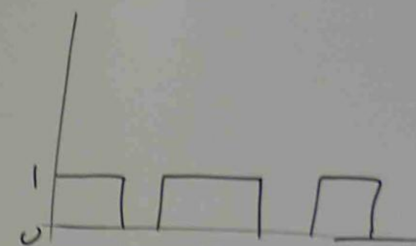
I006

DIGITAL SIGNAL PROCESSING AND CONDITIONING

ANALOG SIGNAL

DIGITAL SIGNAL



ANALOG INFORMATION (OR) ANALOG SIGNALS ARE SUBJECT TO ELECTRICAL NOISE, INTERFERENCE, DRIFT, AMPLIFIER GAIN, LOADING EFFECT ETC.

IN A DIGITALLY ENCODED SIGNAL, A WIRE CARRIES EITHER A HIGH (OR) LOW LEVEL AND IS NOT PARTICULARLY SUSPECTIBLE TO THE PROBLEMS ASSOCIATED WITH ANALOG SIGNAL PROCESSING.

DIGITAL COMPUTER REQUIRES INFORMATION ENCODED IN DIGITAL FORMAT BEFORE IT CAN BE USED.

NUMBER SYSTEM

BINARY —— BASE "2"
OCTAL —— BASE "8"
HEX DECIMAL —— BASE "16"

BINARY

$$N_{10} = a_n \times 2^n + a_{n-1} 2^{n-1} + \cdots a_3 2^3 + a_2 2^2 + a_1 2^1 + a_0 2^0$$

N_{10} = BASE 10 NUMBER — DECIMAL

N_2 = BASE 2 NUMBER — BINARY

Pb FIND THE BINARY EQUIVALENT OF 259_{10}

$259/2 = 129 + 1/2 \longrightarrow a_0 = 1$

$129/2 = 64 + 1/2 \longrightarrow a_1 = 1$

$64/2 = 32 + 0 \longrightarrow a_2 = 0$

$32/2 = 16 + 0 \longrightarrow a_3 = 0$

$16/2 = 8 + 0 \longrightarrow a_4 = 0$

$8/2 = 4 + 0 \longrightarrow a_5 = 0$

$4/2 = 2 + 0 \longrightarrow a_6 = 0$

$2/2 = 1 + 0 \longrightarrow a_7 = 0$

$1/2 = \quad 1/2 \longrightarrow a_8 = 1$

$(a_8\, a_7\, a_6\, a_5\, a_4\, a_3\, a_2\, a_1\, a_0)_2$

$(1\ 0\ 0\ 0\ 0\ 0\ 0\ 1\ 1)_2$

$259_{10} = 100\ 00\ 00\ 11_2$

OCTAL

$$N_{10} = d_n 8^n + d_{n-1} 8^{n-1} + \cdots d_2 8^2 + d_1 8^1 + d_0 8^0$$

Pb FIND BINARY AND DECIMAL EQUIVALENT OF 33_8

OCTAL $\longrightarrow$ BINARY

$33_8 = 3$ & 3

2	3	1
2	1	1
	0	

$= 011$

2	3	1
2	1	1
	0	

$= 011$

$33_8 = 011\ 011_2$

OCTAL TO DECIMAL

$$33_8 = 3 \times 8^1 + 3 \times 8^0$$

$$= 3 \times 8 + 3 \times 1$$

$$= 24 + 3 = 27_{10}$$

$33_8 = 27_{10}$

HEX DECIMAL

$$N_{10} = C_n \times 16^n + C_{n-1} \times 16^{n-1} + \cdots C_2 \times 16^2 + C_1 \times 16^1 + C_0 \times 16^0$$

HEX DECIMAL NUMBERS

1H, 2H, 3H, 4H, 5H, 6H, 7H, 8H, 9H

$10 \longrightarrow$ AH, $11 \longrightarrow$ BH, $12 \longrightarrow$ CH, $13 \longrightarrow$ DH, $14 \longrightarrow$ EH, $15 \longrightarrow$ FH

$10 \longrightarrow$ A, $11 \longrightarrow$ B, $12 \longrightarrow$ C, $13 \longrightarrow$ D, $14 \longrightarrow$ E, $15 \longrightarrow$ F

