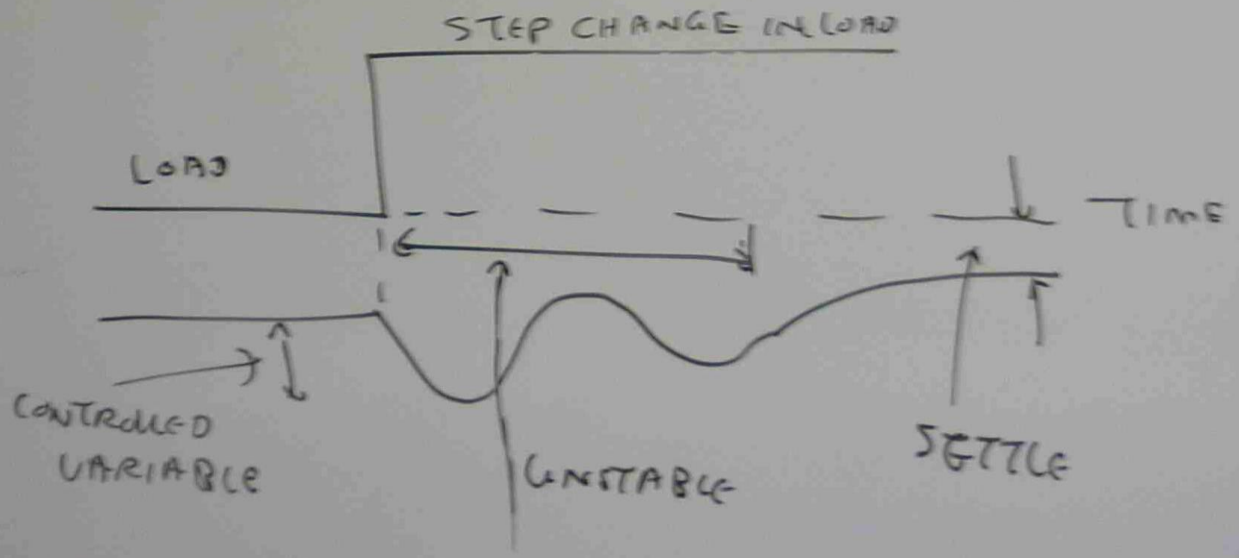
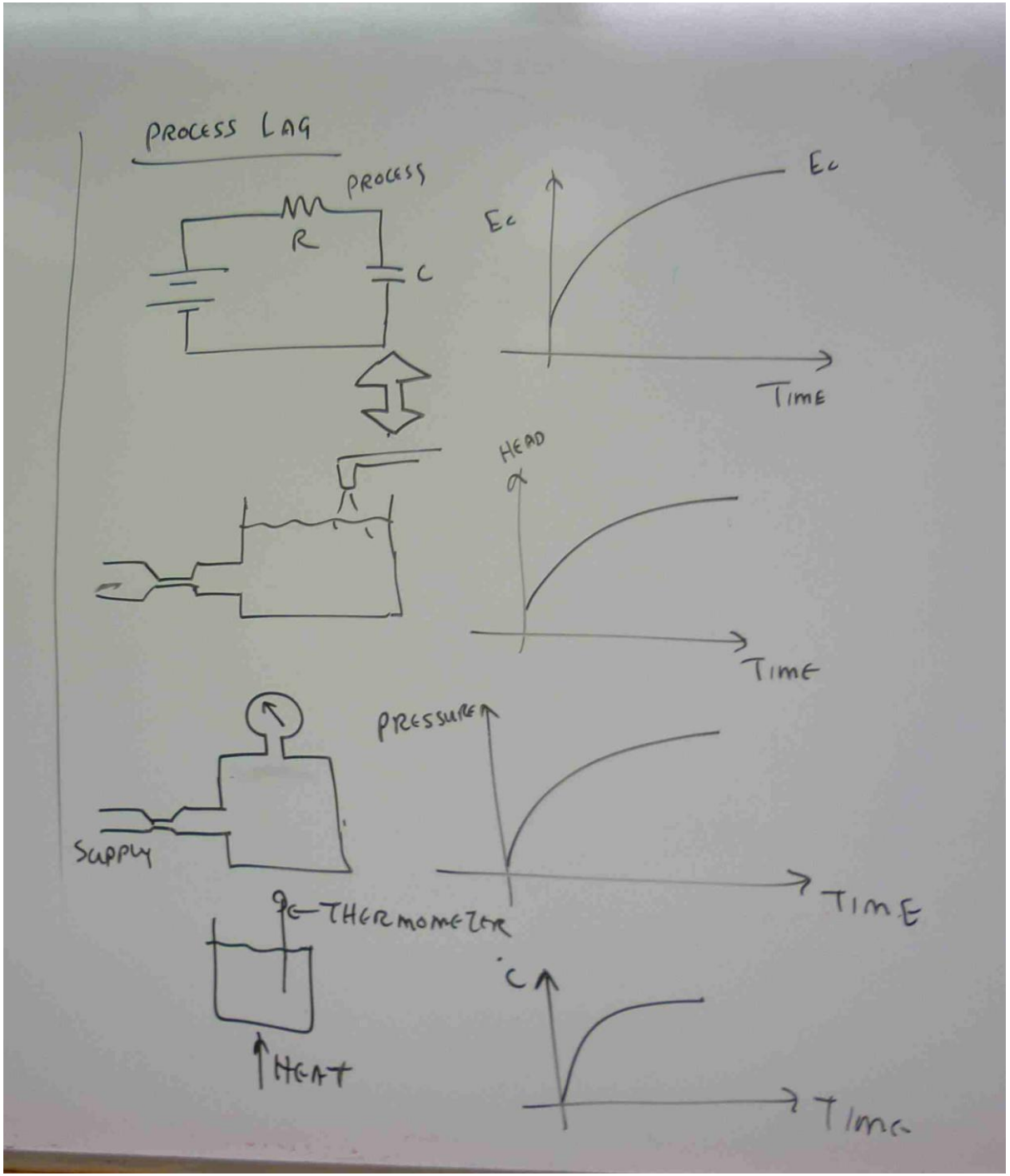
CONTROL SYSTEM EVALUATION

A CONTROL SYSTEM MUST BALANCE THE ENERGY GAINED BY THE PROCESS AGAINST THE ENERGY LOST BY THE PROCESS IN ORDER TO MAINTAIN THE DESIRED VALUE OF THE CONTROLLED VARIABLE.

AFTER A LOAD CHANGE (OR) SET POINT CHANGE, THE CONTROL SYSTEM SHOULD

(1) MINIMISE THE MAXIMUM VALUE OF THE ERROR
(2) MINIMISE THE SETTLING TIME
(3) MINIMISE THE RESIDUAL ERROR.



