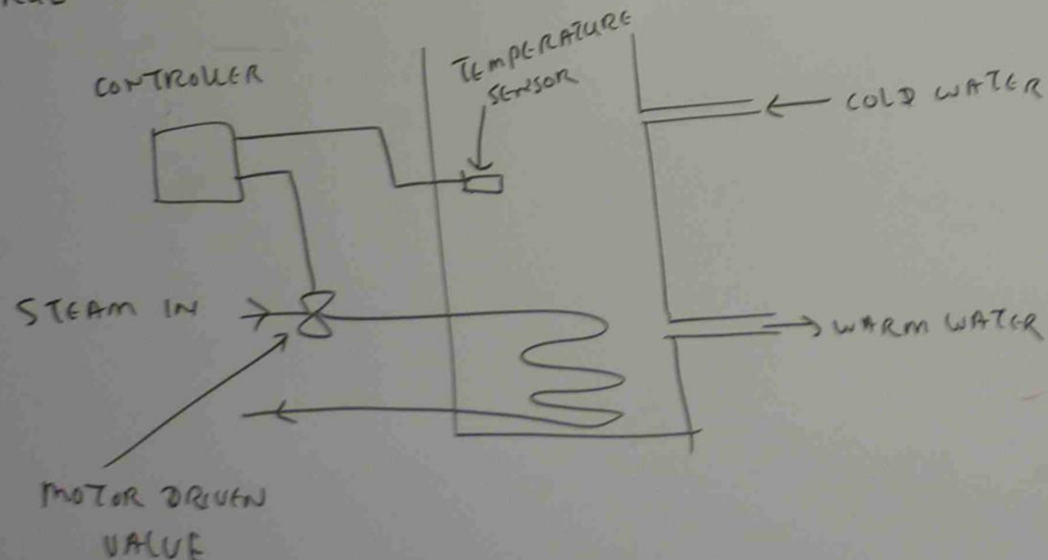
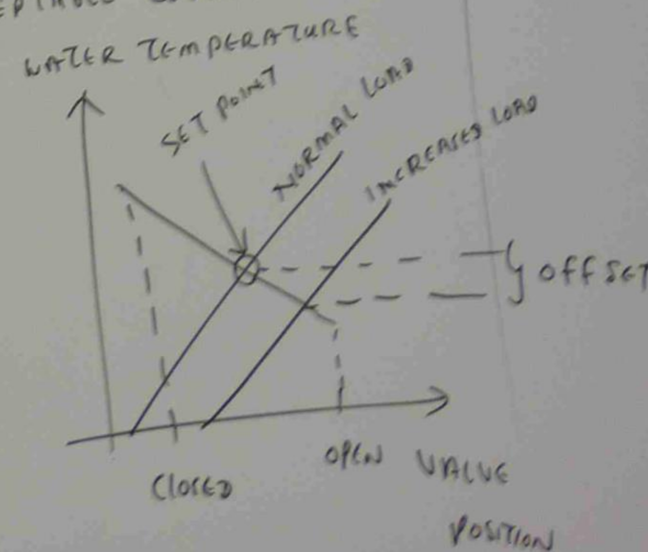
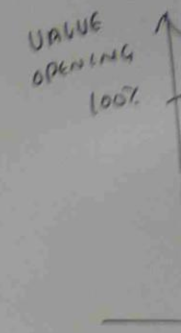
PROPORTIONAL CONTROL

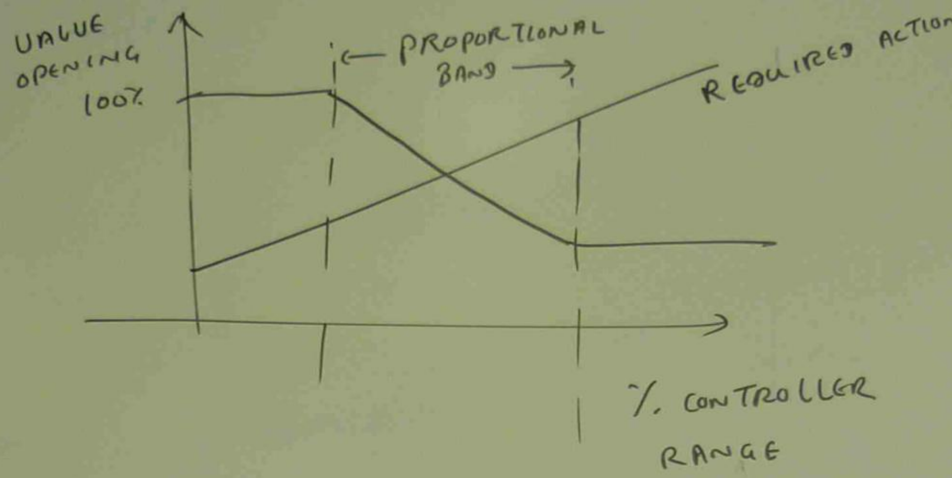
PROPORTIONAL CONTROL PRODUCES A CHANGE IN THE CONTROLLER OUTPUT THAT IS PROPORTIONAL TO THE ERROR SIGNAL. THERE IS A FIXED LINEAR RELATIONSHIP BETWEEN THE CONTROLLED VARIABLE AND THE POSITION OF THE FINAL CONTROLLED ELEMENT.