Pb FIND THE DECIMAL EQUIVALENT OF 47H, 30DH AND A2FH

$$47H \longrightarrow \underset{1}{4}\,\underset{0}{7} = 4 \times 16^1 + 7 \times 16^0 = 4 \times 16 + 7 \times 1 = 71_{10}$$

$$30DH \longrightarrow \underset{2}{3}\,\underset{1}{0}\,\underset{0}{D} = 3 \times 16^2 + 0 \times 16^1 + 13 \times 16^0$$

$$= 3 \times 256 + 0 \times 16 + 13 \times 1$$

$$= 781_{10}$$

$$A2FH \longrightarrow \underset{2\;\,1\;\,0}{A2F} \longrightarrow \underset{2}{10}, \underset{1}{2}, \underset{0}{15}$$

$$= 10 \times 16^2 + 2 \times 16^1 + 15 \times 16^0$$

$$= 10 \times 256 + 2 \times 16 + 15 \times 1$$

$$= 2607_{10}$$

4 3 2 1 0

H

1_{10}

$+ C_{n-1} \times 16^{n-1} + \cdots - C_2 \times 16^2 + C_1 \times 16^1 + C_0 \times 16^0$

...BERS

H, 4H, 5H, 6H, 7H, 8H, 9H

11 → BH, 12 → CH, 13 → DH, 14 → EH, 15 → FH

11 → B 12 → C 13 → D 14 → E 15 → F

DECIMAL EQUIVALENT OF 47H, 30DH AND A2FH

$47 = 4 \times 16^1 + 7 \times 16^0 = 4 \times 16 + 7 \times 1 = 71_{10}$

$30D = 3 \times 16^2 + 0 \times 16^1 + 13 \times 16^0$

$= 3 \times 256 + 0 \times 16 + 13 \times 1$

$= 781_{10}$

HEX → DECIMAL $\times 16^n$

DECIMAL → HEXDECIMAL $\frac{1}{16^n}$

A2FH → A2F → 10, 2, 15

4 3 2 1 0

$= 10 \times 16^2 + 2 \times 16^1 + 15 \times 16^0$

$= 10 \times 256 + 2 \times 16 + 15 \times 1$

$= 2607_{10}$

Pb FIND THE HEX DECIMAL EQUIVALENT OF 29_{10}

175_{10}, 3412_{10}

$29_{10} \rightarrow \frac{29}{16} = 1 + \frac{13}{16} = 1DH$

$175_{10} \rightarrow \frac{175}{16} = 10 + \frac{15}{16} = AFH$

10 ← RESULT

16 | 175
16
15 ← REMAINDER

$3412_{10} =$

213
16 | 3412
32
21
16
52
4...

13
16 | 213
16
53
48
5

16 | 13
13

FH
F
FH

71 $_{10}$

-CIMAL $\times 16^n$

EXDECIMAL $\frac{}{16^n}$

$A2FH \to A2F \to \underset{2}{10}, \underset{1}{2}, \underset{0}{15}$

4 3 2 1 0

$= 10 \times 16^2 + 2 \times 16^1 + 15 \times 16^0$

$= 10 \times 256 + 2 \times 16 + 15 \times 1$

$= 2607_{10}$

Pb FIND THE HEXDECIMAL EQUIVALENT OF 29_{10}

175_{10}, 3412_{10}

$29_{10} \to \frac{29}{16} = 1 + \frac{13}{16} = 1DH$

$175_{10} \to \frac{175}{16} = 10 + \frac{15}{16} = AFH$

$$\begin{array}{r|l} & 10 \leftarrow \text{RESULT} \\ 16 & 175 \\ & 16 \\ \hline & 15 \leftarrow \text{REMAINDER} \end{array}$$

$3412_{10} = \frac{3412}{16} = 213 + \frac{4}{16} = 4$

$$\begin{array}{r|l} & 213 \\ 16 & 3412 \\ & 32 \\ \hline & 21 \\ & 16 \\ \hline & 52 \\ & 48 \\ \hline & 4 \end{array}$$

$$\begin{array}{r|l} & 13 \\ 16 & 213 \\ & 16 \\ \hline & 53 \\ & 48 \\ \hline & 5 \end{array}$$

$\frac{213}{16} = 13 + \frac{5}{16} = 5$

$$\begin{array}{r|l} 16 & 13 \\ \hline & 13 \end{array}$$

$\frac{13}{16} = 0 + \frac{13}{16} = 13 = D$

$3412_{10} = D54H$

NEGATIVE NUMBER

2's complement method is utilized to represent the negative numbers.

Method (1) -1011_2 to be represented by 2's complement method

$$\begin{array}{r} 100000 \\ -\quad 1011 \\ \hline 10101 \end{array}$$

10101 ← Two complement.

