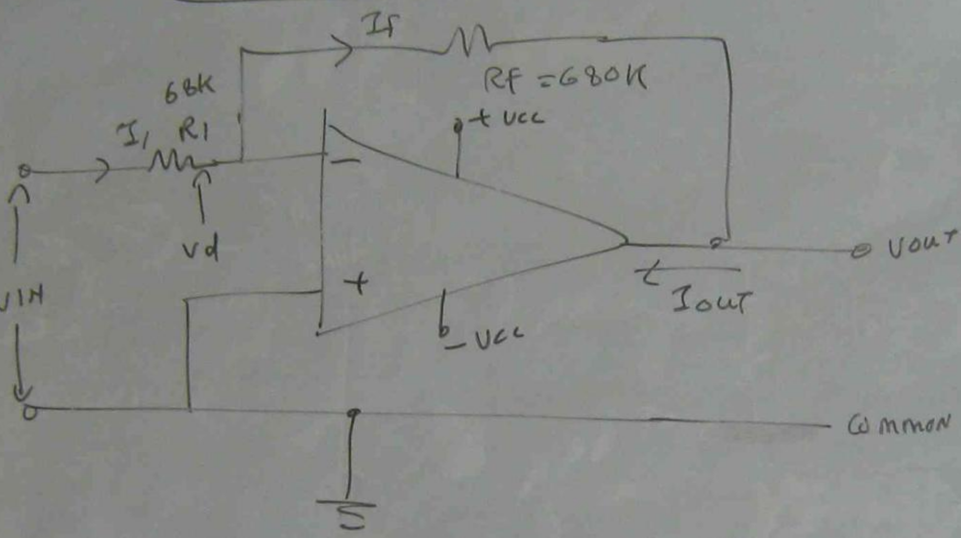
MOTOR SPEED IS SENSED BY TACHO GENERATOR ATTACHED TO MOTOR SHAFT.

WHEN MOTOR IS OVER SPEED, SUCH SPEED IS SENSED AND PROPORTIONAL VOLTAGE IS PRODUCED.

THIS VOLTAGE IS THEN FED BACK TO OP-AMP (−) TERMININAL & IT IS COMPARED WITH REFERENCE VOLTAGE APPLIED TO (+) TERMINAL.