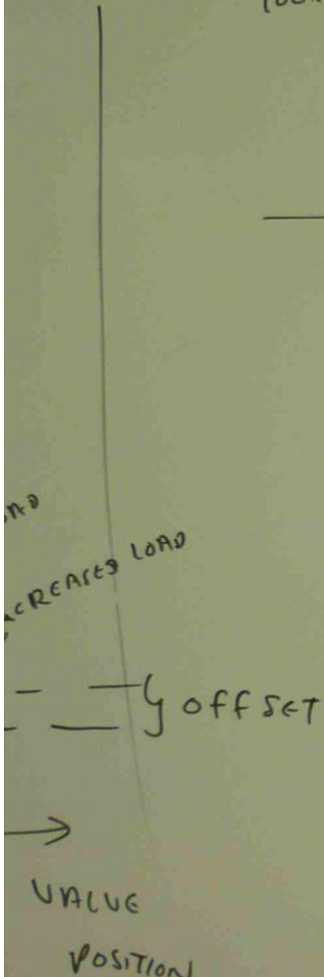
PROPORTIONAL CONTROL IS USED ON PROCESSES WITH A SMALL CAPACITANCE AND FAST MOVING LOAD CHANGES WHERE THE GAIN CAN BE MADE LARGE ENOUGH TO REDUCE THE OFFSET TO AN ACCEPTABLE LEVEL.







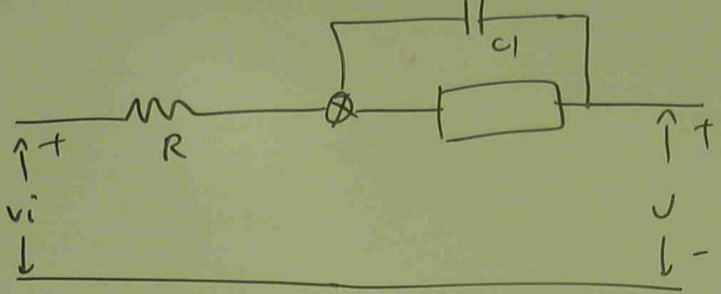




INTEGRAL CONTROL (RESET CONTROL)

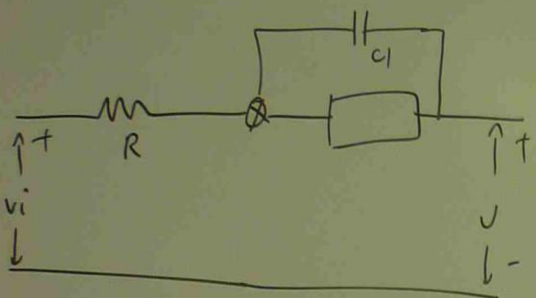
INTEGRAL CONTROL (RESET CONTROL) IS CONTINUOUS AND THE OUTPUT OF THE CONTROL ELEMENT CHANGES AT A RATE PROPORTIONAL TO THE MAGNITUDE AND DURATION OF THE ERROR SIGNAL

IT IS USED WITH PROPORTIONAL CONTROL



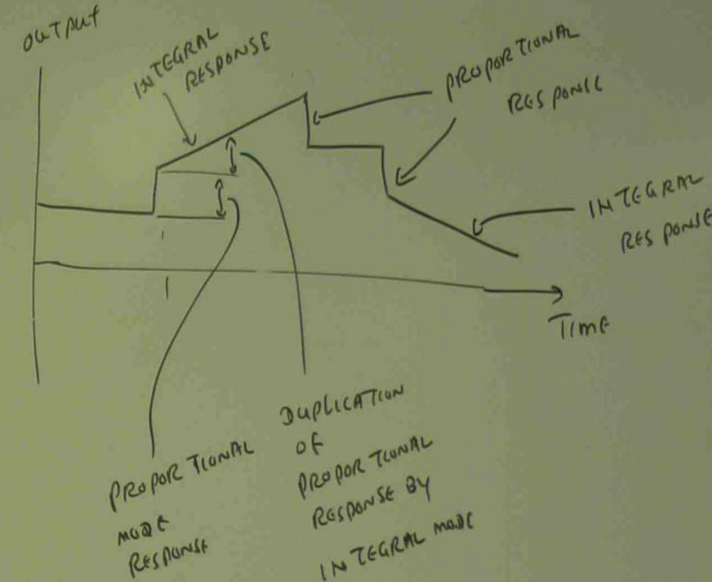
$$u = \frac{1}{T}\int_0^t u\,dt + v_i T_i$$

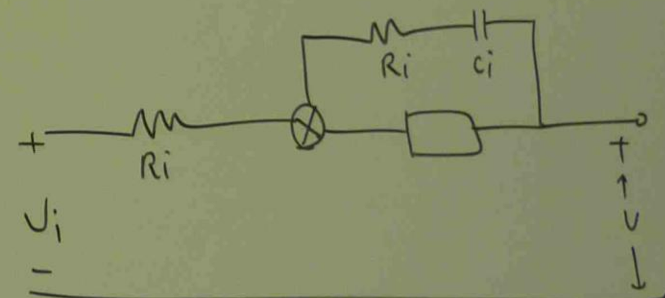
PROPORTIONAL + INTEGRAL (PI) MODE PROVIDES AN AUTOMATIC RESET ACTION WHICH ELIMINATES THE PROPORTIONAL OFFSET. PI CONTROL IS USED ON PROCESSES WITH LARGE LOAD CHANGES WHEN PROPORTIONAL MODE ALONE IS NOT CAPABLE OF REDUCING THE OFFSET TO AN ACCEPTABLE LEVEL



$$v = \frac{1}{T}\int_0^t u \, dt + v_i T_i$$

PROPORTIONAL + INTEGRAL (PI) MODE PROVIDES AN AUTOMATIC RESET ACTION WHICH ELIMINATES THE PROPORTIONAL OFFSET. PI CONTROL IS USED ON PROCESSES WITH LARGE LOAD CHANGES WHEN PROPORTIONAL MODE ALONE IS NOT CAPABLE OF REDUCING THE OFFSET TO AN ACCEPTABLE LEVEL

