SOLID STATE SWITCHING DEVICES

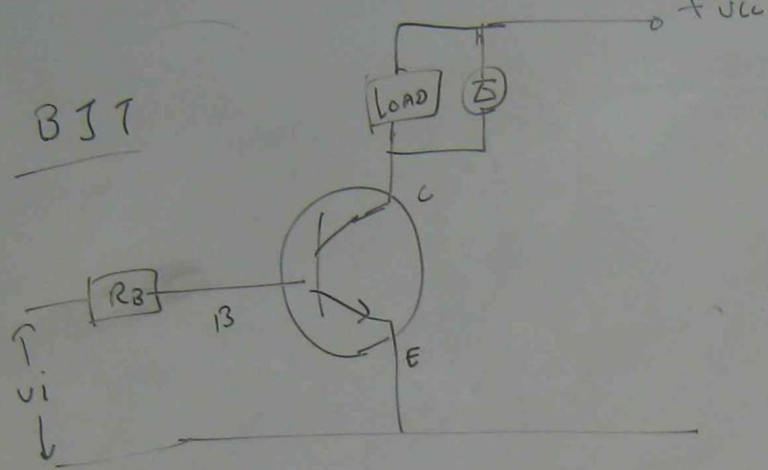
BJT (BIPOLAR JUNCTION TRANSISTORS)

SCR (SILICON CONTROL RECTIFIER) (THYRISTOR)

SEMI CONDUCTORS ARE USED WHERE HIGH SPEED SWITCHING IS REQUIRED. THE IDEAL SEMICONDUCTOR SWITCH SHOULD HAVE THE FOLLOWING CHARACTERISTICS

- INFINITE OFF STATE RESISTANCE
- ZERO ON STATE RESISTANCE
- ZERO SWITCHING TIME
- LOW CONTROL SIGNAL LEVEL.

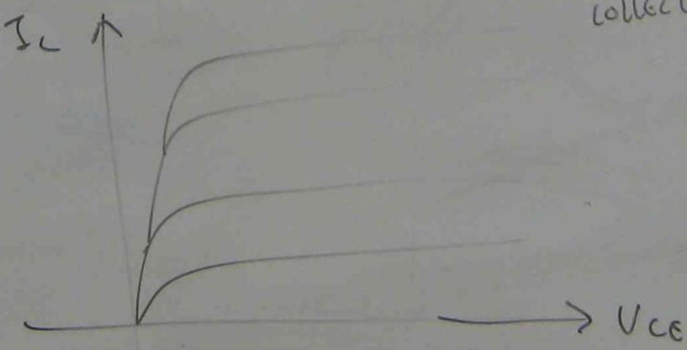
BJT



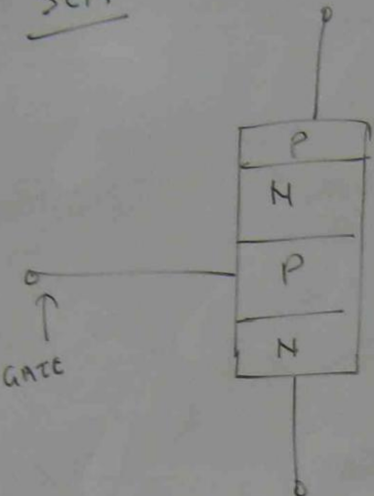
OPERATION

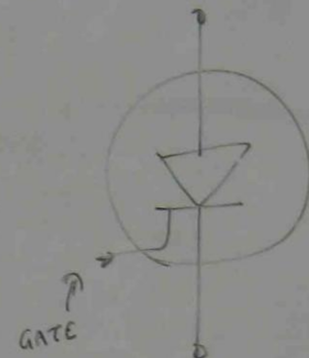
SWITCH OFF - BJT OPERATES IN CUT OFF REGION - $V_{CE} \simeq V_{CC} \Rightarrow$ CUTOFF