THE DIFFERENCE IS THEN AMPLIFIED & SENT TO CONTROL DEVICE

INVERTING AMPLIFIER



$$V_{OUT} = -I_1 R_f$$

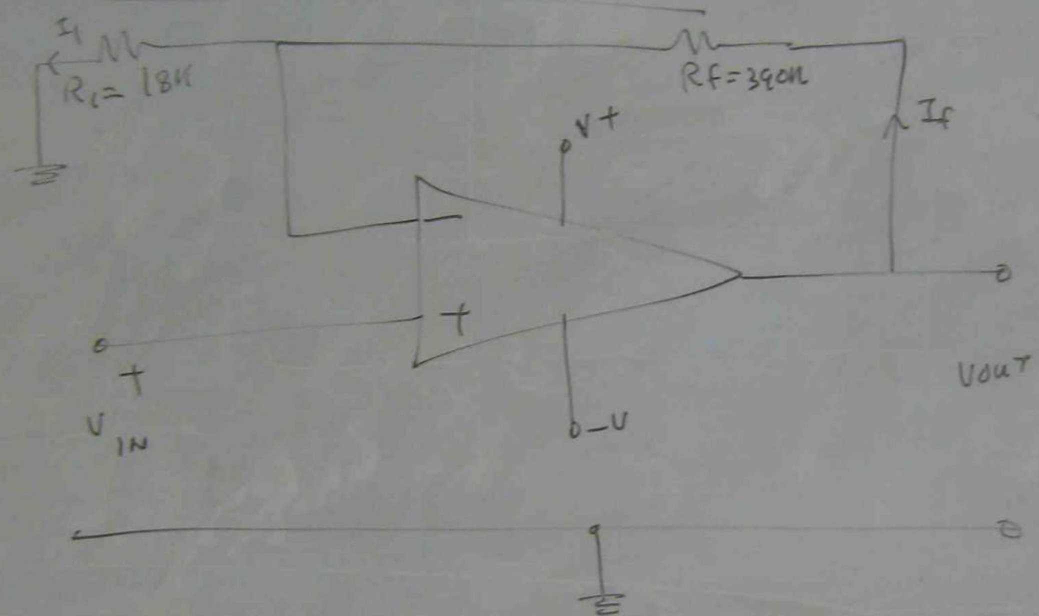
$$I_1 = \frac{V_{IN}}{R_1}$$

$$A_V = \frac{V_{OUT}}{V_{IN}}$$

$$I_1 = I_f$$

$$V_{RF} = I_f R_f - I_1 R_f$$

NON INVERTING AMPLIFIER



$$V_{IN} = V(+) = V(-)$$

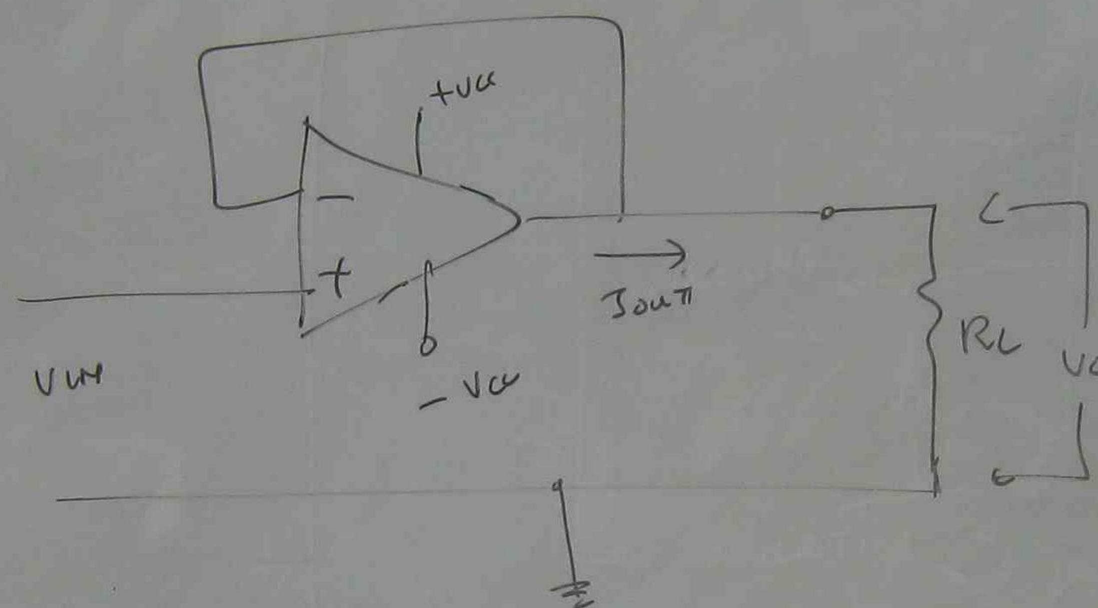
$$A_V = \frac{V_{OUT}}{V_{IN}}$$

$$I_1 = I_f$$

$$A_V = \frac{R_f}{R_1} + 1$$

$$V_{OUT} = V_{R_1} + V_{R_f}$$

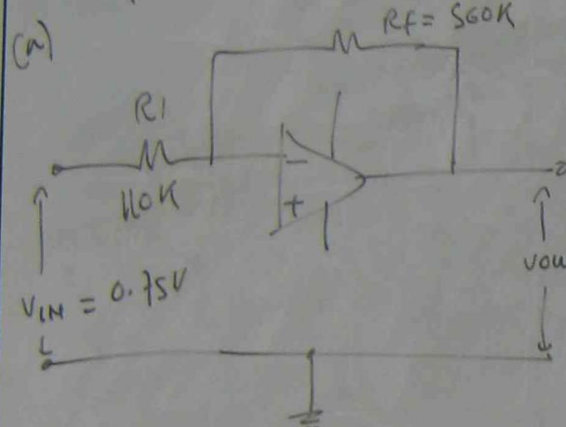
VOLTAGE FOLLOWER

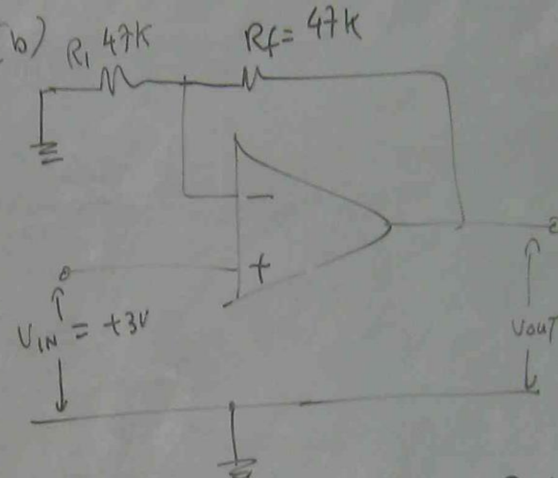


$$V_{IN} = V_{(+)} - V_{(-)} - V_{OUT}.$$

PROBLEMS

ASSUMING IDEAL OP-AMPS. DETERMINE THE VOLTAGE GAIN AND OUTPUT VOLTAGE FOR EACH CIRCUIT





(a) $I_1 = \frac{V_{IN}}{R_1} = \frac{0.75}{110k} = 6.8 \times 10^{-6}$ Amp

$V_{OUT} = -I_1 R_f = -6.8 \times 10^{-6} \times 560 \times 10^{3} = -3.8V$

$|V_{OUT}| = 3.8V$

$A_V = \frac{V_{OUT}}{V_{IN}} = \frac{3.8}{0.75} = 5.06$

(b) $A_V = \frac{R_f}{R_1} + 1$

$= \frac{47}{47} + 1 = 2$

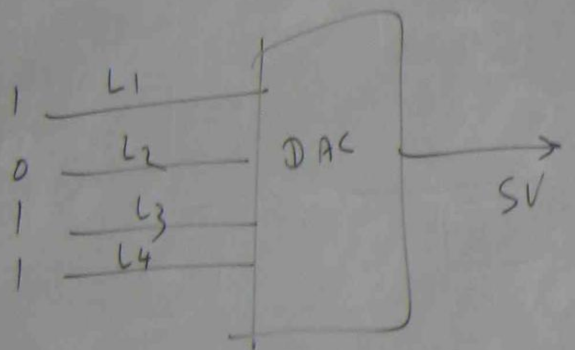
$V_{OUT} = A_V \times V_{IN}$