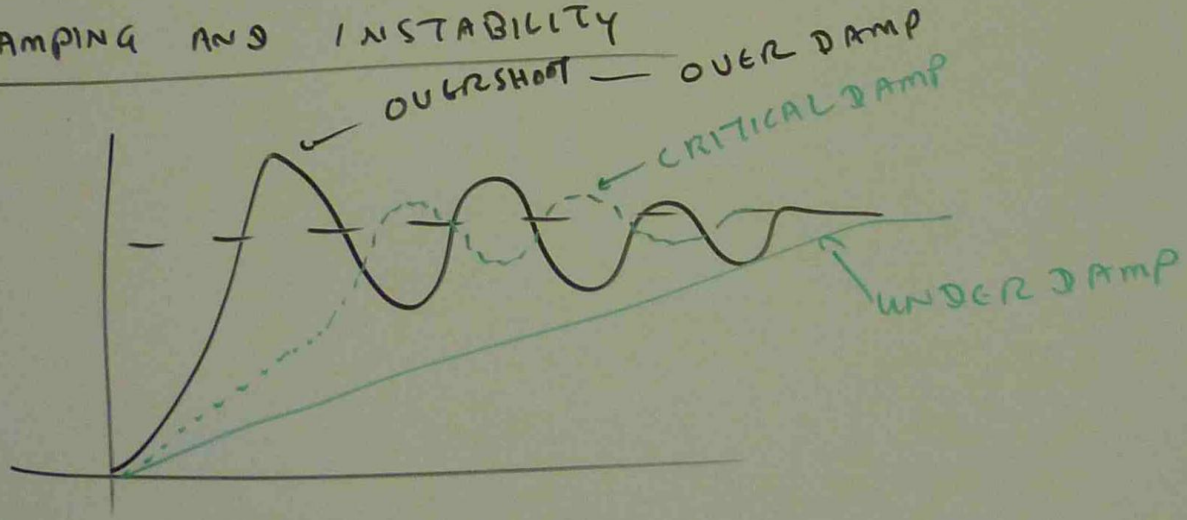

PROCESS LAG
PROCESS
R
C
Ec
Ec
TIME
HEAD
TIME
SUPPLY
PRESSURE
TIME
THERMOMETER
HEAT
°C
TIME

ELECTRICAL, HYDRAULIC, PNUEMATIC AND THERMAL HAVE IDENTICAL RESPONSE CHARACTERISTICS (EXPONENTIAL CURVE).

PROCESS CAPACITY AND RESISTANCE

INERTIA – THE RELUCTANCE OF A SYSTEM TO CHANGE ITS STATE OR ITS TENDENCY TO PERSIST IN ITS PRESENT STATE.

DAMPING AND INSTABILITY



TWO POSITION CONTROL

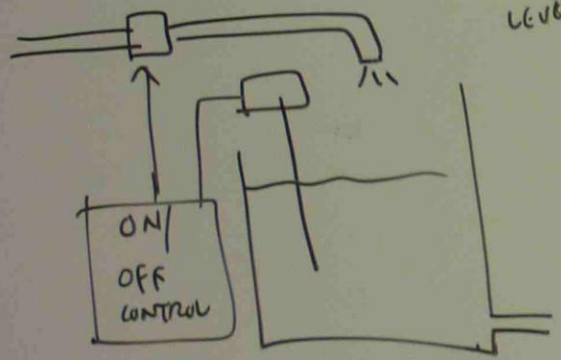
TWO POSITION CONTROL IS USED WHERE

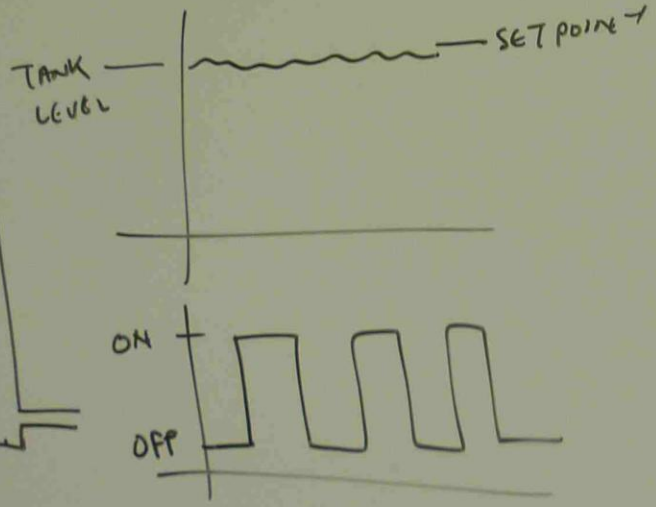
- PRECISE CONTROL IS NOT REQUIRED
- PROCESS HAS A LARGE CAPACITY
- ENERGY IN FLOW IS RELATIVELY SMALL COMPARED TO ENERGY WITHIN THE PROCESS.

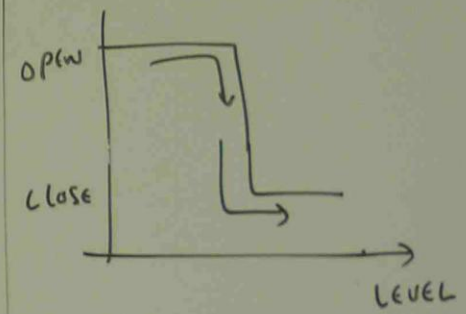
LEVEL CONTROL

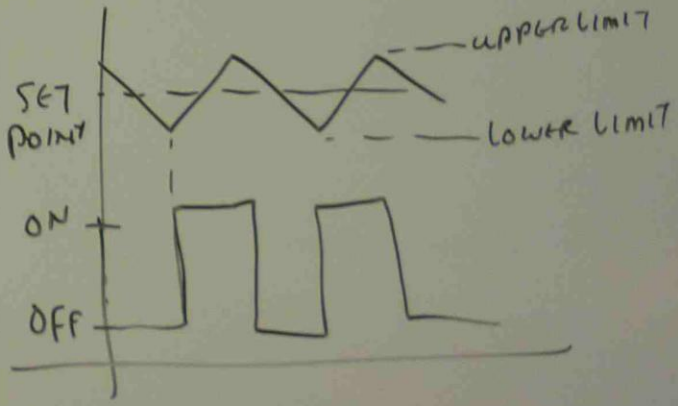
- DIFFERENTIAL GAP CONTROL
  - UPPER LIMIT
  - LOWER LIMIT