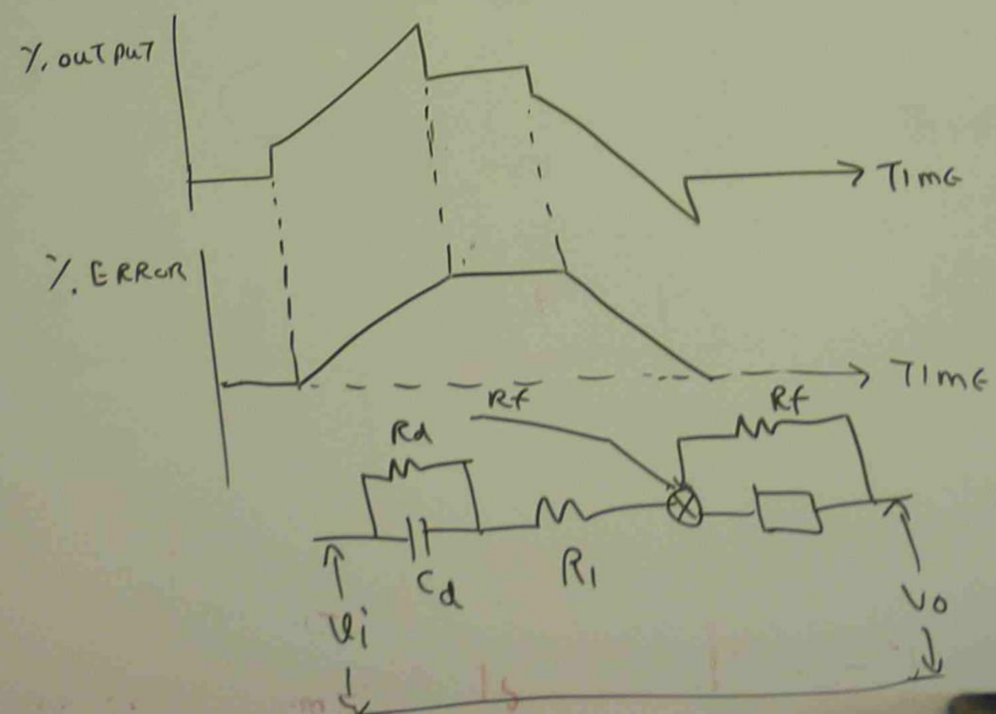




$$u = k u_i + \frac{k}{T_i}\int_0^t v \, dt + v_0$$

PROPORTIONAL + DERIVATIVE (PD) CONTROL

PROPORTIONAL + DERIVATIVE (PD) CONTROL PROVIDES A CHANGE IN THE CONTROLLER OUTPUT WHICH IS PROPORTIONAL TO THE ERROR SIGNAL AND THE DERIVATIVE MODE PROVIDES AN ADDITIONAL CHANGE IN THE CONTROLLER OUTPUT WHICH IS PROPORTIONAL TO THE RATE OF CHANGE OF ERROR SIGNAL. THE DERIVATIVE MODE ANTICIPATES THE FUTURE VALUE OF THE ERROR SIGNAL AND CHANGES THE CONTROLLER OUTPUT ACCORDINGLY.

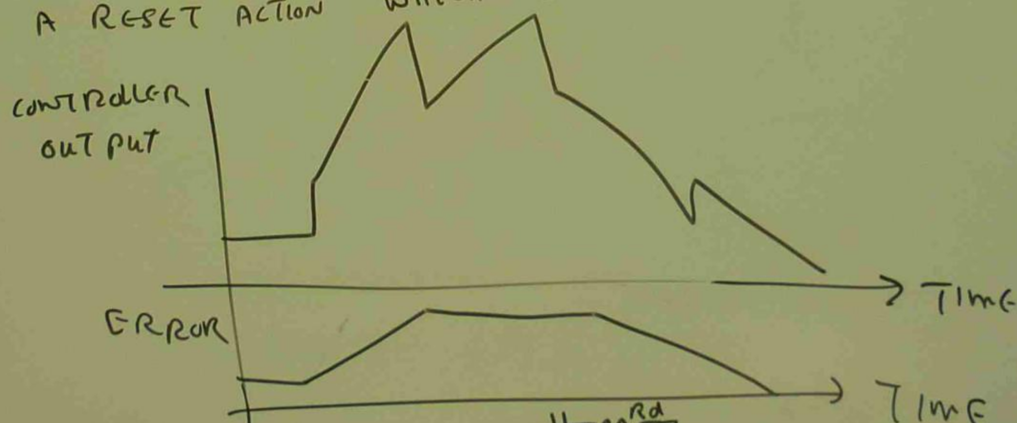


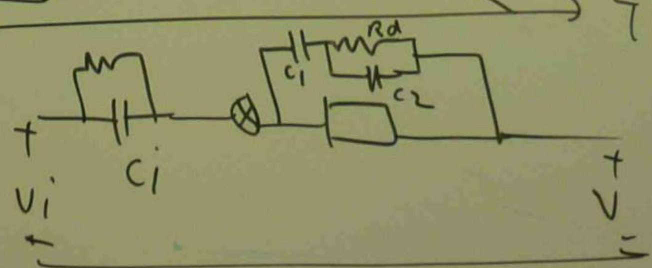
PROPORTIONAL + INTEGRAL + DERIVATIVE (PID) CONTROL

PID IS REFERRED TO AS A THREE MODE CONTROLLER.