$-1011_2 = 10101_2$

Method (2)

$$\begin{array}{r} 100000 \\ 1011 \\ \hline 10101 \end{array}$$

SAME

$10101 \longrightarrow 10101$

ADD (1)

OPPOSITE

OPPOSITE

OPPOSITE

$-1011_2 = 10101_2$

2's complement

Pb $-1010_2 = ?$ 2's complement

$$\begin{array}{r} 100000 \\ -\quad 1010 \\ \hline 10110 \end{array}$$

SAME

FIRST 1

ADD

$-1010_2 = 10110_2$

BEFORE REACHING THE FIRST 1 FROM RIGHT TO LEFT, JUST WRITE THE SAME NUMBER

AFTER FIRST 1 THEN WRITE OPPOSITE NUMBERS.

FINALLY ADD 1 AT THE FRONT.

FRACTIONAL BINARY NUMBERS

$$N_{10} = b_1 2^{-1} + b_2 2^{-2} + b_3 2^{-3} + \cdots b_n 2^{-n}$$

N_{10} = BASE 10 NUMBER LESS THAN 1

FRACTIONAL BINARY TO DECIMAL CONVERSION

Pb FIND THE BASE 10 EQUIVALENT OF THE BINARY NUMBER 0.11010_2

$$N_{10} = 1\times 2^{-1} + 1\times 2^{-2} + 0\times 2^{-3} + 1\times 2^{-4} + 0\times 2^{-5}$$

$$= 1\times\frac{1}{2} + 1\times\frac{1}{2^2} + 0\times\frac{1}{2^3} + 1\times\frac{1}{2^4} + 0\times\frac{1}{2^5}$$