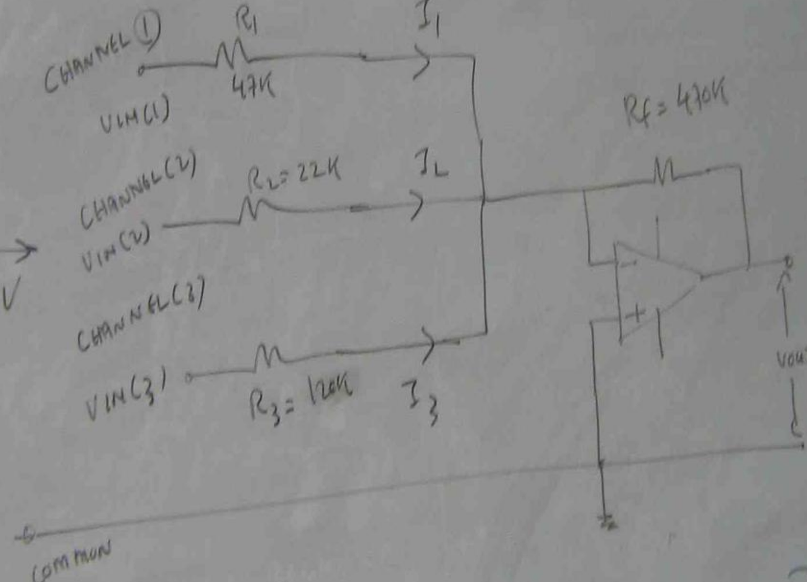
$= 2 \times 3$

$= 6V$

OPERATIONAL AMPLIFIER CIRCUIT (2)

THE IDEAL INVERTING SUMMER AMPLIFIER





$$V_{rms} = \sqrt{\frac{V_1^2 + V_2^2 + V_3 \ldots}{2}}$$

011 ⟶ 5V

110 ⟶ 7V

$$V_0 = -\left[\frac{R_f}{R_1} V_1 + \frac{R_f}{R_2} V_2 + \frac{R_f}{R_3} V_3\right]$$

ph

FOR THE GIVEN CIRCUIT

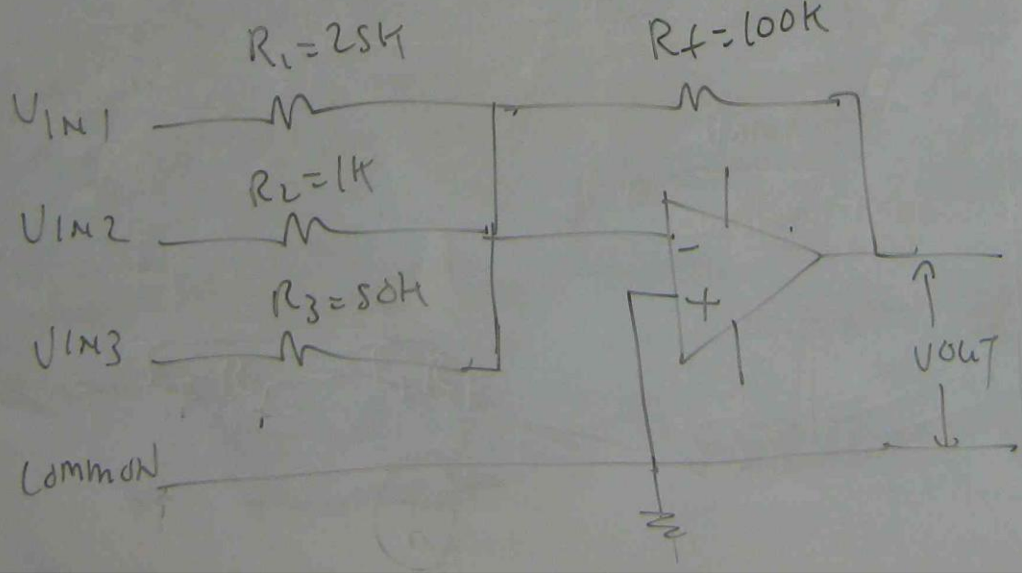
(a) CALCULATE THE VALUES OF THE CURRENT FLOWING IN EACH RESISTOR

I_{R_1}, I_{R_2}, I_{R_3}, I_f

(b) CALCULATE VOLTAGE GAIN OF EACH INPUT CHANNEL

(c) CALCULATE OUTPUT VOLTAGE GIVEN THAT

$V_{IN1} = 0.4V$, $V_{IN2} = -0.1V$, $V_{IN3} = +5V$



(a) $I_{R_1} = \dfrac{V_{IN1}}{R_1} = \dfrac{0.4}{25k} = 0.016 \text{ mA}$

$I_{R_2} = \dfrac{V_{IN2}}{R_2} = \dfrac{-0.1}{1k} = -0.1 \text{ mA}$

$I_{R_3} = \dfrac{V_{IN3}}{R_3} = \dfrac{5}{50k} = 0.1 \text{ mA}$

$I_F = I_{R_1} + I_{R_2} + I_{R_3} = 0.016 + (-0.1) + 0.1 = 0.016 \text{ mA}$

(b) $A_{v_1} = \dfrac{R_f}{R_1} = \dfrac{100}{25} = 4$

$A_{v_2} = \dfrac{R_f}{R_2} = \dfrac{100}{1} = 100$

$A_{v_3} = \dfrac{R_f}{R_3} = \dfrac{100}{50} = 2$

(c)