LEVEL CONTROL



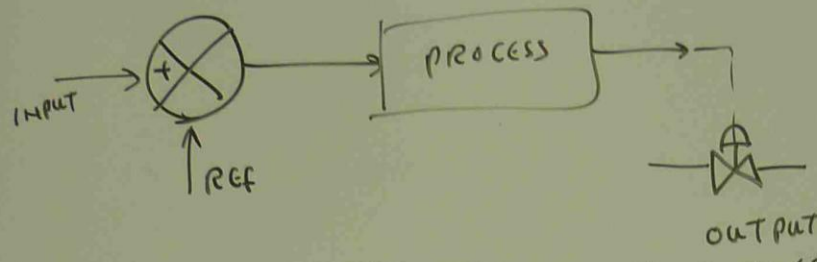






PRECISE CONTROL / PROPORTIONAL CONTROL

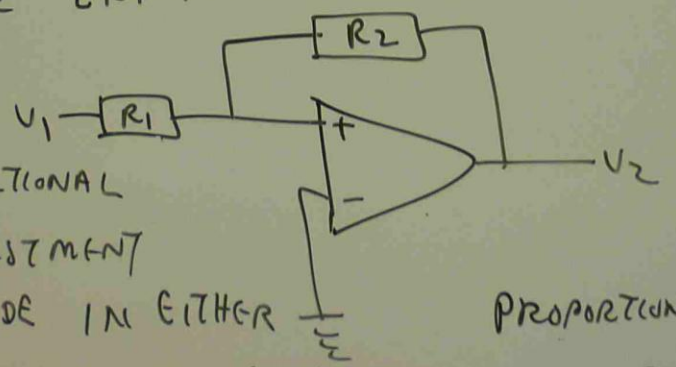
PROVIDE A CORRECTION PROPORTIONAL TO THE SIZE (MAGNITUDE) OF THE ERROR.

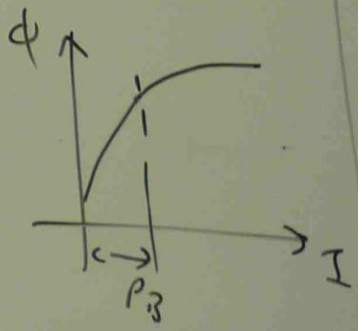


PROPORTIONAL CONTROL THE AMOUNT OF POWER DELIVERED TO THE PROCESS AND THIS WILL REDUCE AS THE ERROR IS REDUCED

$$\text{GAIN} = \frac{\text{CHANGE IN OUTPUT}}{\text{CHANGE IN INPUT}} = \frac{\text{O/P}}{\text{I/P}}$$

OUTPUT = ERROR × CONTROLLER GAIN





THE PROPORTIONAL GAIN ADJUSTMENT CAN BE MADE IN EITHER PROPORTIONAL CONTROL

(a) GAIN (K_p) ADJUST R_2 (b) % PROPORTIONAL BAND (PB)

$$GAIN = \frac{100}{\%.PB}$$

$$\%.PB = \frac{100}{GAIN}$$

Ex ① $\%.PB = 66.67\%$, CALCULATE GAIN

Ex ② $\%.PB = 200\%$ CALCULATE GAIN

Ex ③ $GAIN = 1$ CALCULATE $\%.PB$

Ex ④ $GAIN = 0.75$ CALCULATE $\%.PB$

Ex ①

$$GAIN = \frac{100}{\%.PB}$$

$$= \frac{100}{66.67}$$

$$= 1.5$$

Ex ②

$$GAIN = \frac{100}{\%.PB}$$

$$= \frac{100}{200}$$

$$= 0.5$$

Ex ③

$$\%.PB = \frac{100}{GAIN}$$

$$= \frac{100}{1}$$

$$= 100\%$$

Ex ④

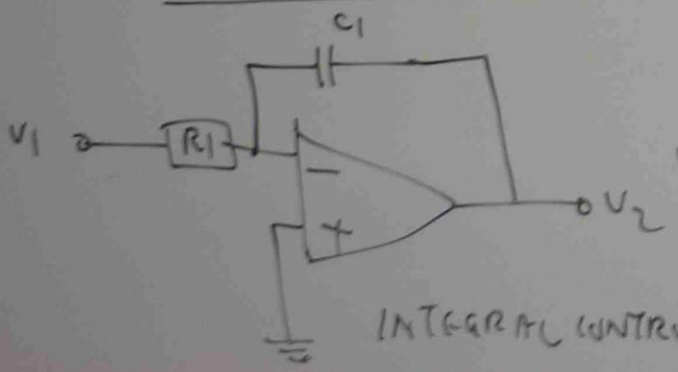
$$\%.PB = \frac{100}{0.75}$$

$$= 133$$

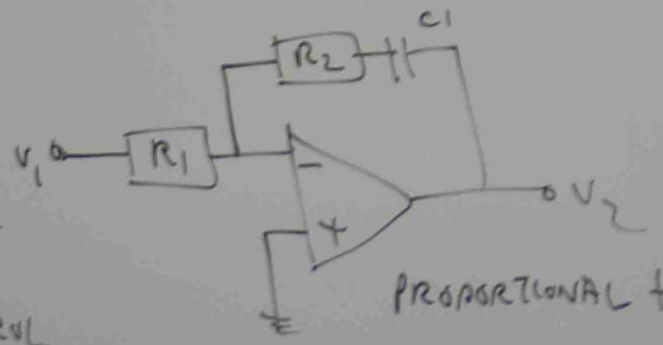
PROPORTIONAL + INTEGRAL CONTROL (P+I)

- INTEGRAL CONTROL IS RARELY USED BY ITSELF. IT IS USED WITH PROPORTIONAL CONTROL
- INTEGRAL CONTROL IS ALSO KNOWN AS RESET.
- INTEGRAL ACTION PROVIDES A CORRECTION PROPORTIONAL TO THE MAGNITUDE AND TIME DURATION OF ERROR.
- INTEGRAL ACTION ELIMINATES OFFSET DUE TO LOAD CHANGES WHICH WILL OCCUR WITH PROPORTIONAL CONTROL.