THE PID CONTROL MODE IS USED ON PROCESS WITH SUDDEN LARGE LOAD CHANGES WHEN ONE (OR) TWO MODE CONTROL IS NOT CAPABLE OF KEEPING THE ERROR WITHIN ACCEPTABLE LIMITS.

THE DERIVATIVE MODE PRODUCES AN ANTICIPATORY ACTION WHICH REDUCES THE MAXIMUM ERROR PRODUCED BY SUDDEN LOAD CHANGES. THE INTEGRAL MODE PROVIDES A RESET ACTION WHICH ELIMINATES THE PROPORTIONAL OFFSET.





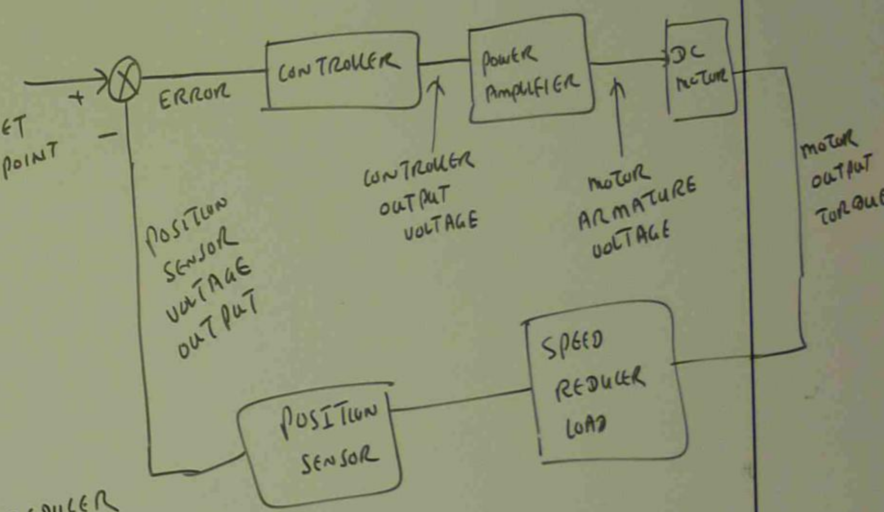
CONTROL MODE SUMMARY

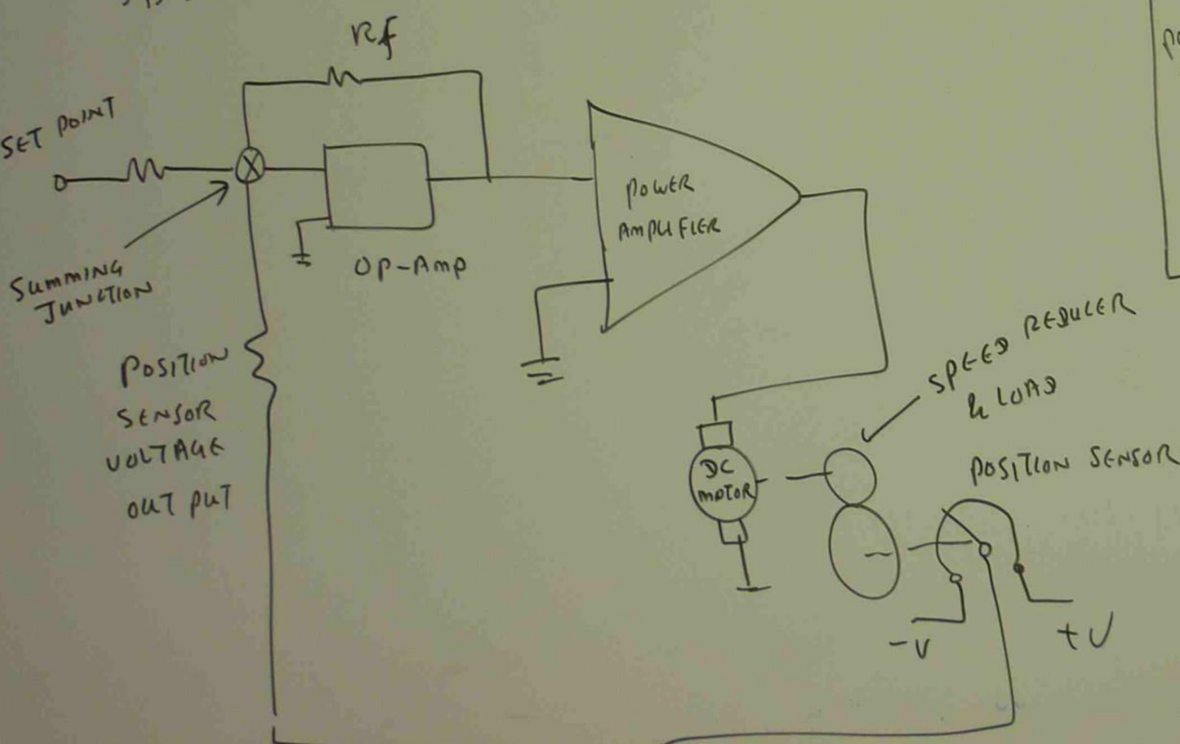
CONTROL MODE	PROCESS REACTION DELAY (MINIMUM)	TRANSFER LAG (MAXIMUM)	DEAD TIME (MAXIMUM)	SIZE OF LOAD DISTURBANCE (MAXIMUM)	SPEED OF LOAD DISTURBANCE (MAXIMUM)
ON - OFF	LONG ONLY (CAN NOT BE SHORT)	VERY SHORT	VERY SHORT	SMALL	SLOW
PROPORTIONAL ONLY	LONG (OR) MODERATE (CAN NOT BE TOO SHORT)	MODERATE	MODERATE	SMALL	SLOW
PROPORTIONAL + INTEGRAL	ANY	MODERATE	MODERATE	ANY	SLOW
PROPORTIONAL + DERIVATIVE	LONG (OR) MODERATE (CAN NOT BE TOO SHORT)	MODERATE	MODERATE	SMALL	ANY
PROPORTIONAL + INTEGRAL + DERIVATIVE	ANY	ANY	ANY	ANY	ANY