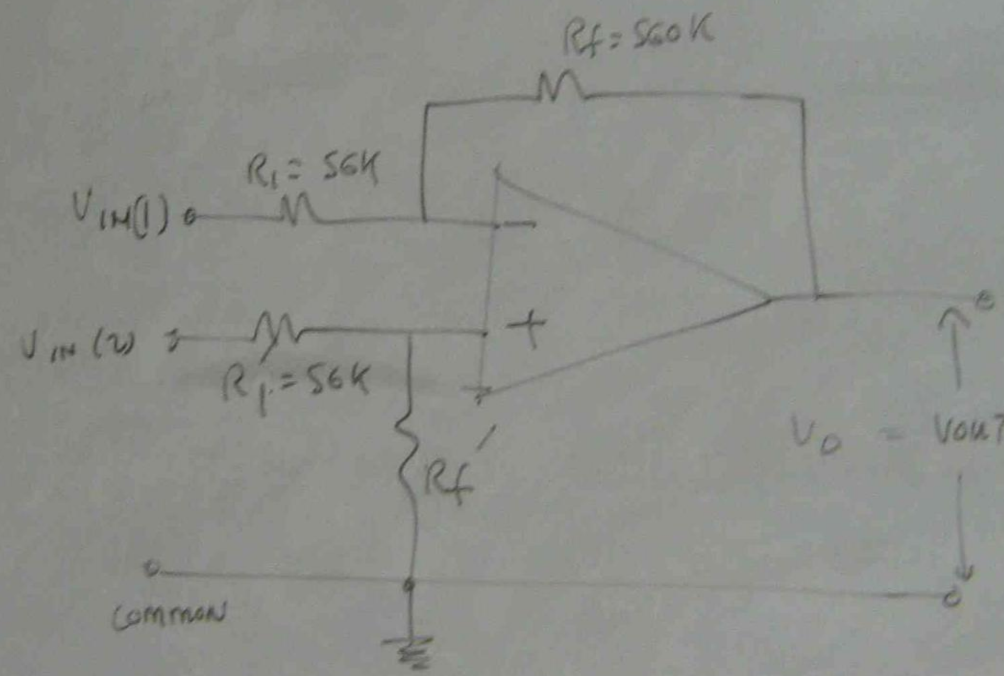
$$V_0 = -\left[\frac{R_f}{R_1} v_1 + \frac{R_f}{R_2} v_2 + \frac{R_f}{R_3} v_3\right]$$