OP-AMP CIRCUIT SHOWING INTEGRAL CONTROL AND PROPORTIONAL + INTEGRAL CONTROL



INTEGRAL CONTROL



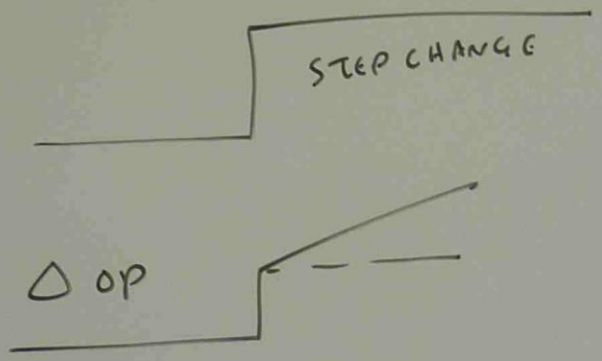
PROPORTIONAL + INTEGRAL CONTROL

CALIBRATION

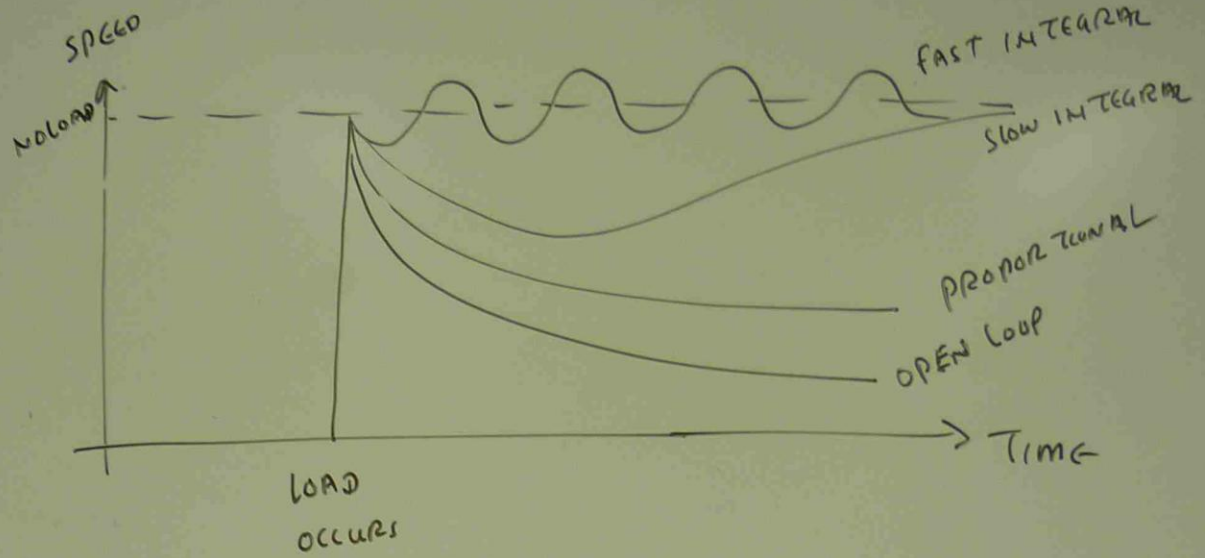
CALIBRATE IN (1) INTEGRAL TIME (SECONDS / REPEAT)
(2) REPEAT PER SECOND.

INTEGRAL TIME (T_i)

TIME TAKEN FOR INTEGRAL ACTION TO REPEAT THE CHANGE DUE TO PROPORTIONAL ACTION



TOTAL CHANGE IN OUTPUT = CHANGE DUE TO PROPORTIONAL + CHANGE DUE TO INTEGRAL PROPORTION.



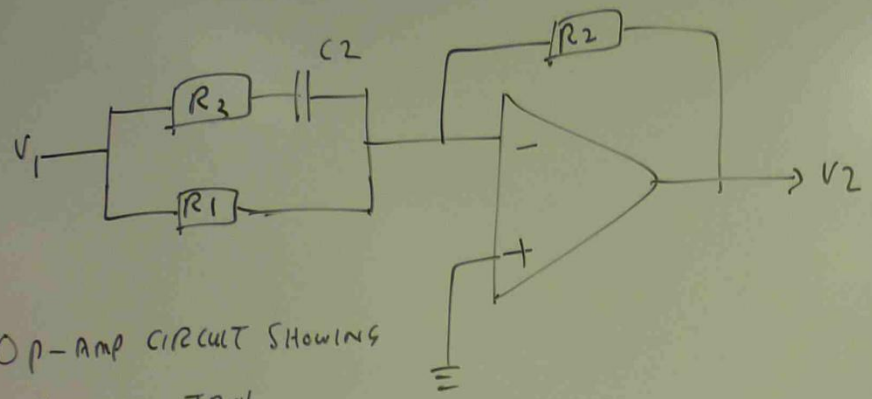
PROPORTIONAL + DERIVATIVE CONTROL (P+D)

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

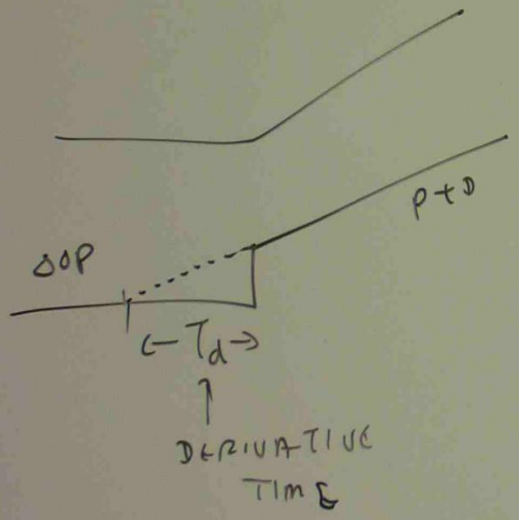
APPLICATION — TEMPERATURE CONTROL, HYDRAULIC PRESSURE, TURBULENT LEVEL CONTROL.

PURPOSE OF DERIVATIVE ACTION — TO SPEED UP THE RESPONSE TIME

TO REDUCE OVERSHOOTS.

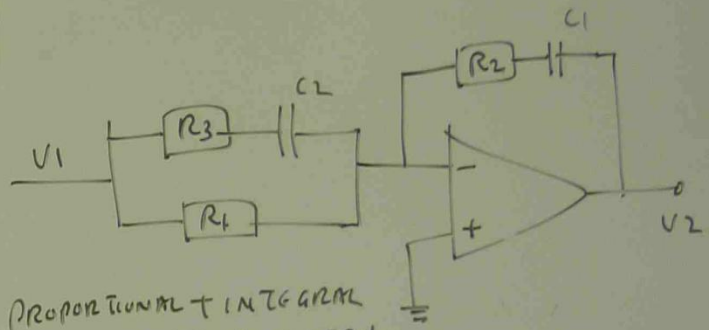


OP-AMP CIRCUIT SHOWING P+D CONTROL



PROPORTIONAL + INTEGRAL + DERIVATIVE CONTROL (PID)

RESET FUNCTION (INTEGRAL) IS COMBINED WITH PROPORTIONAL + DERIVATIVE CONTROL FUNCTION



PROPORTIONAL + INTEGRAL + DERIVATIVE CONTROL

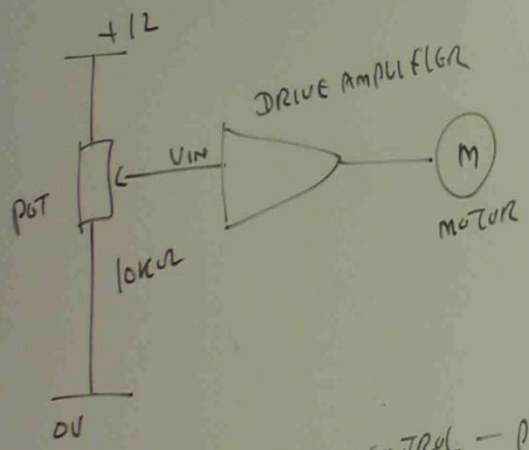
THIS USED ON PROCESS WHERE SUDDEN LARGE LOAD OCCUR AND ONE OR TWO MODE OF CONTROL IS NOT CAPABLE OF KEEPING ERROR WITHIN ACCEPTABLE LIMIT