SWITCH ON - BJT OPERATES IN SATURATION REGION - BASED CURRENT INCREASES TILL NO FURTHER INCREASE IN COLLECTOR CURRENT



SCR

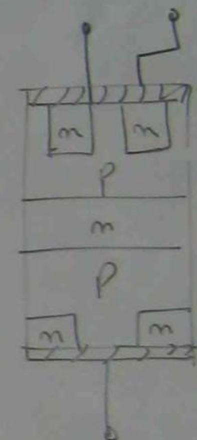




IT NEEDS TO PROVIDE GATE FIRING SIGNAL TO MAKE SCR CONDUCTION

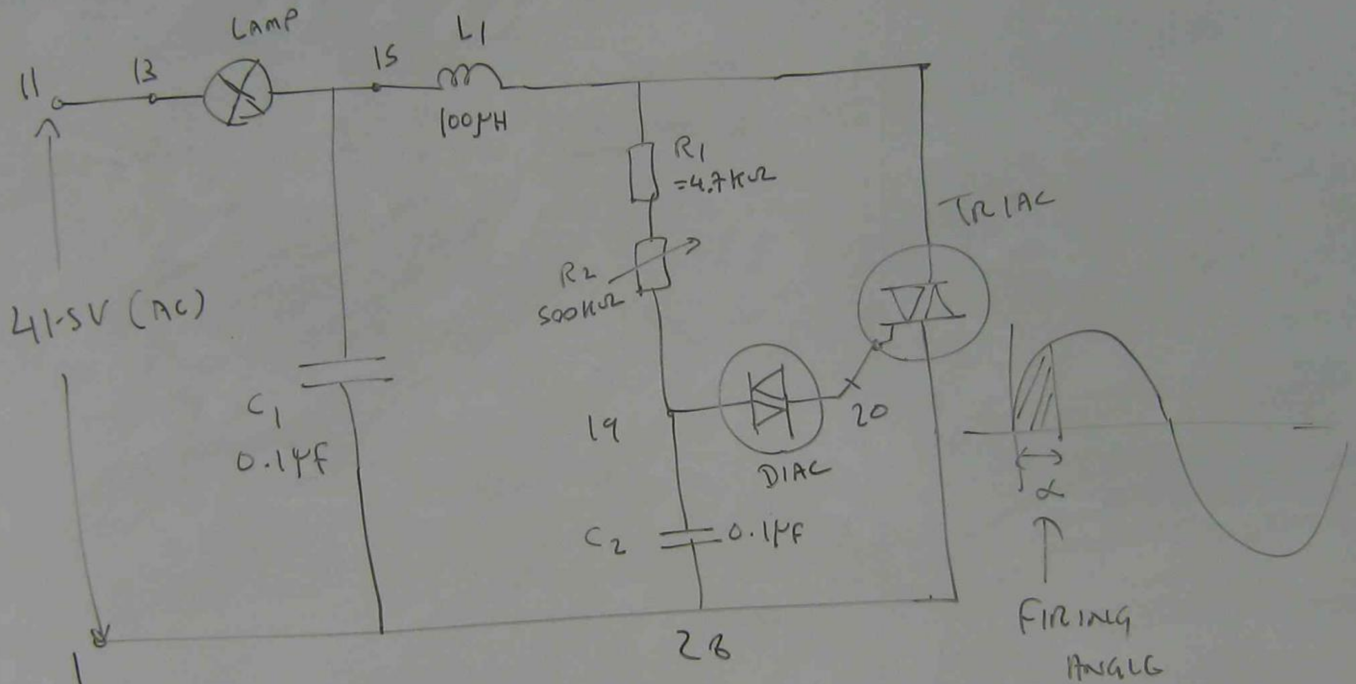
TRIAC

BI DIRECTIONAL 3 TERMINAL DEVICE



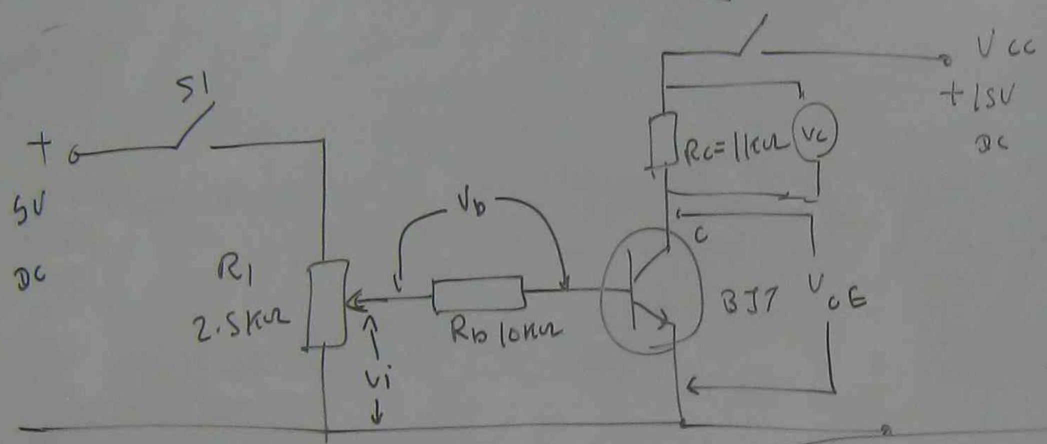
STRUCTURE

PHASE CONTROL CIRCUIT BY DIAC & TRIAC



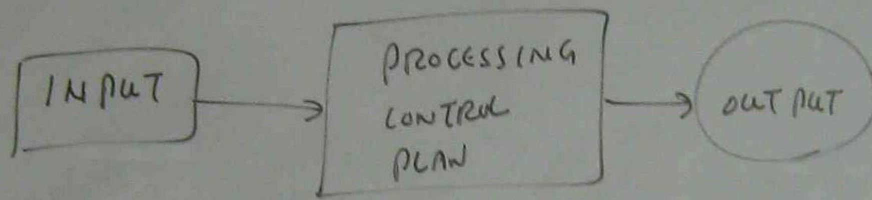
BY ADJUSTING POTENTIO METER, THE VOLTAGE ACROSS DIAC AND THE CURRENT FLOWS INTO TRIAC CAN BE ADJUSTED RESULTING THE VALUE OF GATE FIRING ANGLE WHICH REGULATES THE CONDUCTION OF TRIAC.

BIPOLAR JUNCTION TRANSISTOR SWITCHING CIRCUIT



STEP	INPUT BASE VOLTAGE V_i	BASE VOLTAGE V_b	BASE CURRENT $I_b = \frac{V_b}{R_b}$	COLLECTOR VOLTAGE (V_c)	COLLECTOR CURRENT $= \frac{V_c}{R_c}$	V_{CE}	BJT CONDUCTION
1							
2							
3							
4							

CONTROL SYSTEM



INPUT

- PROVIDED BY TRANSDUCERS WHICH CONVERT PHYSICAL QUANTITIES INTO ELECTRICAL SIGNALS.
- THESE TRANSDUCERS MAY TRANSMIT INFORMATION (SIGNAL) IN EITHER DIGITAL (OR) ANALOGUE FORM

TRANSDUCER	VARIABLE BEING SENSED	TYPE OF INFORMATION	ANALOG OR DIGITAL
THERMOCOUPLE	TEMPERATURE	SMALL VOLTAGE (mv)	ANALOG
THERMOSTAT	TEMPERATURE	ELONGATION	DIGITAL
THERMISTOR	TEMPERATURE	CHANGE OF RESISTANCE	ANALOG
STRAIN GAUGE	STRESS	COMPRESSION ↓ ELECTRICAL VOLTAGE	ANALOG
TACHO GENERATOR	SPEED	VOLTAGE	ANALOG
LIMIT SWITCH	POSITIONS	TRAVEL LEVEL	DIGITAL
BELLOWS	PRESSURE	COMPRESSION EXPENSION	DIGITAL/ANALOG

OUTPUT

CONVERT OUTPUT SIGNAL TO CONTROL THE PROCESS

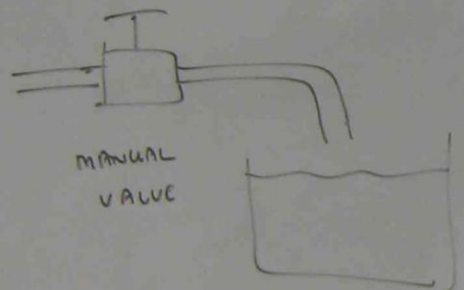
FINAL CONTROL ELEMENT (FCE)

FCE	QUANTITY PRODUCED	TYPE OF INPUT SIGNAL
MOTOR	ROTATIONAL MOTION	ELECTRICAL
PUMP	FLUID	ELECTRICAL / MECHANICAL
VALVE	FLUID	ON / OFF SWITCHING
SOLENOID	MAGNETIC	ELECTRICAL
RELAY	CURRENT INTERRUPTION	ELECTRICAL

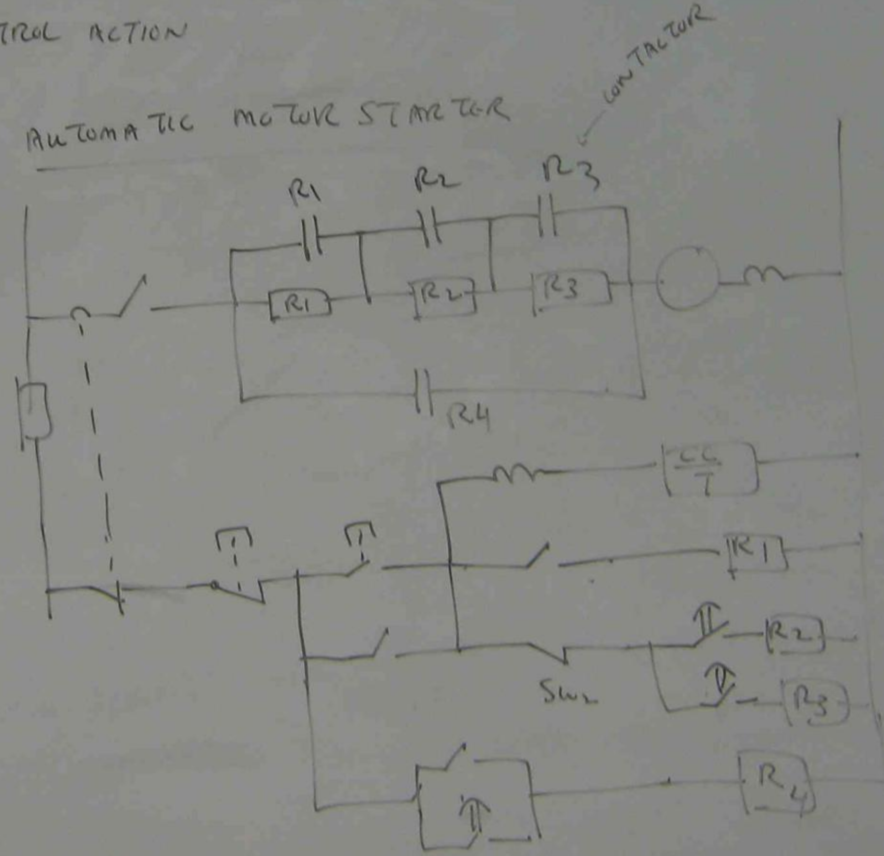
OPEN LOOP AND CLOSED LOOP CONTROL SYSTEM