$$= -\left[4 \times 0.4 + 100 \times (-0.1) + 2 \times 5\right]$$

$$= -\left[1.6 - 10 + 10\right]$$

$$= -1.6\ V$$

IDEAL DIFFERENTIAL AMPLIFIER

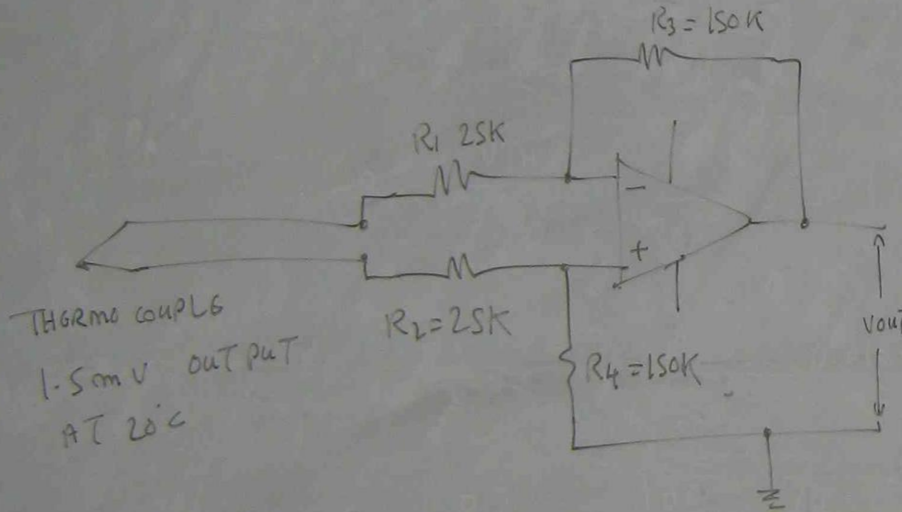


$$V_0 = \frac{R_f}{R_1}\left[V_{IN\,2} - V_{IN\,1}\right]$$

ph FOR THE GIVEN CIRCUIT,

(a) CALCULATE THE DIFFERENTIAL VOLTAGE GAIN OF THE CIRCUIT

(b) CALCULATE THE OUTPUT VOLTAGE FOR THE INPUT VOLTAGE GIVEN ON THE CIRCUIT



$$V_0 = \frac{R_f}{R_1}\left[V_{IN2} - V_{IN1}\right]$$

$R_f = R_3 = 150k$

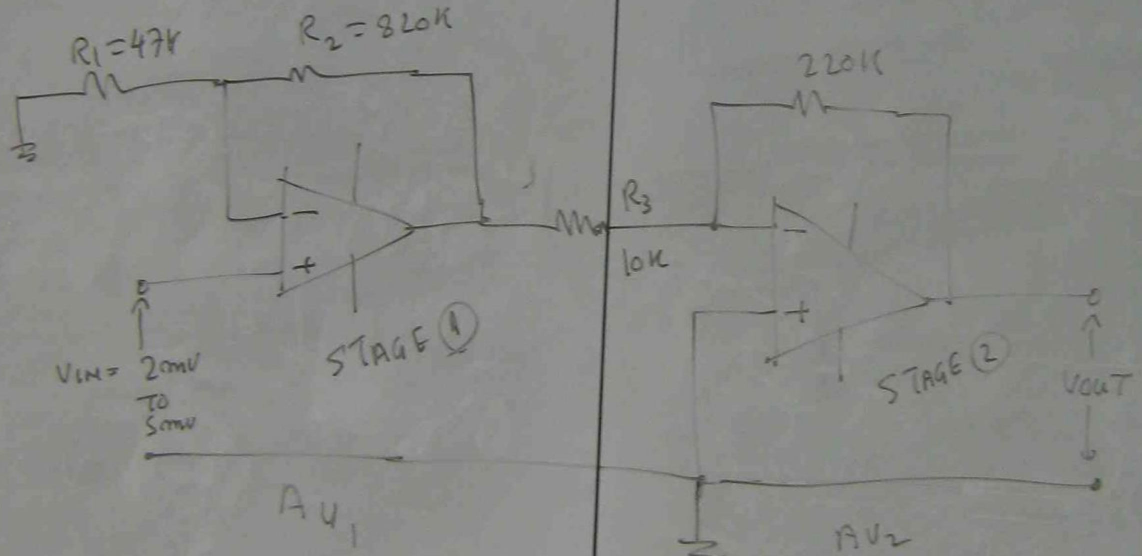
$R_1 = 25k$

$V_{IN2} - V_{IN1} = 1.5\,mV$

(b) $$V_0 = \frac{150}{25}\left[1.5\,mV\right] = 9\,mV$$

(a) $$A_V = \frac{V_0}{V_{IN}} = \frac{9\,mV}{1.5\,mV} = 6$$

CASCADING OPERATIONAL AMPLIFIER CIRCUITS



$$A_{V\,TOTAL} = A_{V_1} \times (-)\,A_{V_2}$$

$$A_{V_1} = 1 + \frac{R_f}{R_1} \quad \text{(NON INVERTING)}$$

$$A_{V_2} = \frac{R_f}{R_1} \quad \text{(INVERTING)}$$

STAGE 1: $R_f = R_2 = 820K$, $R_1 = 47K$

STAGE 2: $R_f = 220K$, $R_1 = R_3 = 10K$

$$A_{V1} = 1 + \frac{820}{47} = 18.44$$

$$A_{V2} = \frac{220}{10} = 22$$

$$A_{V\,TOTAL} = 18.44 \times (-)\,22$$

$$= (-)\,406$$

$$V_{OUT} = A_{V\,TOTAL} \times V_{IN}$$

$$= 406 \times 2\,mV$$

$$= 812\,mV$$

$$= 0.812\,V$$

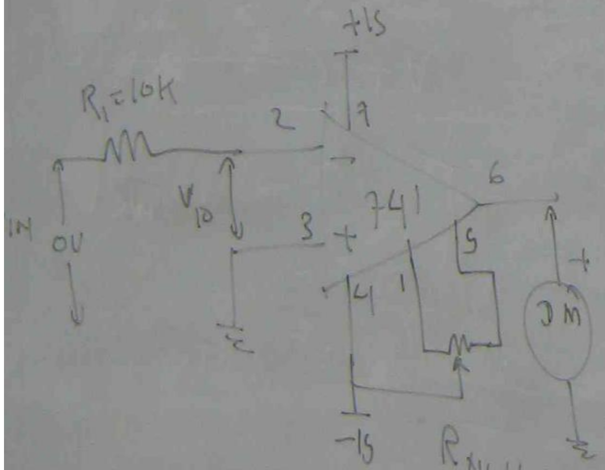
LIMITATIONS OF OPERATIONAL AMPLIFIERS

OPERATIONAL AMPLIFIERS HAVE PRACTICAL LIMITATIONS THAT RESTRICT THEIR FREQUENCY RESPONSE, OUTPUT VOLTAGE ACCURACY, THERMAL STABILITY AND THEIR ABILITY TO FOLLOW THE INPUT VOLTAGE.

APPLYING NEGATIVE TO ANY AMPLIFIER CAN IMPROVE THEIR STABILITY, WIDEN THE BANDWIDTH, RAISE THE INPUT RESISTANCE AND LOWER THE OUTPUT RESISTANCE, BUT AT THE EXPENSE OF OVER ALL VOLTAGE GAIN.