PROPORTIONAL CONTROL - USE FOR STABILITY

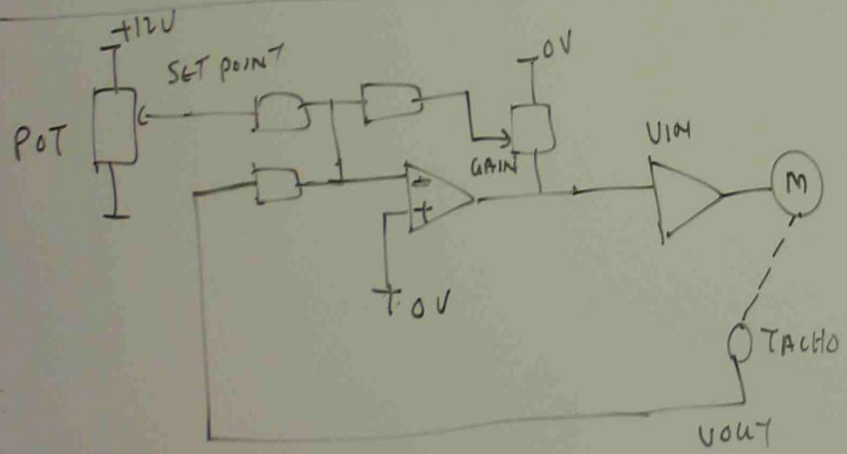
INTEGRAL CONTROL - TO ELIMINATE OFFSET

DERIVATIVE CONTROL - TO OVER COME TIME LAG.

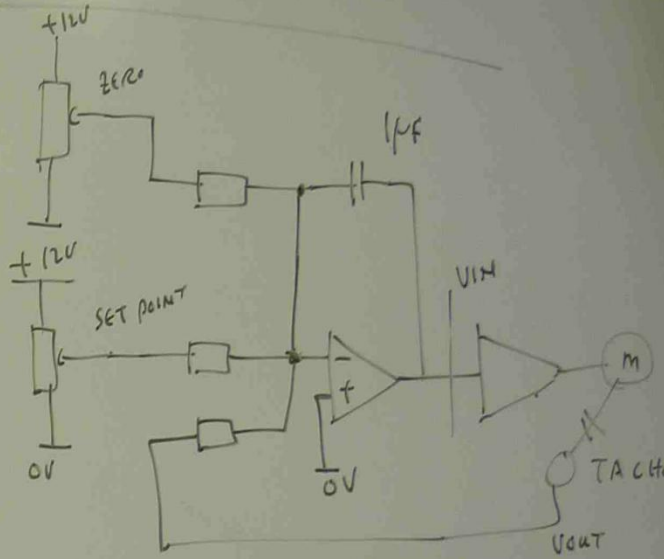
OPEN LOOP CONTROL



CLOSED LOOP SPEED CONTROL – PROPORTIONAL CONTROL

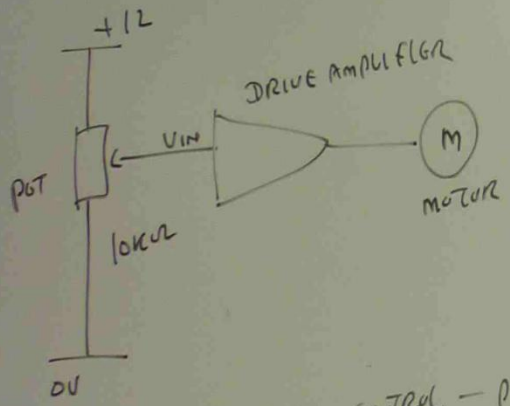


CLOSED LOOP SPEED CONTROL – INTEGRAL CONTROL

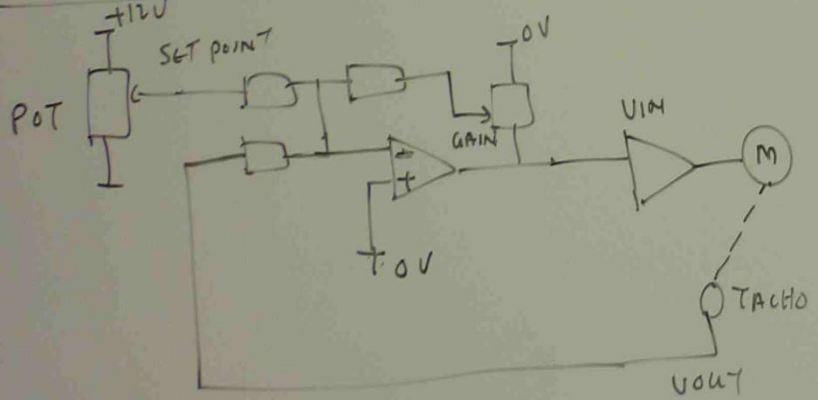


RESET TO RESET THE CIRCUIT, PUT THE OUT PUT TO ZERO VOLT, SHORT OUT THE RESET CAPACITOR MOMENTARILY.