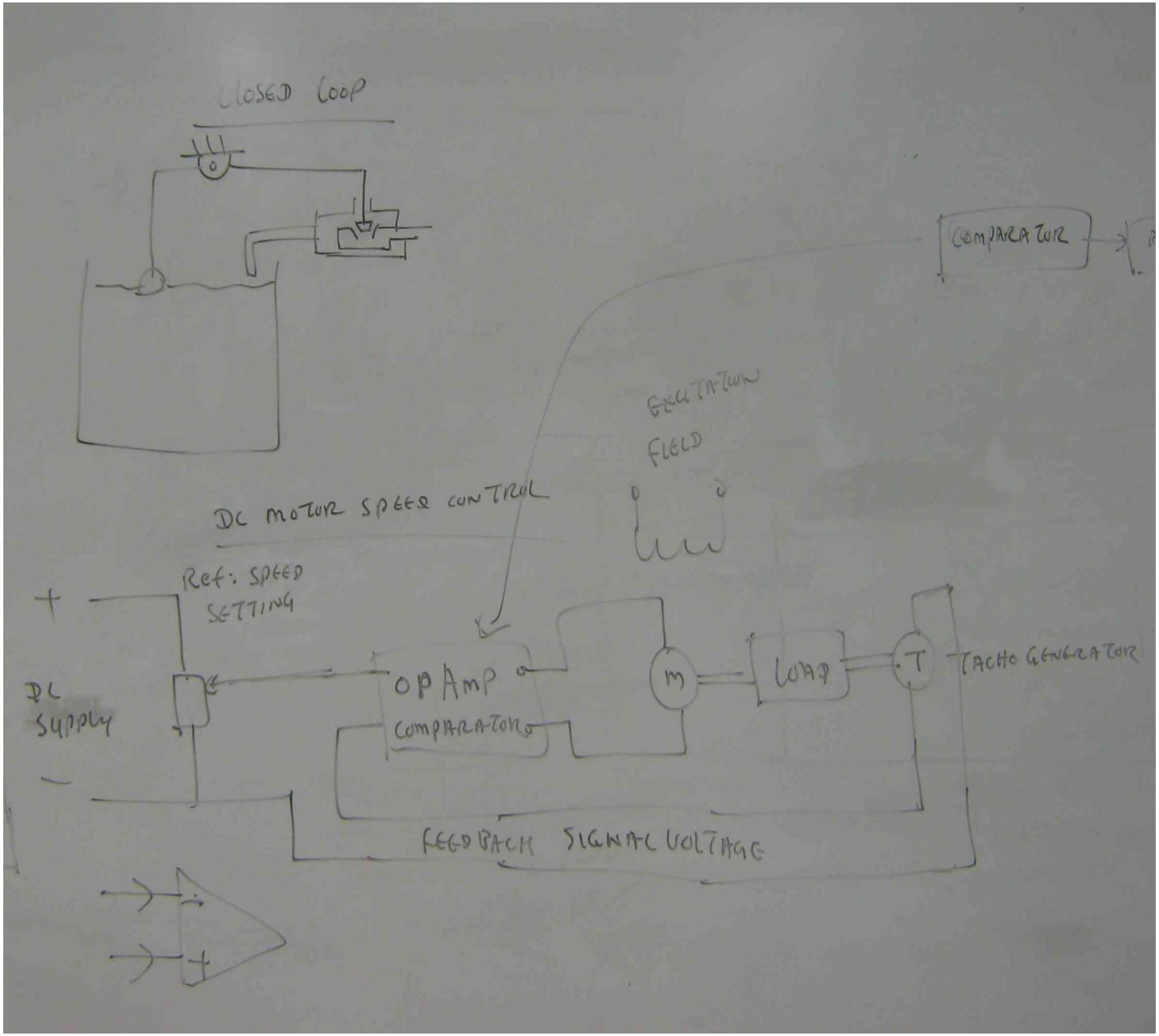
OPEN LOOP

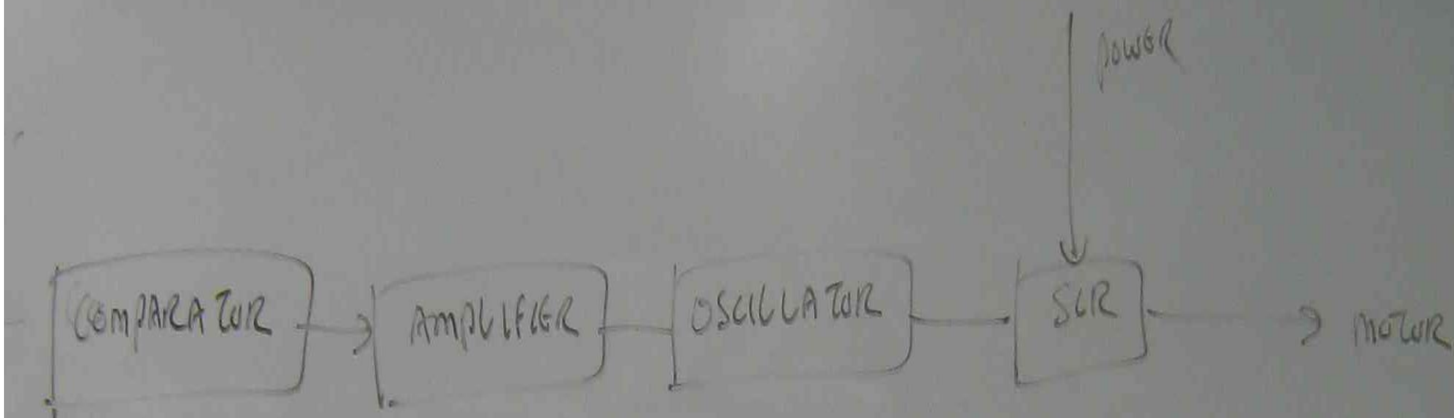
IT DOES NOT COMPARE THE ACTUAL RESULT AND DESIRED RESULT TO DETERMINE THE CONTROL ACTION



AUTOMATIC MOTOR STARTER




CLOSED LOOP
COMPARATOR
EXCITATION
FIELD
DC MOTOR SPEED CONTROL
Ref: SPEED
SETTING
+
DC
SUPPLY
−
OP AMP
COMPARATOR
M
LOAD
T
TACHO GENERATOR
FEEDBACK SIGNAL VOLTAGE
+