THE INPUT OFFSET VOLTAGE

IT IS THE DC DIFFERENTIAL INPUT VOLTAGE THAT EXISTS INTERNALLY BETWEEN THE INVERTING AND NON INVERTING TERMINALS OF A PRACTICAL OP-AMP.



ADJUST FOR $V_{OUT} = 0V$

INPUT BIAS CURRENT

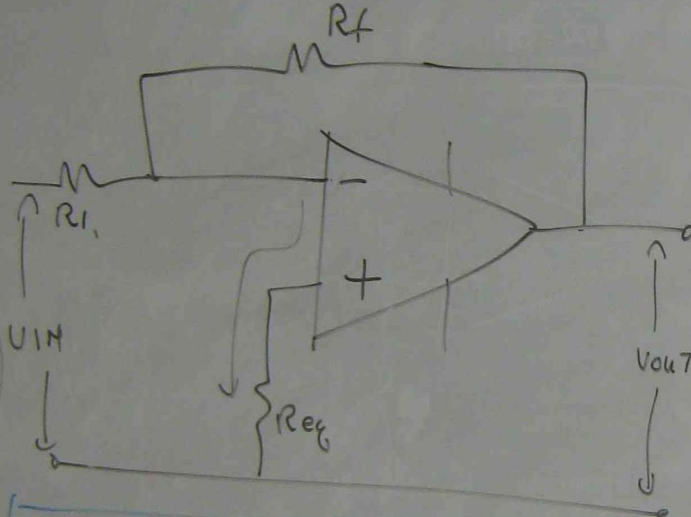
$$I_B = \frac{I_{B_1} + I_{B_2}}{2}$$

I_B = INPUT BIAS CURRENT

I_{B_1} = DC BIAS CURRENT INTO NON INV... TERM...

I_{B_2} = DC BIAS CURRENT INTO INVERTIN... TERMIN...

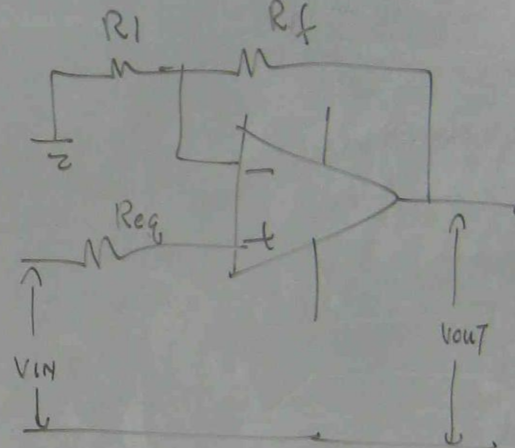
OFFSET MINIMIZING RESISTOR & INPUT OFF SET CURRENT



INVERTING

$$R_{eq} = \frac{R_1 R_f}{R_1 + R_f} = R_1 \| R_f$$

OFFSET MINIMIZING RESISTANCE

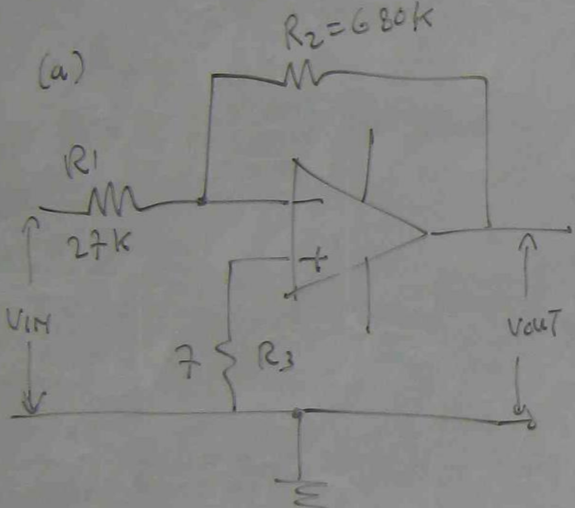


NON INVERTING

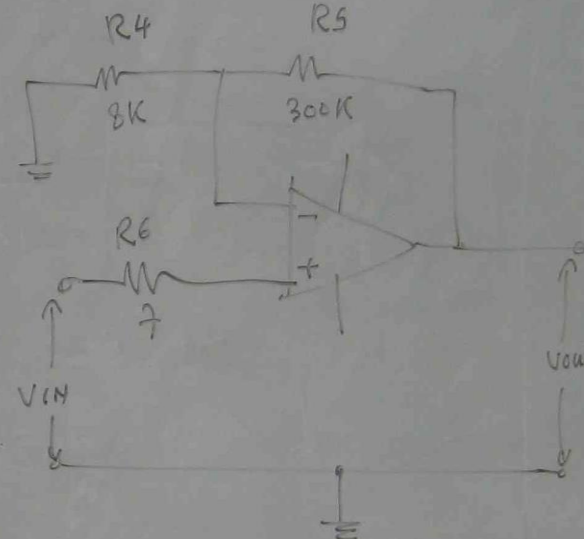
INPUT OFFSET CURRENT

DIFFERENCE IN THE CURRENTS INTO THE TWO INPUT TERMINALS WHEN THE OUTPUT IS AT ZERO ph/ FOR THE GIVEN CIRCUITS, DETERMINE THE VALUE OF THE OFFSET MINIMIZING RESISTOR.