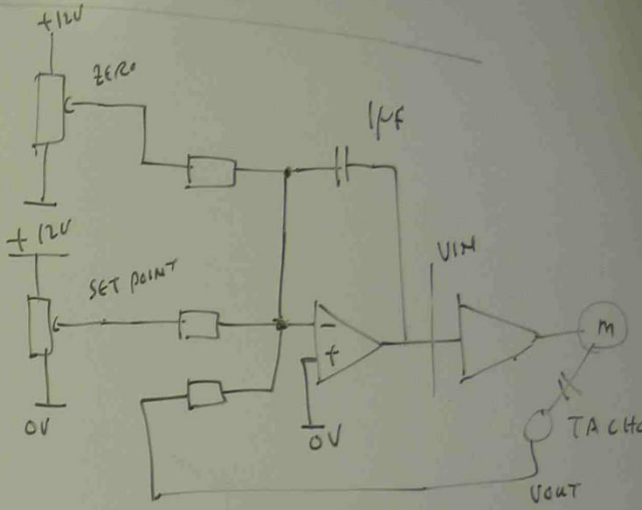
OPEN LOOP CONTROL



CLOSED LOOP SPEED CONTROL – PROPORTIONAL CONTROL

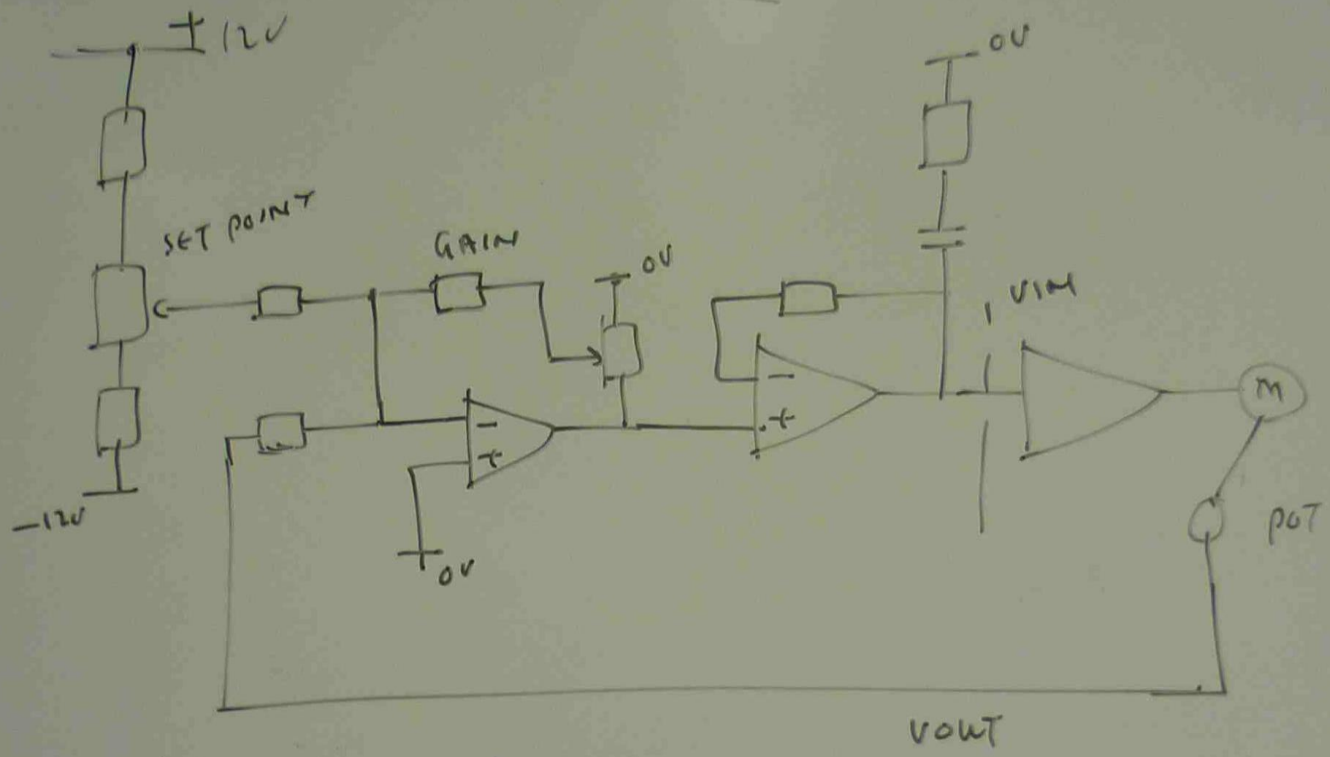


CLOSED LOOP SPEED CONTROL – INTEGRAL CONTROL



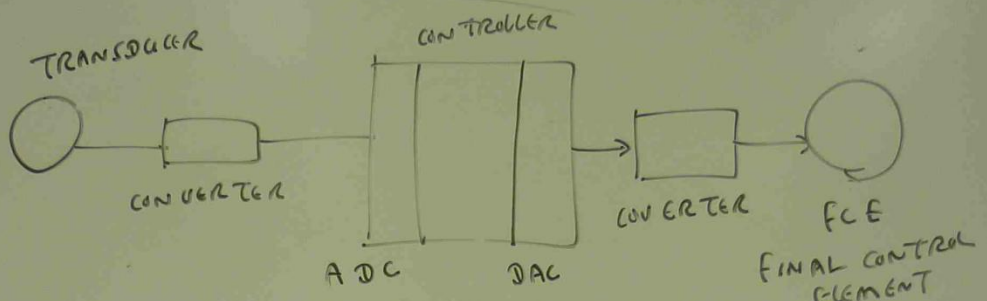
RESET TO RESET THE CIRCUIT, PUT THE OUT PUT TO ZERO VOLT, SHORT OUT THE RESET CAPACITOR MOMENTARILY.

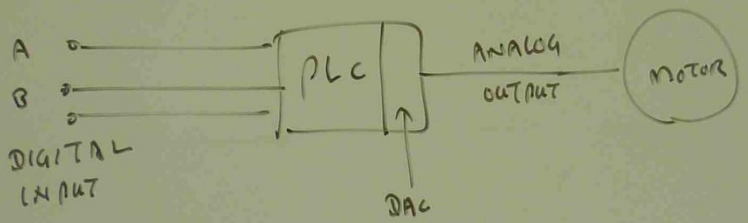
PROPORTIONAL + DERIVATIVE CONTROL

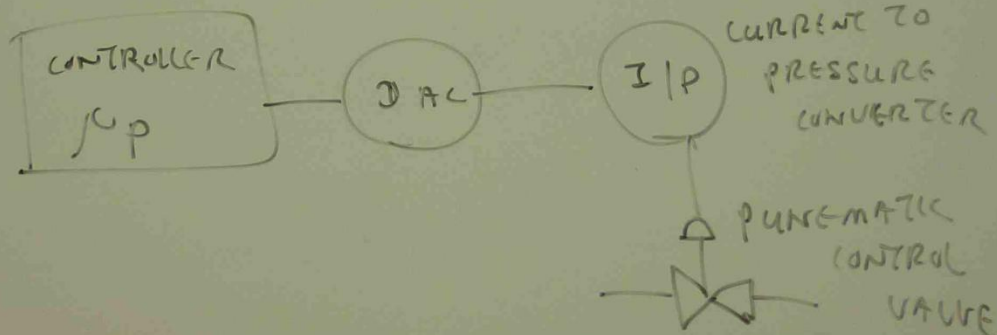


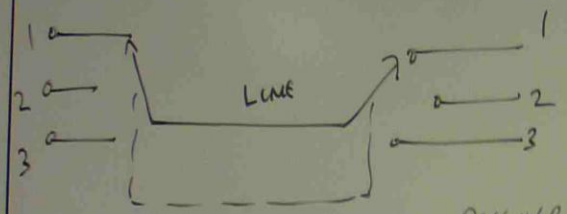
※ HIGHER RATE OF CHANGE ROTATE MORE ANGLE ON POTENTIO METER.