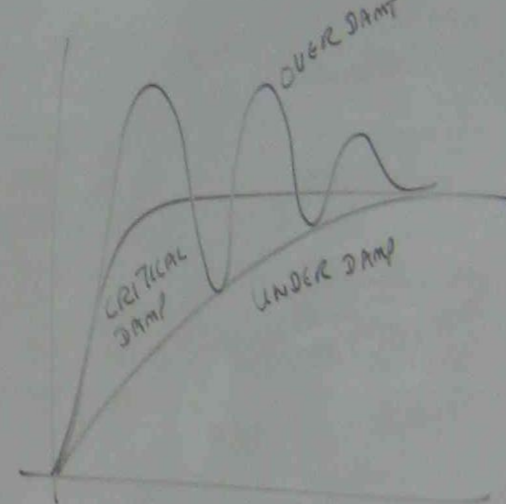
CLOSED LOOP CONTROL IS USED TO ENSURE THE CONTROL SYSTEM RESPONDS CORRECTLY TO CHANGES IN LOAD (DISTURBANCES) IN SUCH A WAY THAT OUTPUT PERFORMANCE DOES NOT VARY BEYOND CERTAIN PRE-DETERMINED LIMITS SET POINTS.

PROCESSING SECTION

IT CONTAINS THE CONTROL PLAN. IT CAN BE EITHER

- HARD WIRED
- PROGRAMMABLE

HARD WIRED	PROGRAMMABLE
RELAY	COMPUTER
DIGITAL ELECTRO STATIC LOGIC	MICRO COMPUTER
ANALOG ELECTRONIC	PLC
PNUEMATIC	
HYDRAULIC	



IT NEEDS TO ACHIEVE THE CRITICAL DAMP IN CONTROLLED FUNCTIONS.

TWO POSITIONS CONTROL

TWO POSITIONS CONTROL IS USED WHERE

(1) PRECISE CONTROL IS NOT REQUIRED

(2) PROCESS HAS A LARGE CAPACITY

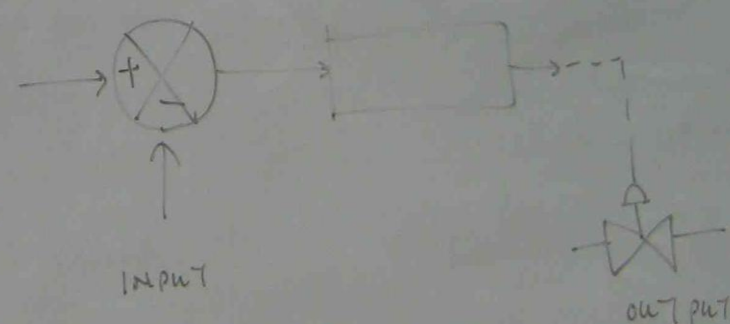
(3) ENERGY FLOW IS RELATIVELY SMALL COMPARED TO ENERGY WITH IN THE PROCESS

EXAMPLE

TEMPERATURE CONTROL
HEATING CONTROL
LEVEL CONTROL

PROPORTIONAL CONTROL

THIS CONTROL METHOD ALLOWS THE FINAL CONTROL ELEMENT TO BE POSITIONED WHICH IS DETERMINED BY THE RELATIONSHIP BETWEEN THE MEASURED VARIABLE SPEED AND THE OUT PUT



$$\text{GAIN} = \frac{\text{CHANGE IN OUTPUT}}{\text{CHANGE IN INPUT}}$$

OUTPUT = ERROR × CONTROLLER GAIN.

ACCURACY IN CONTROL SYSTEM

STABILITY

PROPORTIONAL + INTEGRAL CONTROL

(P + I)

ELIMINATE OFFSET

\+

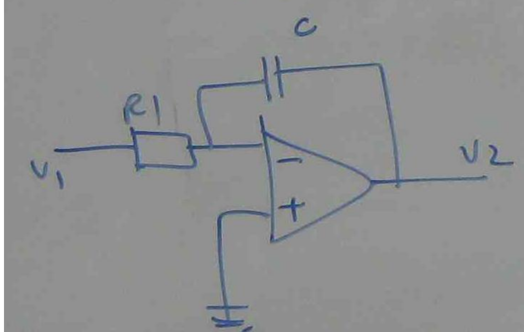
PROPORTIONAL + DERIVATIVE CONTROL

(P + D)

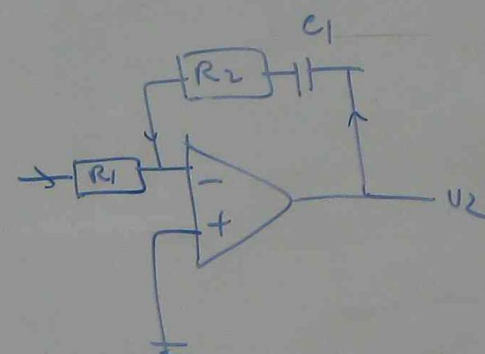
= PR

INTEGRAL CONTROL IS KNOWN AS RESET. THIS CONTROLLER RESETS PROPORTION VARIABLE TO SET POINT

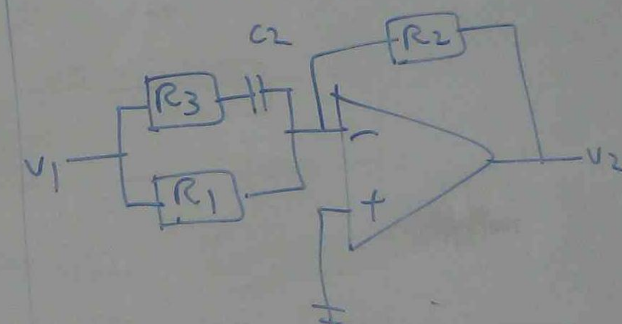
DERIVATIVE CONTROL (RATE) PROVIDES A CORRECTION PROPORTIONAL TO THE RATE OF CHANGE OF ERROR