(a)



(b)



$R_f = 680K \quad (R_2)$

$R_1 = 27K$

$$R_{eq} = \frac{R_f R_1}{R_f + R_1} = \frac{680 \times 27}{680 + 27} =$$

$R_1 = R_4 = 8K$

$R_f = R_5 = 300K$

$$R_{eq} = \frac{300 \times 8}{300 + 8}$$

COMMON MODE REJECTION RATIO

IDEAL OPERATIONAL AMPLIFIER ONLY AMPLIFIES THE INPUT VOLTAGE AND IT SHOULD COMPLETELY RAJECT THE COMMON MODE INPUT VOLTAGES CAUSED BY NOISE.

CMRR (COMMON MODE REJECTION RATIO) = $\frac{A_d}{A_c}$ (OR) $20 \log \frac{A_d}{A_c}$

NOISE IN OUTPUT VOLTAGE

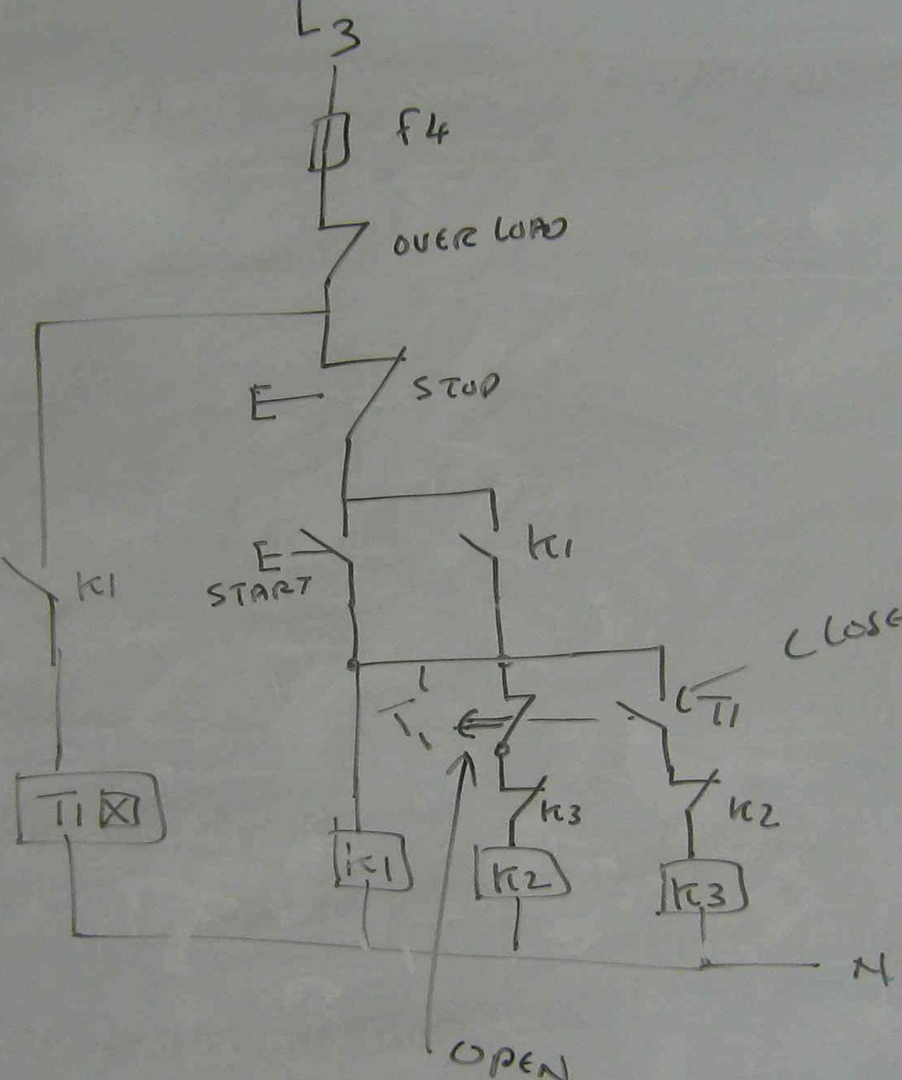
UNWANTED ELECTRICAL SIGNAL PRESENT IN OUTPUT SIGNALS ARE CLASSIFIED AS NOISE.

NOISE CAN PRESENCE FROM 0.01 HZ TO FREQUENCIES OVER 1 MHZ.