CONTROL LOOP CONDITIONING



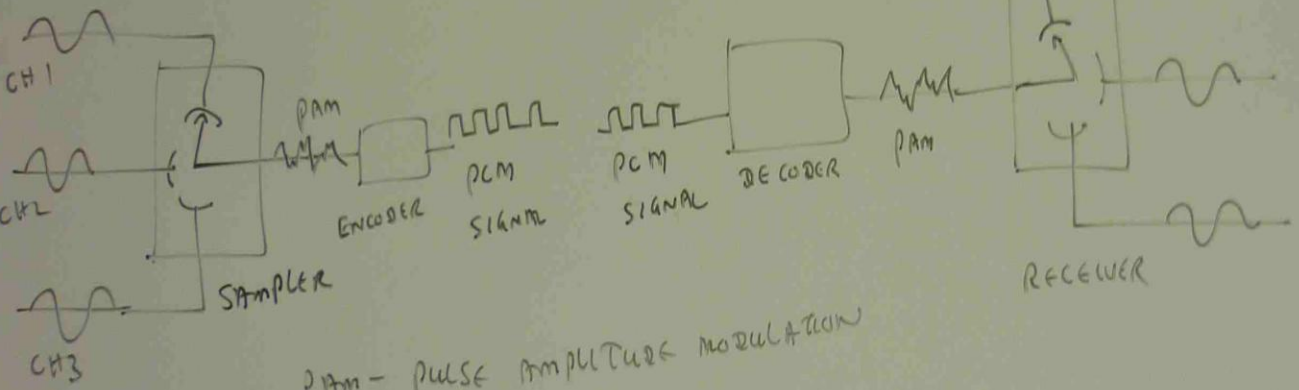






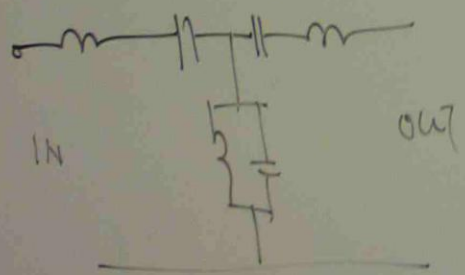
TRANSMITTER SYNCHRONIZED MULTIPLEXER

RECEIVER MULTIPLEXER

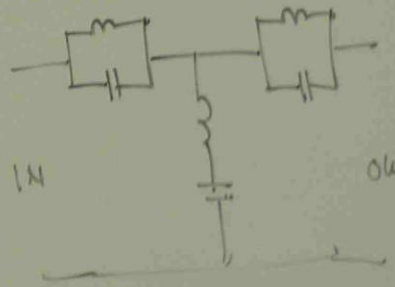


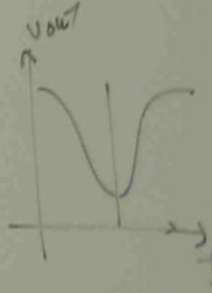
PAM - PULSE AMPLITUDE MODULATION

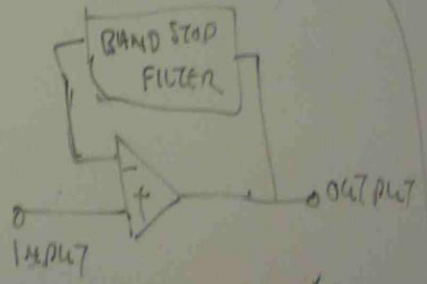
PCM - PULSE CODE MODULATION



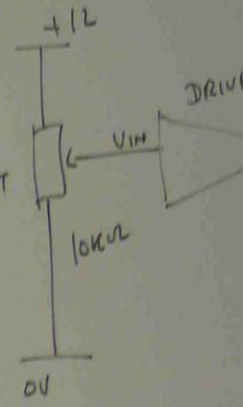
BAND PASS FILTER



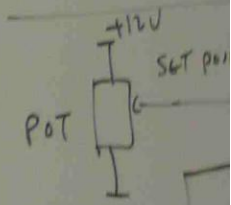




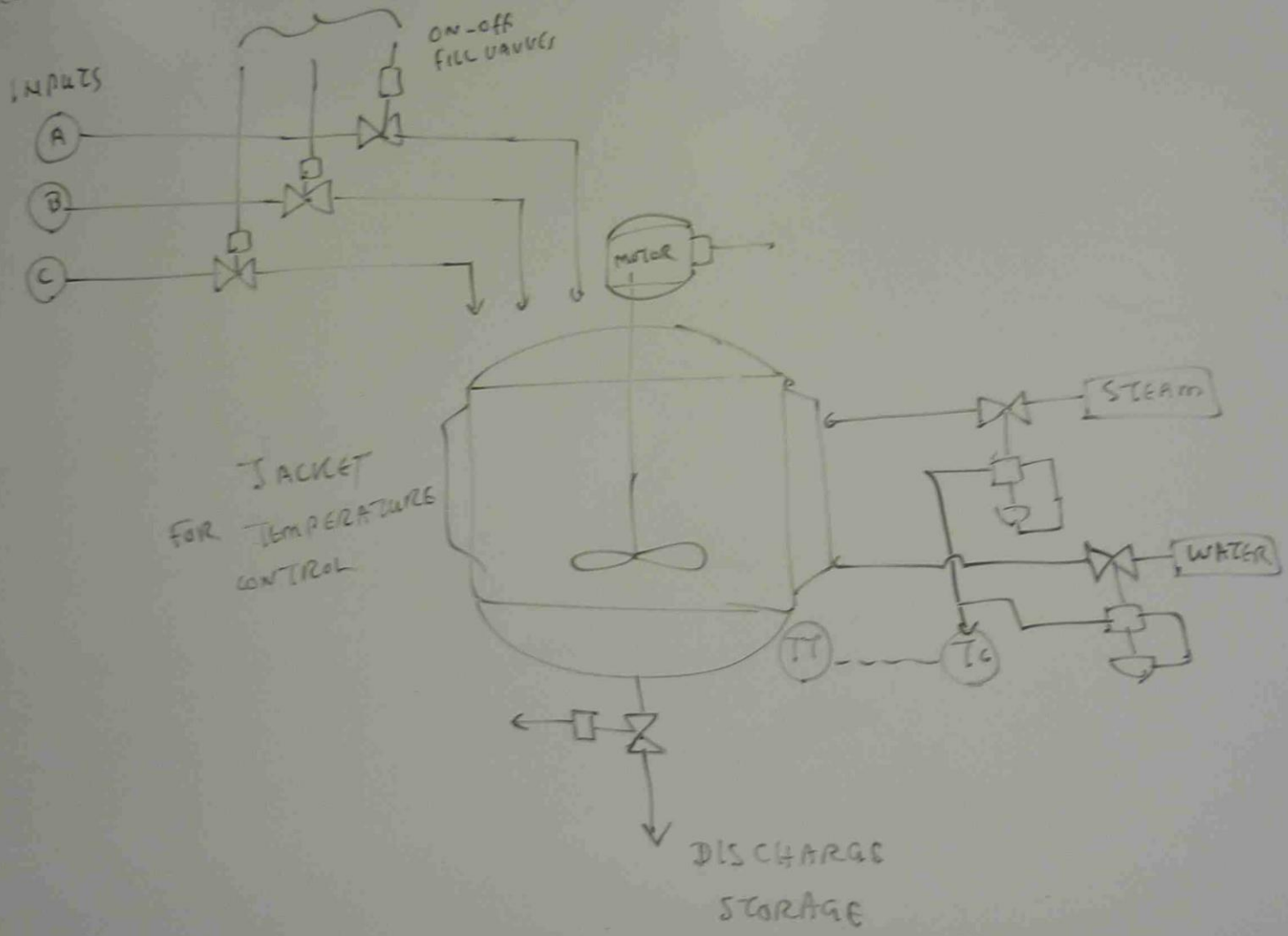
OPEN LOOP CONTROL



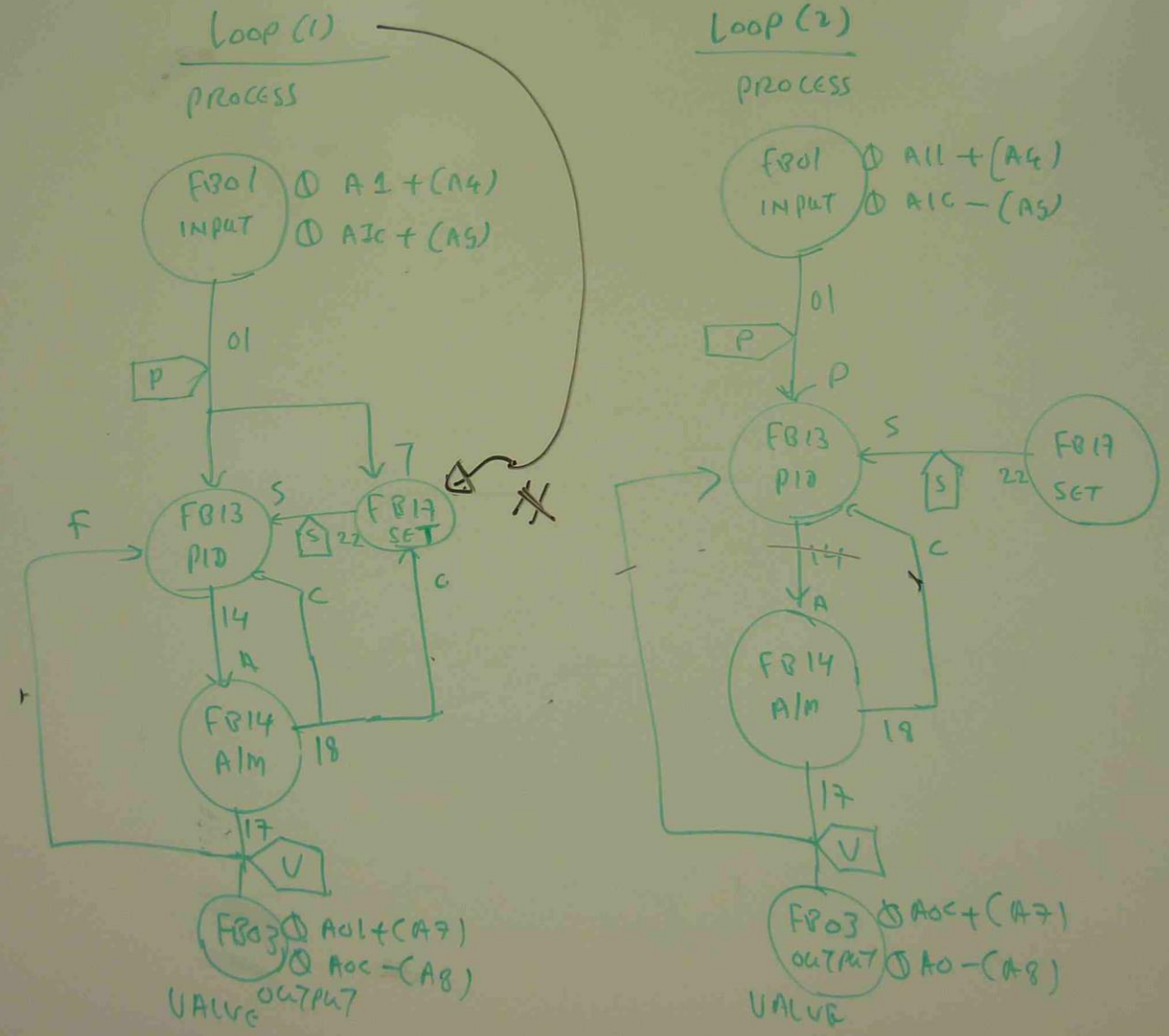
CLOSED LOOP SP



6 SKETCH A DIAGRAM WHICH INCLUDES BOTH BATCH CONTROL AND CONTINUOUS CONTROL



Q — COMPARE THE CONTROLLER CONFIGURATION DIAGRAMS SHOWN BELOW AND ANSWER THE FOLLOWING QUESTIONS



(a) IDENTIFY INPUT TERMINALS.

(b) IDENTIFY OUTPUT TERMINAL