INTEGRAL CONTROL



PROPORTIONAL + INTEGRAL CONTROL

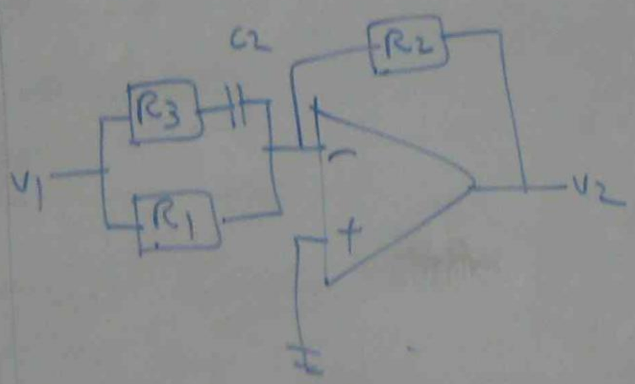


Tem

PROPORTIONAL + DERIVATIVE CONTROL

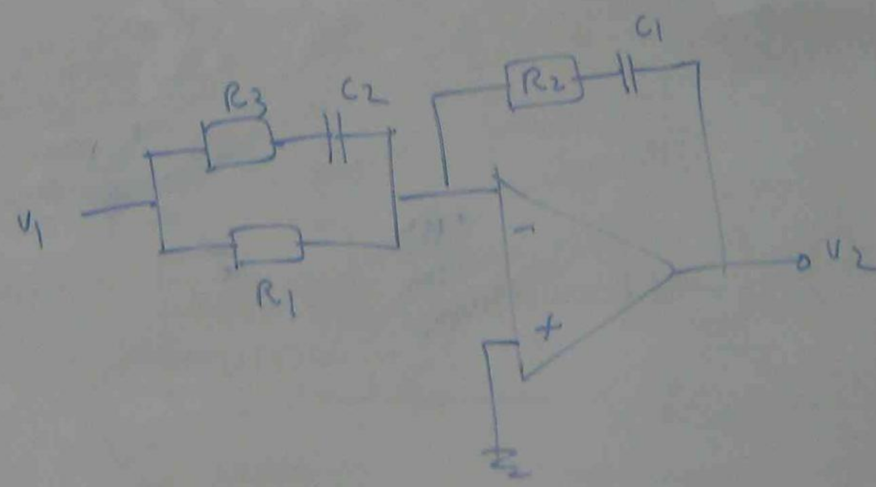
(P + D)

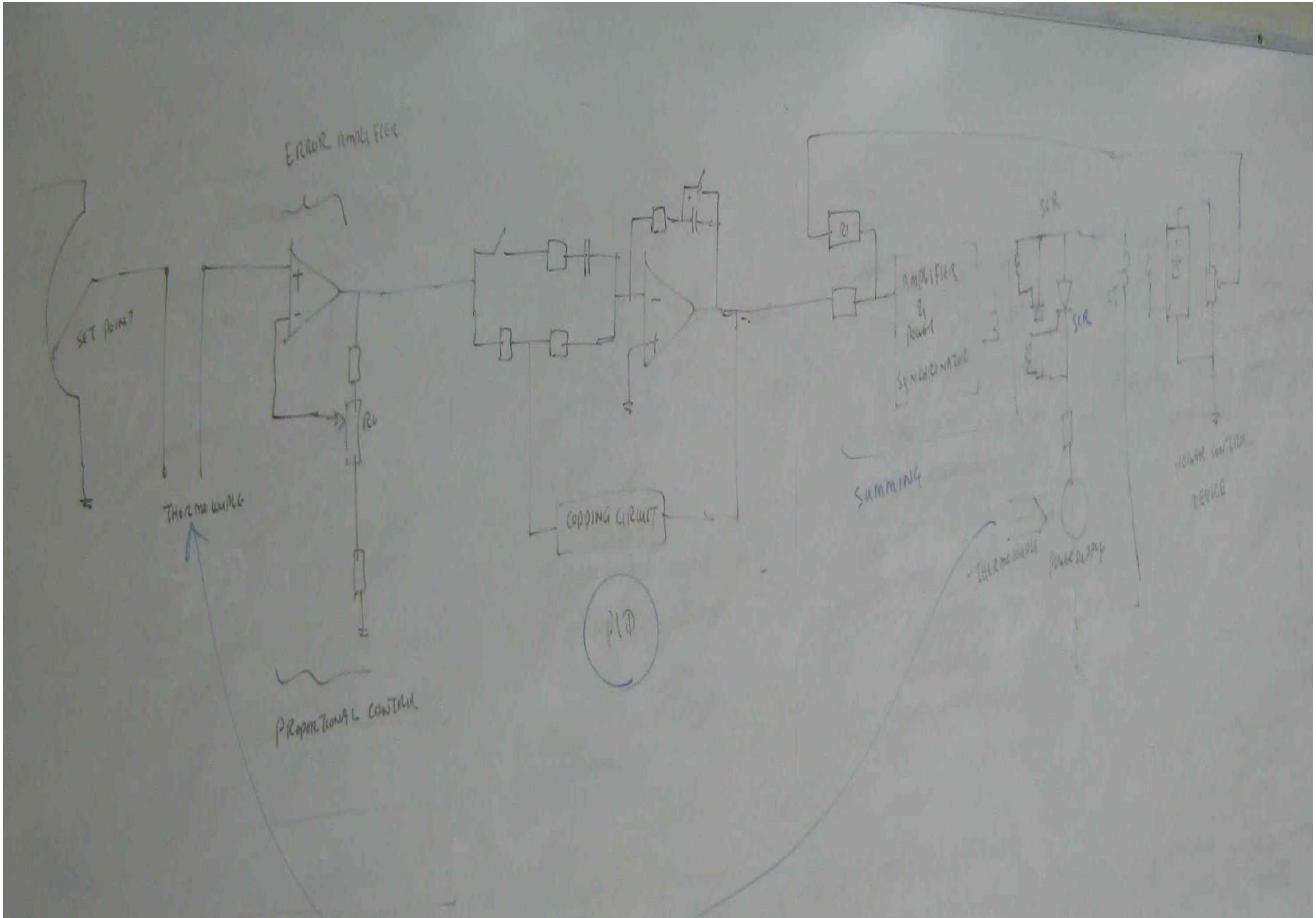
DERIVATIVE CONTROL (RATE) PROVIDES A CORRECTION PROPORTIONAL TO THE RATE OF CHANGE OF ERROR