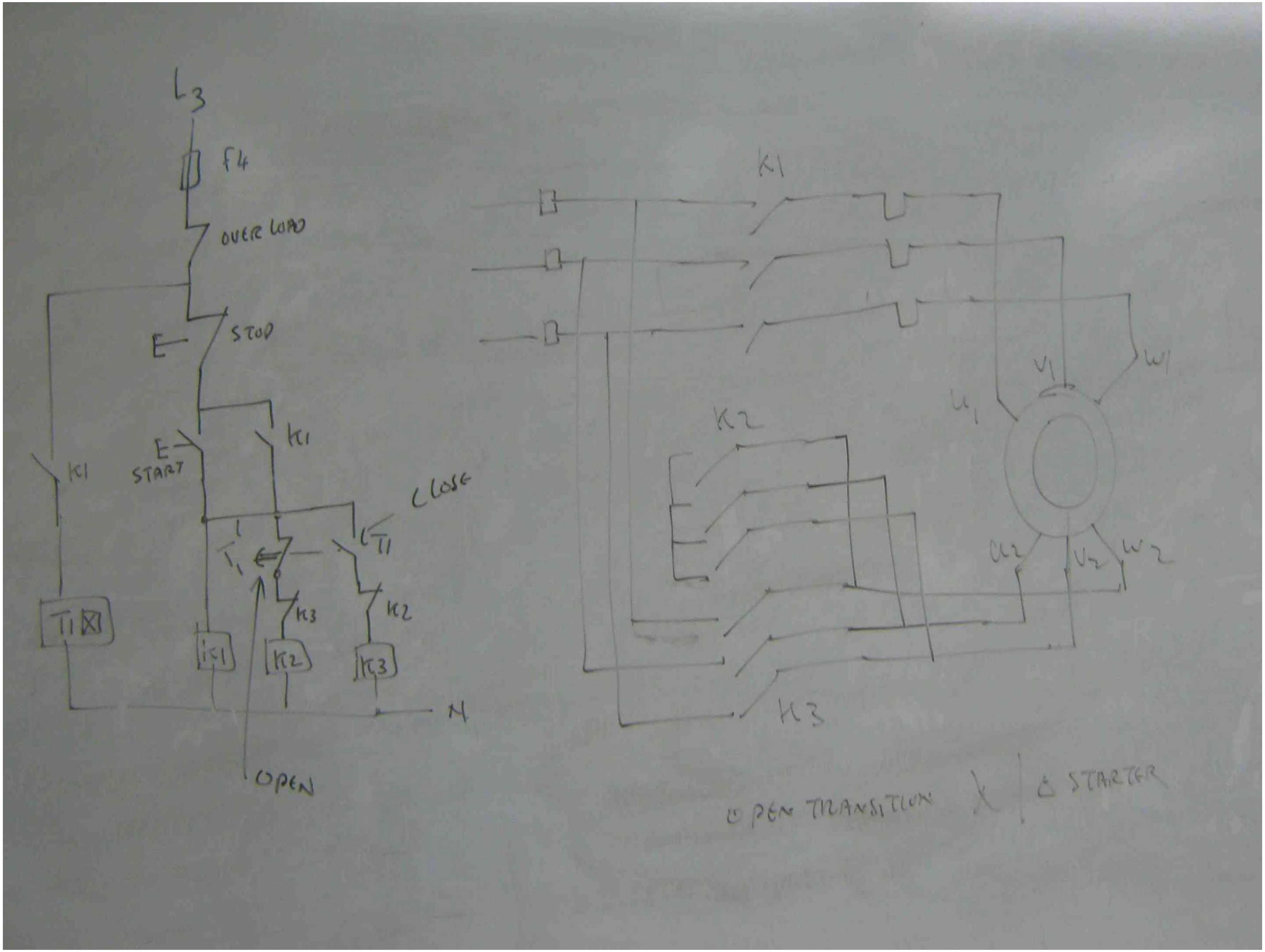
741 OP AMP → NOISE 2μV

TO REDUCE THE NOISE, CAPACITOR IS CONNECTED IN PARALLEL WITH Rf.

NOISE GAIN = $\frac{R_f}{R_1} + 1$



L3
F4
OVER LOAD
STOP
E
E
START
K1
K1
CLOSE
T1
T1
K3
K2
T1
K1
K2
K3
N
OPEN



L3
F4
OVER LOAD
STOP
E
E
START
K1
K1
CLOSE
T1
T1
K3
K2
T1
K1
K2
K3
N
OPEN
K1
K2
K3
U1
V1
W1
U2
V2
W2
OPEN TRANSITION Y | Δ STARTER

- WHEN START IS PRESSED, K_1 COIL IS ENERGIZED.
- K_1 CONTACTS ARE CLOSED
- TIMER T_1 IS ENERGIZED AS K_1 CONTACT WHICH IS CONNECTED IN SERIES WITH IT IS CLOSED
- K_2 COIL IS ENERGIZED AS THE CURRENT FLOWS THROUGH K_1 & K_3 NORMALLY CLOSED CONTACTS.
- WHEN K_2 COIL IS ENERGIZED, K_2 CONTACTS ARE CLOSED AND MOTOR STARTS WITH Y CONNECTION
- AFTER SOMETIME, TIMER OPEN T_1' & CLOSE T_1
- BY OPENING T_1', K_2 IS DE-ENERGIZED AND K_2 CONTACTS ARE OPEN.
- BY CLOSING T_1, K_3 COIL IS ENERGIZED AND K_3 CONTACTS ARE CLOSED.
- MOTOR RUNS WITH Δ. AS K_3 CONTACT CONNECTED IN SERIES WITH K_2 COIL IS OPEN, K_2 COIL CAN NOT CLOSE.