(c) IDENTIFY CONTROLLER FUNCTION BLOCK

(d) IDENTIFY AUTO / A|M MANUAL FUNCTION BLOCK

(e) STATE THE PURPOSE OF [P] AND [V]

(f) IDENTIFY THE SET POINT FUNCTION BLOCK

(g) STATE THE DIFFERENCE BETWEEN LOOP 1 & 2

(a) AG , AS

(b) A7 , A8

(c) FB 13

(d) FB 14

(e) P - PROCESS VARIABLE
V - OUTPUT SIGNAL TO VALVE

(f) F B 17

(g) LOOP (1) HAS TRACKING SET POINT

REVIEW QUESTION

(1) (a) EXPLAIN THE BATCH PROCESS

(b) SKETCH A BASIC DIAGRAM REPRESENTING A TYPICAL BATCH PROCESS SYSTEM AND BRIEFLY OUTLINE ITS OPERATION.

A BATCH PROCESS MANUFACTURES A PRODUCT IN BATCHES (DISCRETE AMOUNT) RATHER THAN CONTINUOUSLY. THE REQUIRED INGREDIENTS ARE FED INTO THE PROCESS VESSEL IN THE REQUIRED AMOUNT AND IN RIGHT SEQUENCE. THE VESSEL IS THEN STIRRED / HEATED / PRESSURISED IN AN APPROPRIATE SEQUENCE IN ORDER TO PRODUCE THE DESIRED PRODUCT.