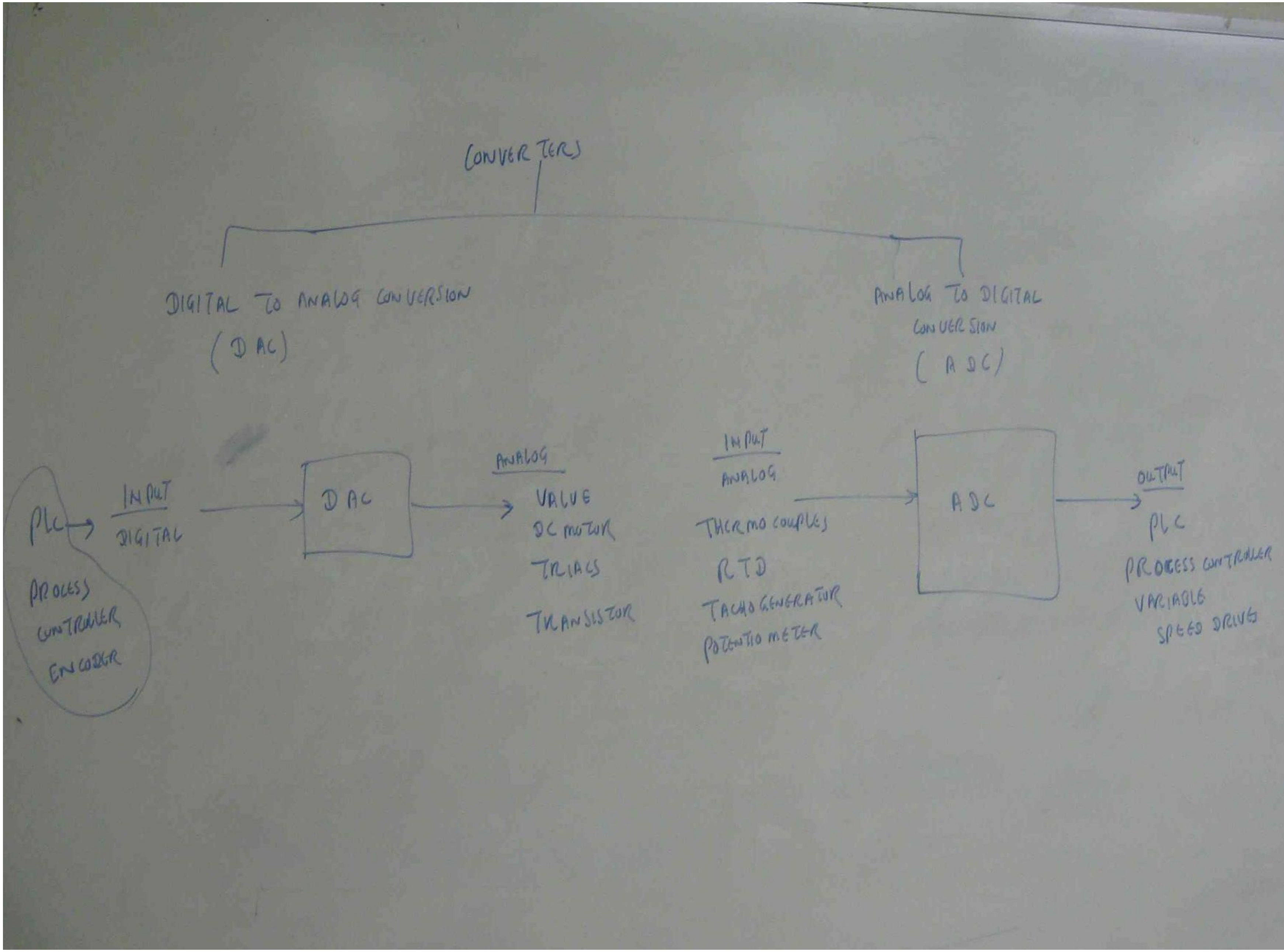


PROPORTIONAL + INTEGRAL + DERIVATIVE CONTROL (PID)

THIS IS USED ON PROCESSES WHERE SUDDEN LARGE LOAD CHANGES OCCUR AND ONE (OR) TWO MODE OF CONTROL IS NOT CAPABLE OF KEEPING ERROR WITH IN ACCEPTABLE LIMIT




ERROR AMPLIFIER
SET POINT
PROPORTIONAL CONTROL
PID
AMPLIFIER &
SUMMING
SCR
SCR
DEVICE

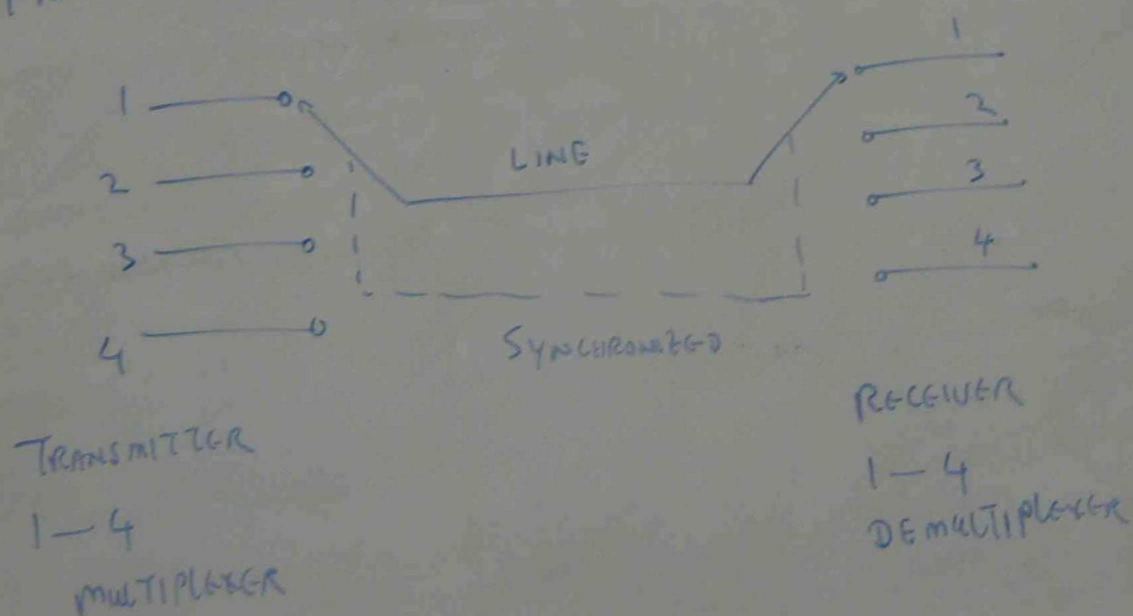

CONVERTERS
DIGITAL TO ANALOG CONVERSION
(DAC)
ANALOG TO DIGITAL
CONVERSION
(ADC)
PLC
PROCESS
CONTROLLER
ENCODER
INPUT
DIGITAL
DAC
ANALOG
VALUE
DC MOTOR
TRIACS
TRANSISTOR
INPUT
ANALOG
THERMOCOUPLES
RTD
TACHOGENERATOR
POTENTIOMETER
ADC
OUTPUT
PLC
PROCESS CONTROLLER
VARIABLE
SPEED DRIVE

MULTIPLEXING

MULTIPLEXING IS A METHOD USED FOR TRANSMITTING MORE THAN ONE SIGNAL THROUGH A SINGLE LINE SHARING TRANSMISSION FACILITIES.

TWO METHODS ARE COMMONLY USED THESE ARE

- TIME DIVISION (SHARING) MULTIPLEXING &
- FREQUENCY DIVISION (SHARING) MULTIPLEXING



POWER OP-AMPS

OP-AMPS ARE AVAILABLE FOR APPLICATIONS THAT REQUIRE AN EXTENSION OF ONE OR MORE ELECTRICAL PARAMETERS. THESE ICS ARE CATEGORIZED AS POWER OP-AMPS.

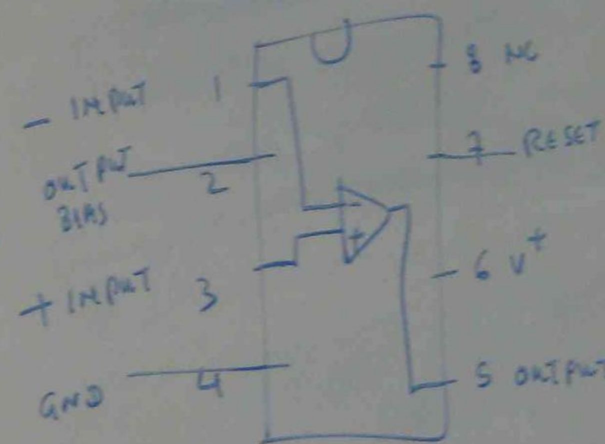
THEY POSSESS THE FOLLOWING CHARACTERISTICS

- HIGH OUTPUT CURRENT
- HIGH OUTPUT VOLTAGE
- HIGH OUTPUT POWER.