ANALOG CONTROL

ANALOG SIGNALS VARY IN A CONTINUOUS MANNER AND MAY TAKE ON ANY VALUE BETWEEN SOME MINIMUM AND MAXIMUM LIMITS. ANALOG CONTROL SYSTEMS DO NOT USE DIGITAL SIGNALS WITHIN THE SYSTEM

BLOCK DIAGRAM



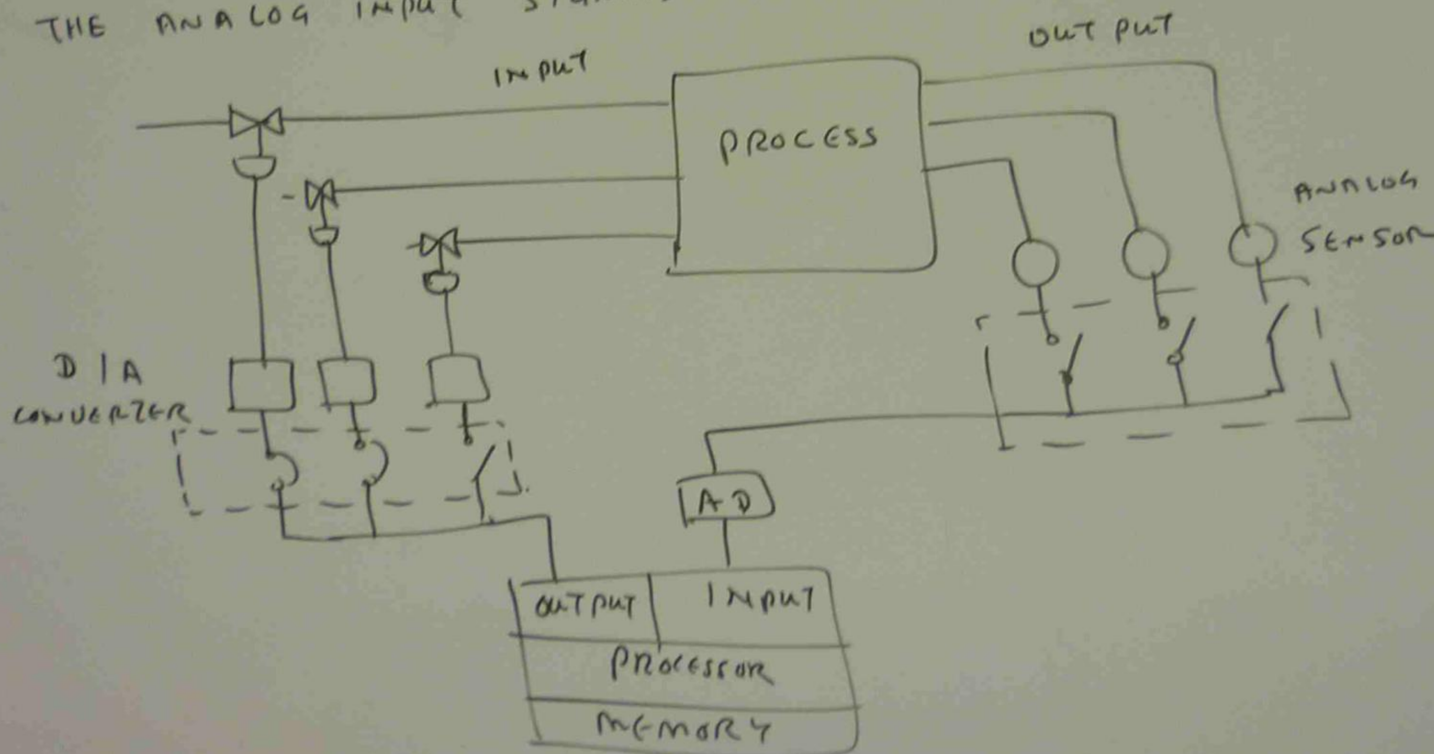


SCHEMATIC DIAGRAM

DIGITAL CONTROL

DIGITAL SIGNALS CAN ONLY BE REPRESENTED IN A FORM THAT HAS FIXED VALUES WITH IN A MAXIMUM SET OF POSSIBLE VALUES. THE VALUES WILL DEPEND ON THE NUMBER OF BITS TO BE USED TO REPRESENT ORIGINAL ANALOG VALUE

IN ANY DIGITAL SYSTEM, THERE MUST BE INTERFACE CIRCUITS TO CONVERT THE ANALOG INPUT SIGNALS TO DIGITAL REPRESENTATION FOR PROCESSING.