$$= \frac{1}{2} + \frac{1}{4} + 0 + \frac{1}{16} + 0$$

$$= 0.8125_{10}$$

FRACTIONAL DECIMAL TO BINARY, OCTAL, HEX DECIMAL

pb FIND THE BINARY, OCTAL AND HEX DECIMAL EQUIVALENT of 0.3125_{10}

$0.3125_{10} \longrightarrow 2 \times 0.3125 = 0.6250 \longrightarrow b_1 = 0$

$2 \times 0.6250 = 1.\underline{250}$ $\quad b_2 = 1$

LEFT

$2 \times 0.250 = 0.500$ $\quad b_3 = 0$

$2 \times 0.500 = 1.0$ $\quad b_4 = 1$

FORMAT $= (0.b_1 b_2 b_3 b_4)_2 = (0.0101)_2$

$0.3125_{10} = 0.0101_2$ BINARY EQUIVALENT

TO CHANGE TO OCTAL

0.0101

3 BINARY BITS ARE TO BE COMBINED.

$0.\underline{010}\,\underline{100}$

3 BINARY BITS

PUT

3 BINARY BIT

$010\ ,\ 100 = (24)_8$

2^2 PLACE 2^1 PLACE 2^0 PLACE

2^2 PLACE 2^1 PLACE 2^0 PLACE

$0\times2^2+1\times2^1+0\times2^0$ | $1\times2^2+0\times2^1+0\times2^0$

$0\times4+1\times2+0$ | $1\times4+0\times2+0\times1$

2 | 4

0.24_8 OCTAL EQUIVALENT

TO CHANGE TO HEX DECIMAL

0.0101

4 BINARY BITS ARE TO BE COMBINED

$0.\underline{0101}\ 0000$

4 BINARY BIT

$0101\ ,\ 0000$

$2^3\ 2^2\ 2^1\ 2^0$ $2^3\ 2^2\ 2^1\ 2^0$

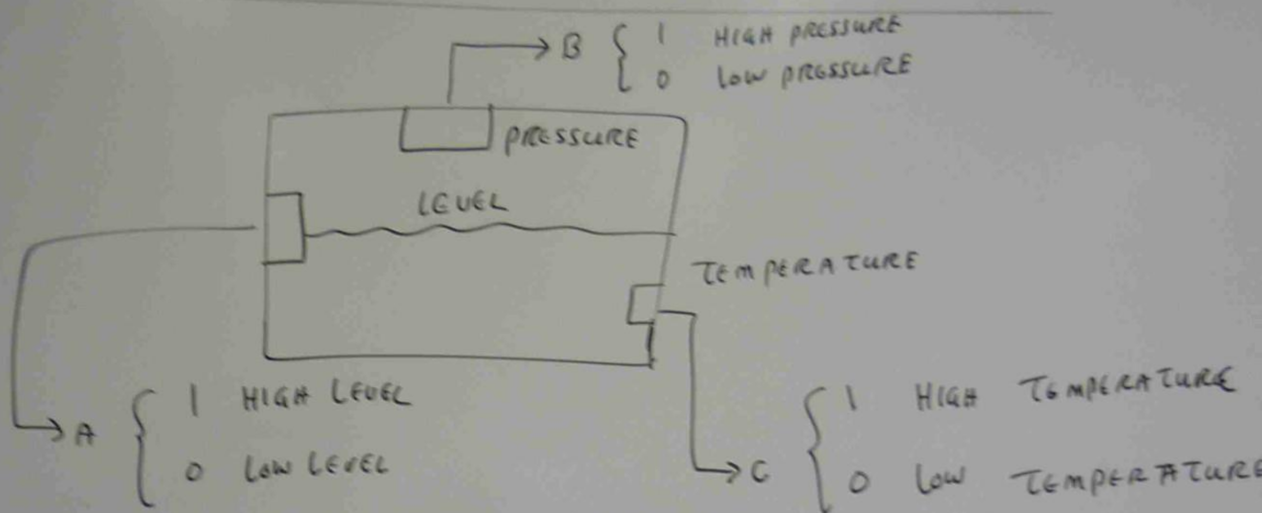
$0\times2^3+1\times2^2+0\times2^1+1\times2^0$

$0+4+0+1=5$

$0\times2^3+0\times2^2+0\times2^1+0\times2^0=0$

0.50H

DESIGNING THE DIGITAL GATE SYSTEM TO CONTROL THE PROCESS



ALARM D { 1 ON, 0 OFF }

ALARM CONDITIONS ARE

1. LOW LEVEL WITH HIGH PRESSURE → ALARM SHOULD OPERATE
2. HIGH LEVEL WITH HIGH TEMPERATURE → ALARM SHOULD OPERATE
3. HIGH LEVEL WITH LOW TEMPERATURE AND HIGH PRESSURE → ALARM SHOULD OPERATE.

LEVEL (A)

LOW LEVEL = $\overline{A}$

HIGH LEVEL = A

PRESSURE (B)

LOW PRESSURE = $\overline{B}$

HIGH PRESSURE = B

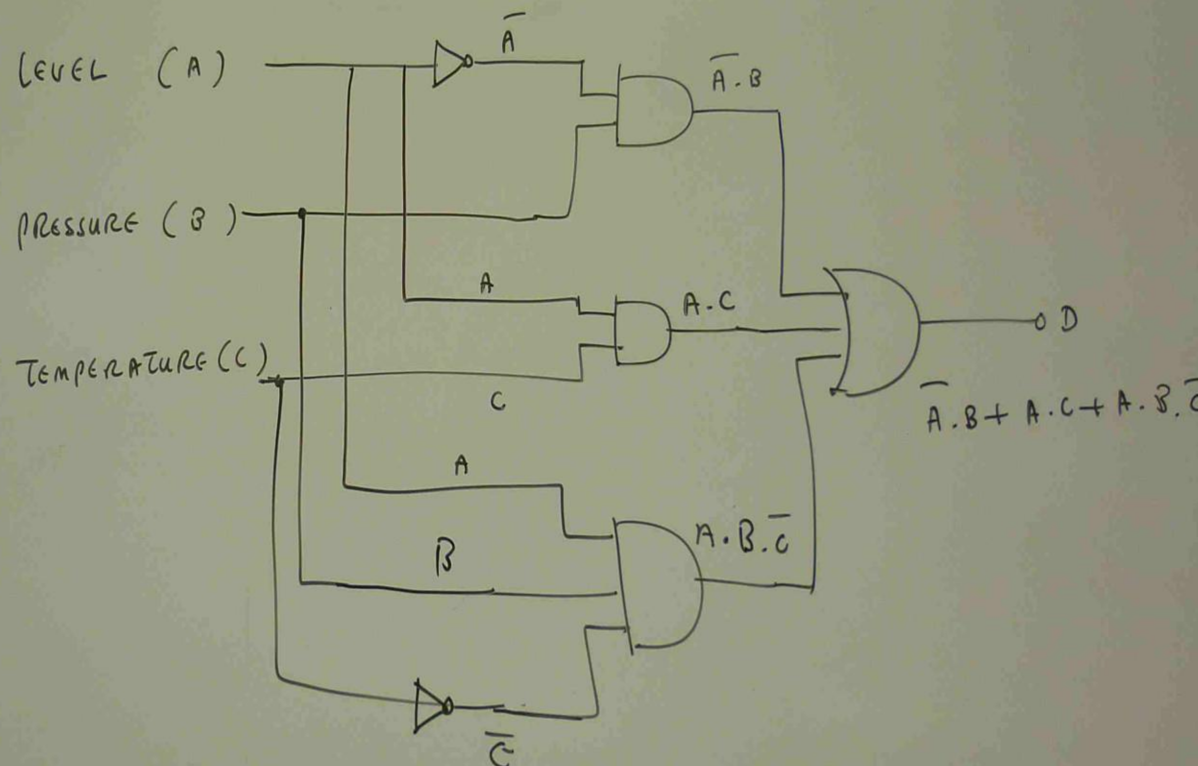
TEMPERATURE (C)