LM 13080 → SMALL POWER OP-AMP

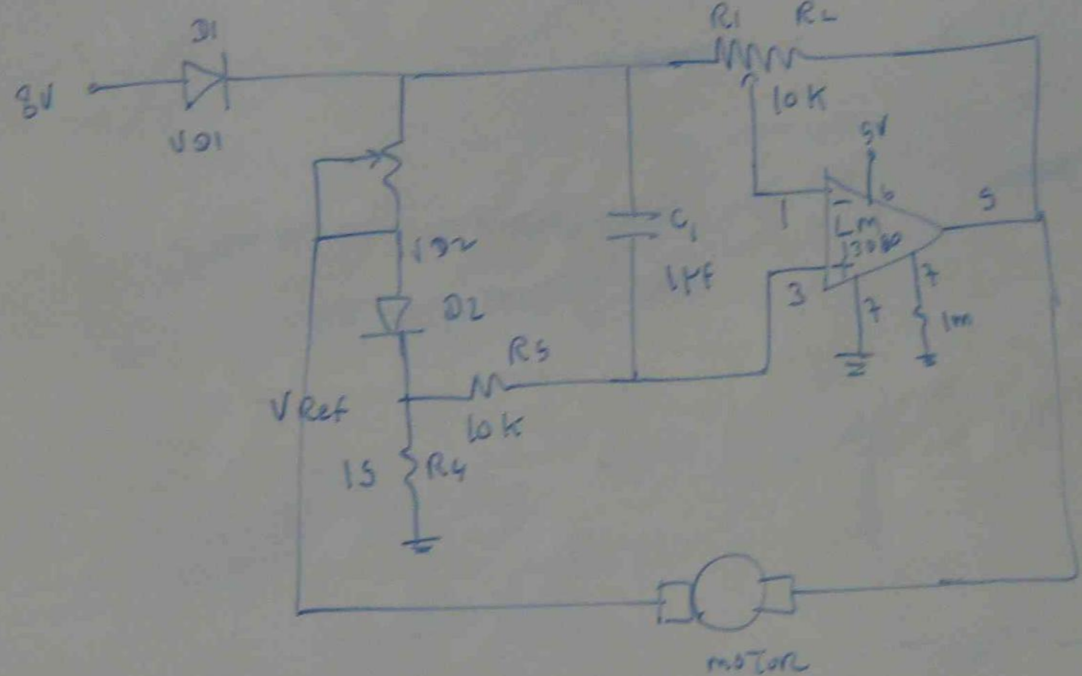
$\pm 3V \rightarrow \pm 15V$

1.25W



LM 13080
(NATIONAL SEMICONDUCTOR)