FINAL CONTROL ELEMENTS

SOLENOIDS

RELAYS & CONTACTORS

DC RELAY / AC RELAY

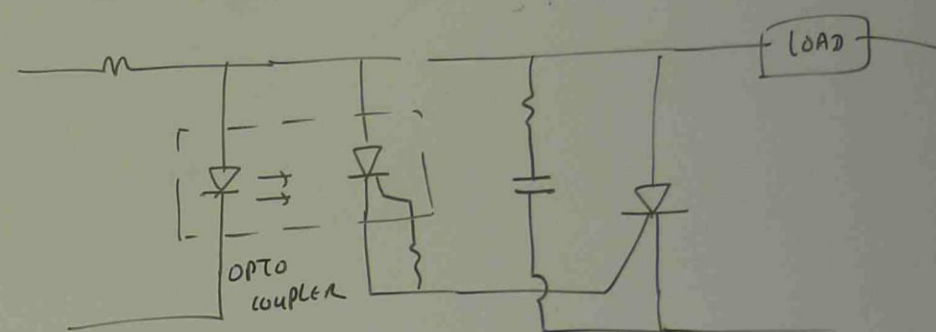
REED RELAY

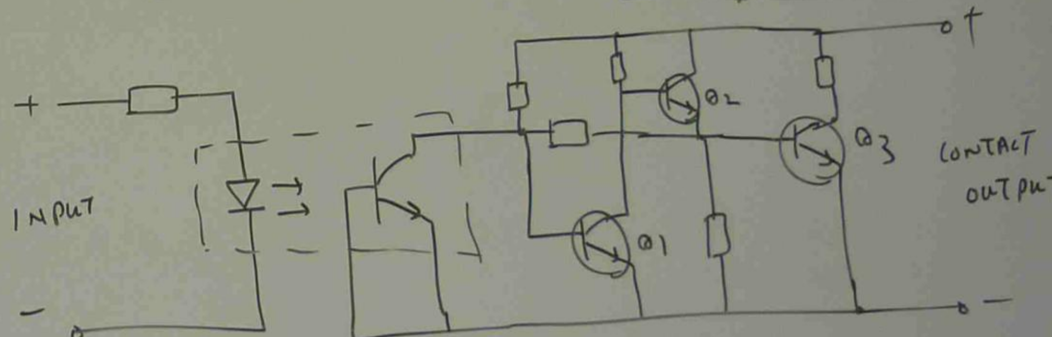
BIPOLAR SWITCHING TRANSISTOR

SILICON CONTROLLED RECTIFIER

FET TRANSISTOR

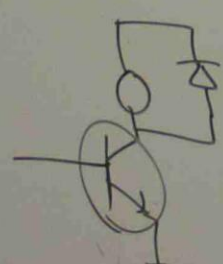
DC OUTPUT MODULES





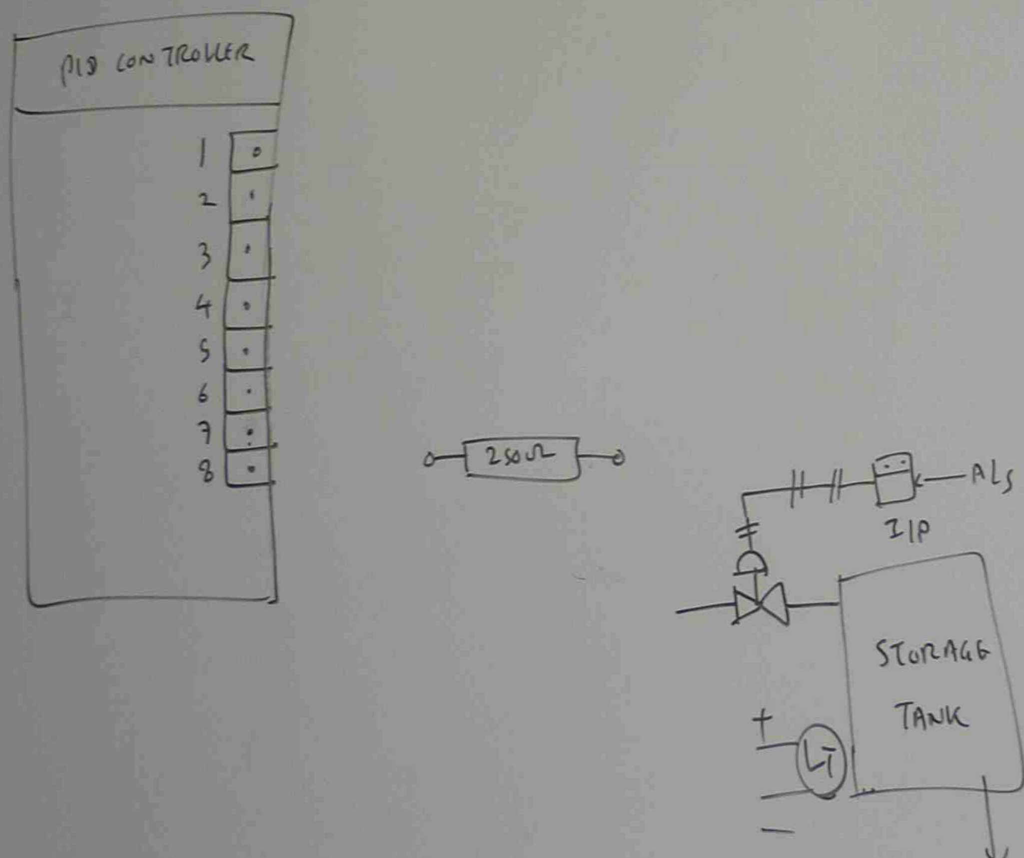
PROTECTING INTERFACE CIRCUITRY

- SURGE PROTECTION BY FREEWHEELING DIODE



CONTROL LOOP DESIGN

Q (a) REFER TO THE DIAGRAM BELOW AND CONNECT THE COMPONENTS TO PROVIDE THE FEEDBACK CONTROL OF THE TANK LEVEL



1 - +26V DC TRANSMITTER SUPPLY

2 - DIGITAL OUTPUT 1

3 - DIGITAL OUTPUT 2

4 - ANALOG OUTPUT (+)

5 - ANALOG OUTPUT COMMON (−)

6 - ANALOG INPUT 2 (+)