LOW TEMPERATURE = $\overline{C}$

HIGH TEMPERATURE = C

$$D = \overline{A}.B + A.C + A.B.\overline{C}$$

TO DEVELOP DIGITAL GATES



PROGRAMMABLE LOGIC CONTROLLERS

PLC ARE PARTICULARLY SUITED TO THE SOLUTION OF CONTROL PROBLEMS ASSOCIATED WITH BOOLEAN EQUATIONS AND BINARY LOGIC PROBLEMS IN GENERAL. THEY ARE A COMPUTER BASED OUT GROWTH OF RELAY SEQUENCE CONTROLLERS.

BUSES AND TRI STATE BUFFERS

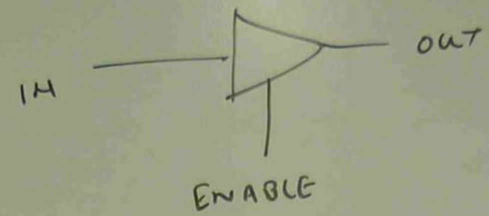
AN 8 BIT COMPUTER MAY HAVE A DATA BUS WITH 8 LINES IN PARALLEL . ALL DATA INPUT AND OUTPUT TO THE COMPUTER ARE CARRIED OVER THESE LINES.

TRI STATE BUFFERS

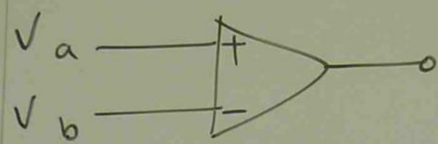
THIS IS A DEVICE THAT ACTS LIKE A SWITCH.

TRI STATE BUFFER HAS 3 STATES ON IT'S OUTPUT

LOGIC 1 , LOGIC 0 HIGH IMPEDANCE (OPEN CIRCUIT)



COMPARATORS



$$\begin{cases} 1 & V_a > V_b \\ 0 & V_a < V_b \end{cases}$$

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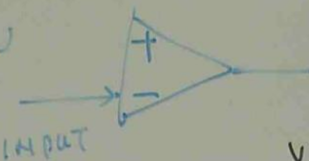
pb A PROCESS CONTROL SYSTEM SPECIFIES THAT TEMPERATURE SHOULD NEVER EXCEED 160°C IF THE PRESSURE ALSO EXCEEDS 10 Pa. DESIGN AN ALARM SYSTEM TO DETECT THIS CONDITION USING TEMPERATURE AND PRESSURE TRANSDUCERS WITH TRANSFER FUNCTION OF 2.2 mV/°C AND 0.2V/Pa RESPECTIVELY.