MOTOR SPEED CONTRAL



$$V_{motor} = \frac{R_2 \left(V_{D2} + I_3 R_3\right)}{R_1} + V_{D1}$$

$$V_{D_1} = V_{IN} - V_{Ref}$$

SIEMENS TCA 2365

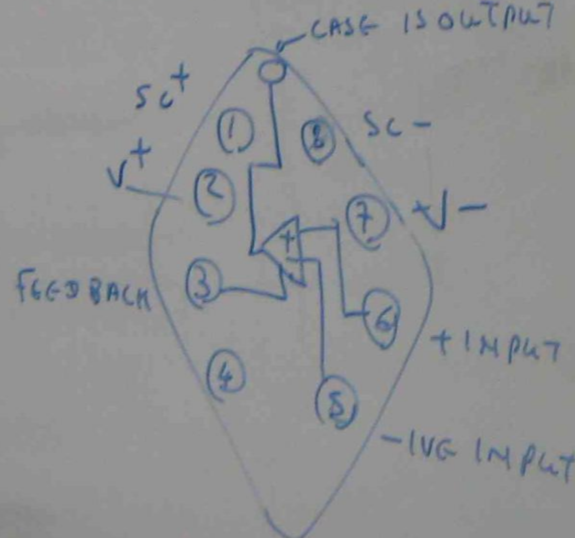
LM 384 , LM 2002 – 8W

5W

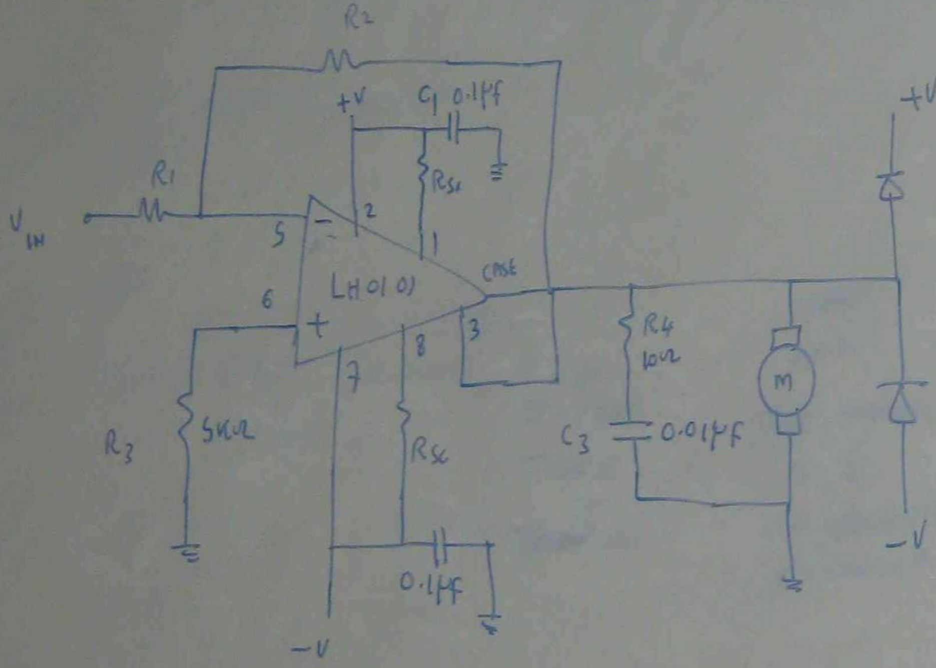
POWER OP-AMP – ENHANCED POWER

OP-AMPS CAN SUPPLY ± 40V, CAPABLE OF DISSIPATING 10 → 100W

LH 0101 POWER-OP-AMP → IT CAN DISSIPATE UP TO 60W WHEN MOUNTED ON HEAT SINK



LH0101 AS SERVO MOTOR AMPLIFIER



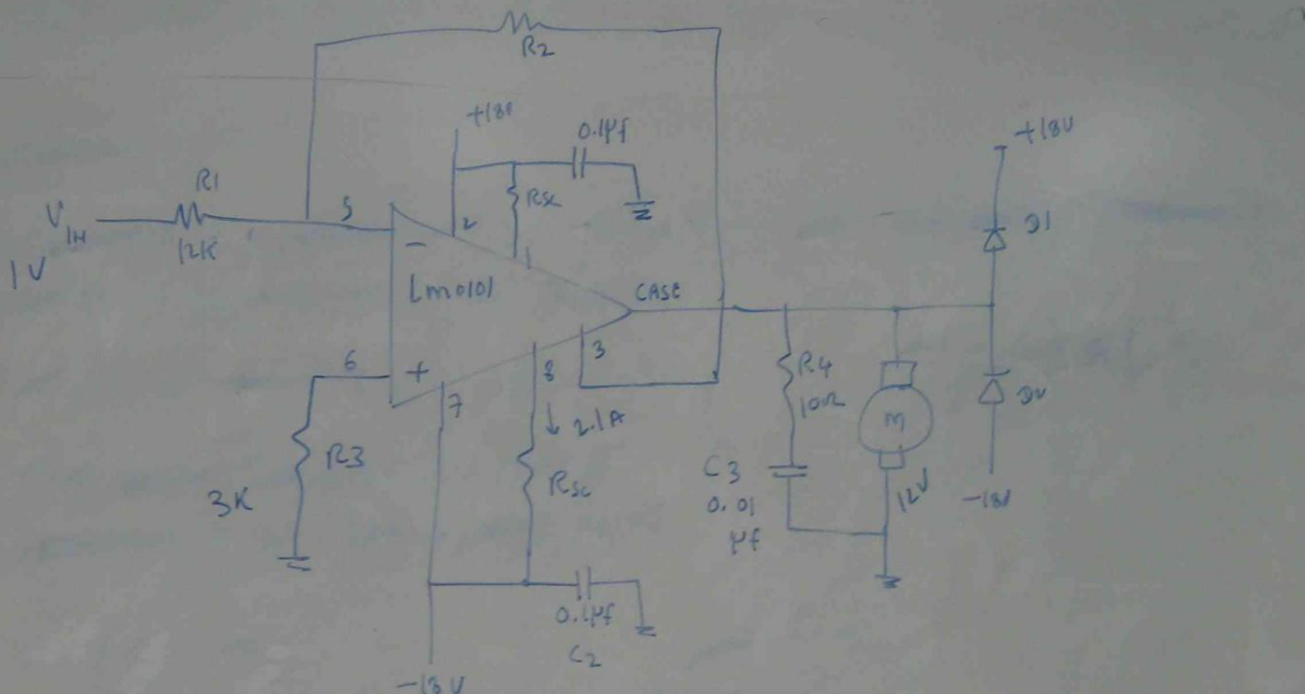
COMPENSATION

R_{SC} = SET CURRENT LIMIT

$$R_{SC} = \frac{0.6V}{I_L}$$

OP A541

$$R_{SC} = \frac{0.809}{I_{LM}} - 0.057$$



THE ABOVE CIRCUIT CONTROL THE SPEED OF SMALL DC MOTOR MOTOR HAS MAXIMUM RATING OF 12 V AT 2 A

(a) CALCULATE R_{SC} TO LIMIT THE CURRENT TO 2.1A

(b) DETERMINE THE VALUE OF R_2 IF INPUT VOLTAGE 1V IS TO CAUSE THE MOTOR TO RUN FULL SPEED

(c) CALCULATE TOTAL POWER DISSIPATED IN MOTOR AND POWER OP-AMP AT MAXIMUM RATING OF MOTOR

$$R_{sc} = \frac{0.6\,V}{I_L} = \frac{0.6 \times 18}{2.1} = 5.14\,\Omega$$

$V_{OUT} = 12V$

$V_{IN} = 1\,1V$

$$V_{OUT} = V_{IN}\left(1 + \frac{Rf}{R_1}\right)$$

$$12 = 1\left(1 + \frac{Rf = R_2}{12K}\right)$$

$$12 - 1 = \frac{R_2}{12}$$

$$11 = \frac{R_2}{12}$$

$R_2 = 11 \times 12 = 132\,k\Omega$

P_{OUT} = MOTOR POWER = $12 \times 2 = 24\,W$

$$A_V = \frac{V_{OUT}}{V_{IN}} = \frac{12}{1} = 12$$

$A_P = A_V \times A_I$

$= 12 \times 1$

$= 12$

$$P_{IN} = \frac{P_{OUT}}{A_P} = \frac{24}{12} = 2\,W$$

P_{OUT} = MOTOR POWER = $12 \times 2 = 24\,W$

$P_{SC} = \frac{V^2}{R_{SC}} = \frac{18^2}{5.14} = 63\,W$ #

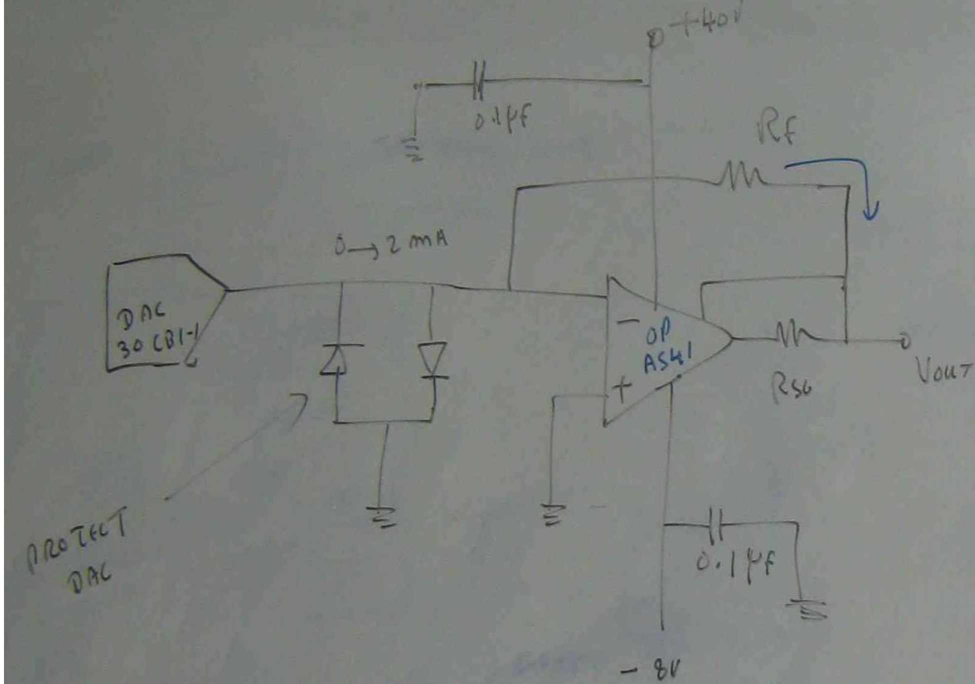
$A_V = \frac{V_{OUT}}{V_{IN}} = \frac{12}{1} = 12$

$A_P = A_V \times A_I$

$= 12 \times 1$

$= 12$

$P_{IN} = \frac{P_{OUT}}{A_P} = \frac{24}{12} = 2\,W$



THE ABOVE CIRCUIT IS DIGITALLY CONTROLLED POWER SUPPLY

OUT PUT CURRENT FROM DAC IS 0 → 2 mA

(a) CALCULATE R_F TO GET 30V OUT PUT

(b) FIND R_{SC} TO LIMIT CURRENT 4 A

(a) $R_f \times 2mA = 30V$

$$R_f = \frac{30}{2mA} = 15\,k\Omega$$

(b)

$$R_{sc} = \frac{0.809}{I_{Lim}} - 0.057$$

$$= \frac{0.809}{4} - 0.057$$

$$= 0.2025 - 0.057$$

$$= 0.1455\ \Omega$$