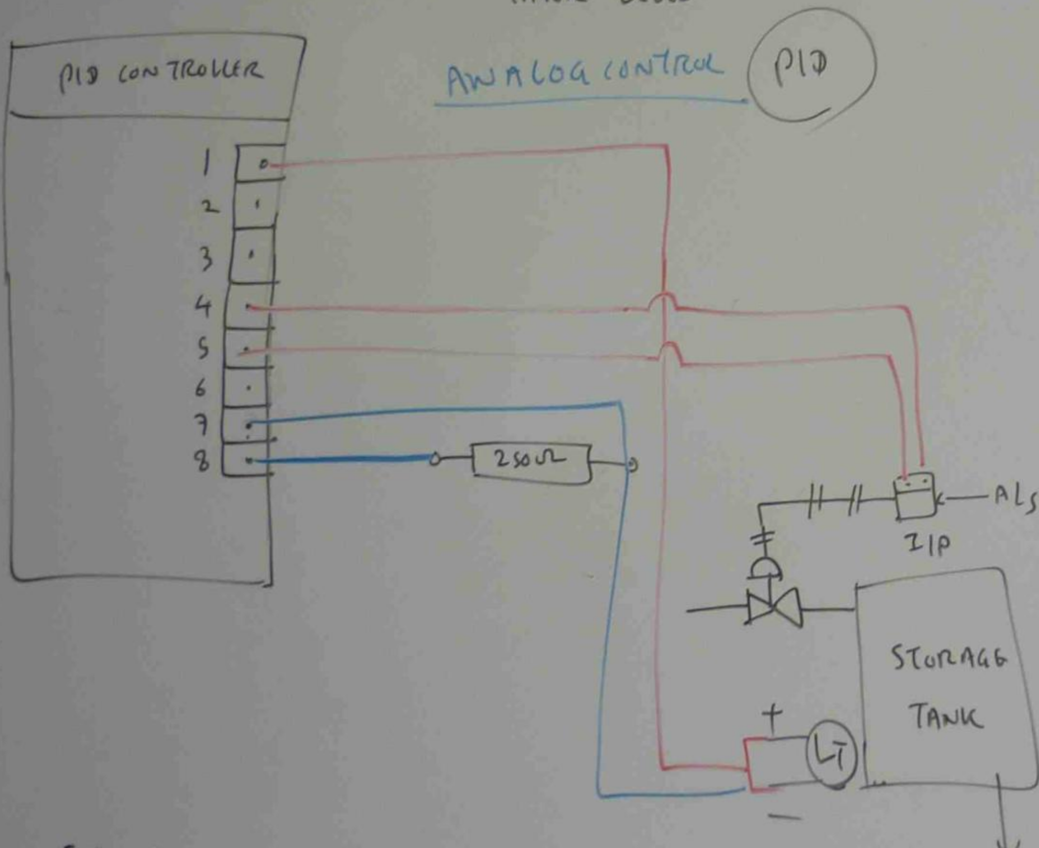
7 - ANALOG INPUT 1 (+)

8 - ANALOG INPUT COMMON (−)

(b) DRAW A SIMPLIFIED DIAGRAM

CONTROL LOOP DESIGN

Q (a) REFER TO THE DIAGRAM BELOW AND CONNECT THE COMPONENTS TO PROVIDE THE FEEDBACK CONTROL OF THE TANK LEVEL



1 - +24V DC TRANSMITTER SUPPLY

2 - DIGITAL OUTPUT 1

3 - DIGITAL OUTPUT 2

4 - ANALOG OUTPUT (+)

5 - ANALOG OUTPUT COMMON (−)

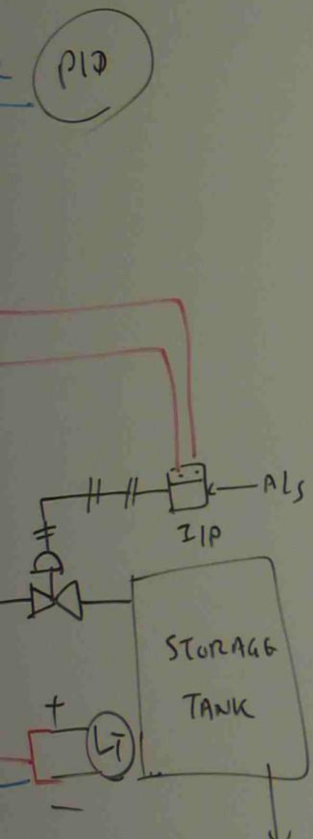
6 - ANALOG INPUT 2 (+)

7 - ANALOG INPUT 1 (+)

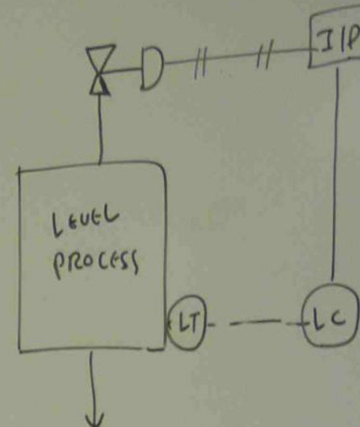
8 - ANALOG INPUT COMMON (−)

(b) DRAW A SIMPLIFIED DIAGRAM

...HE COMPONENTS TO PROVIDE

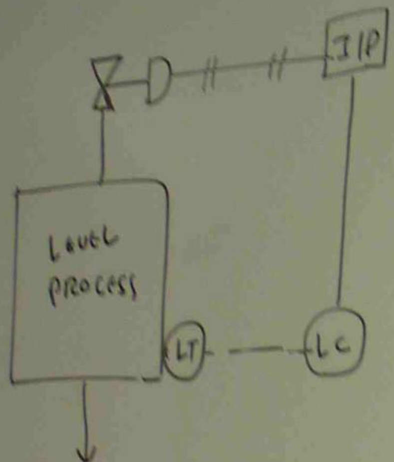


1 - +24V DC TRANSMITTER SUPPLY
2 - DIGITAL OUTPUT 1
3 - DIGITAL OUTPUT 2
4 - ANALOG OUTPUT (+)
5 - ANALOG OUTPUT COMMON (-)
6 - ANALOG INPUT 2 (+)
7 - ANALOG INPUT 1 (+)
8 - ANALOG INPUT COMMON (-)



LT - LOWER LEVEL TANK SENSOR
LC - LEVEL CONTROL
I/P - INPUT DRIVER

2
CONN...
CON...



LOWER LEVEL TANK SENSOR

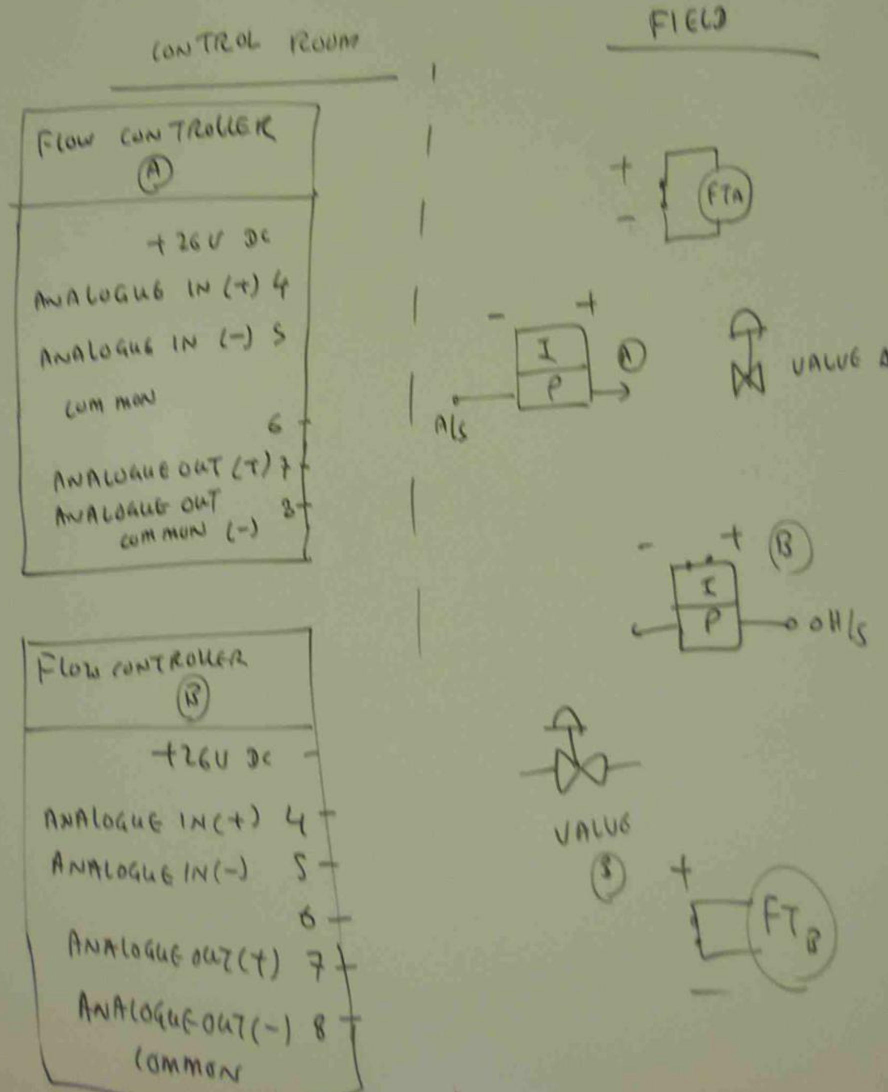
LEVEL CONTROL

INPUT DRIVER

(INTEGRAL | PROPORTIONAL)

RATIO CONTROL

Q/ CONNECT THE COMPONENTS BELOW TO PROVIDE RATIO CONTROL



DIGITA

DIGITAL SIGNAL

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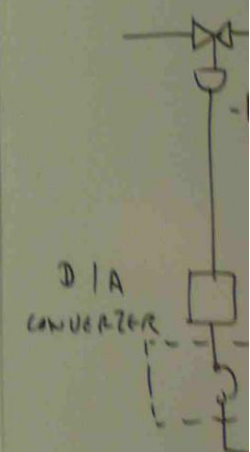

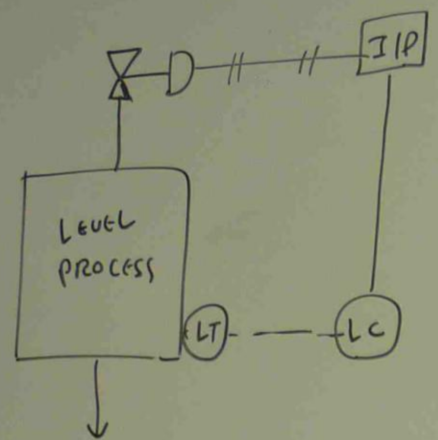

LT - LOWER LEVEL TANK SENSOR
LC - LEVEL CONTROL
I/P - INPUT DRIVER
(INTEGRAL / PROPORTIONAL)

FTA, FTB - SENSORS

I/P INTEGRAL / PROPORTIONAL CONTROL DRIVERS FOR VALUE A & B

RATIO CONTROL

Q/ CONNECT THE COMPONENTS BELOW TO PROVIDE RATIO CONTROL