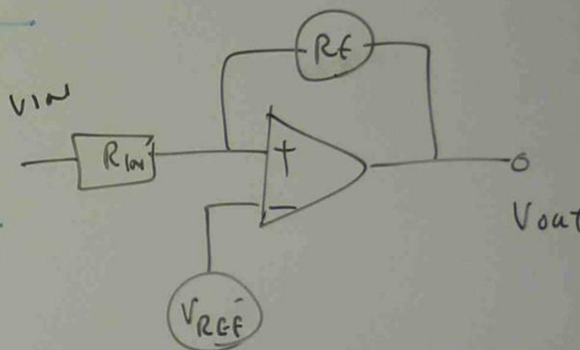
TEMPERATURE CONTROL
PRESSURE CONTROL } HAPPENS AT THE SAME TIME → AND

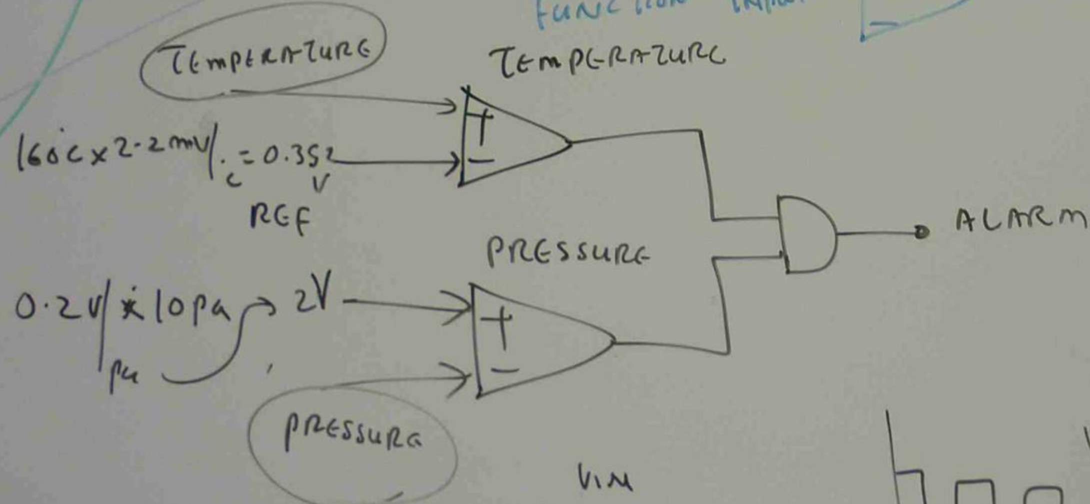
COMPARATOR

INVERTING FUNCTION

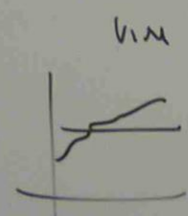


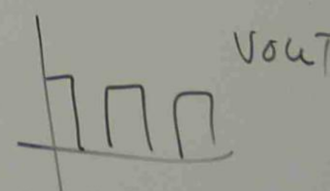
NON INVERTING FUNCTION





$$V_{IN} = V_{REF} - \frac{R_{IN}}{R_{REF}} \times V_O$$





HYSTERESIS COMPARATOR

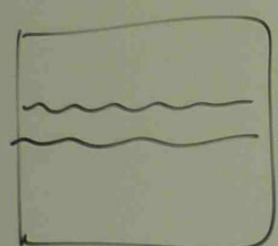
WHEN USING COMPARATOR, SWINING ABOUT THE REFERENCE LEVEL CAN CAUSE WRONG OPERATION.

SUCH PROBLEM CANBE SOLVED BY PROVIDING DEAD BAND BY USING HYSTERESIS COMPARATOR

$$V_{IN} = V_{Ref} - \underbrace{\frac{R}{R_f} V_0}_{\substack{\text{DEAD BAND} \\ \text{HYSTERESIS}}}$$

Pb A TRANSDUCER CONVERTS THE LIQUID LEVEL IN A TANK TO VOLTAGE ACCORDING TO THE TRANSFER FUNCTION (20 mV / cm)

A COMPARATOR IS SUPPOSED TO GO HIGH (5V) WHENEVER THE LEVEL BECOMES 50 cm. SPLASHING CAUSES THE LEVEL TO FLUCTUATE BY ± 3 cm . DEVELOP A HYSTERESIS COMPARATOR TO PROTECT AGAINST THE EFFECTS OF SPLASHING.



LEVEL CHANGE → VOLTAGE

REF NOMINAL REFERENCE OCCURS AT 50 cm

$$V_{Ref} = 50\,cm \times 20\,mV/cm = 1000\,mV = 1V$$

FLUCTUATION (± 3cm)

NOISE

$$(\pm 3\,cm) \times 20\,mV/cm = \pm 60\,mV$$

— IN A TANK TO VOLTAGE

mV/cm)

V) WHENEVER THE LEVEL

EL TO FLUCTUATE BY

PARATOR TO PROTECT

50cm

$V/_{cm}$ = 1000 mV = 1V

$mV/_{cm}$ = ± 60 mV

— +60 mV

LEVEL

— −60 mV

60 + 60 = 120 mV ⟶ 150 mV (APPROXIMATION

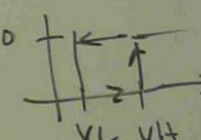
DEAD BAND VOLTAGE ⟹ $\frac{R}{R_f} \times V_{HIGH}$ = DEAD BAND VOLTAGE

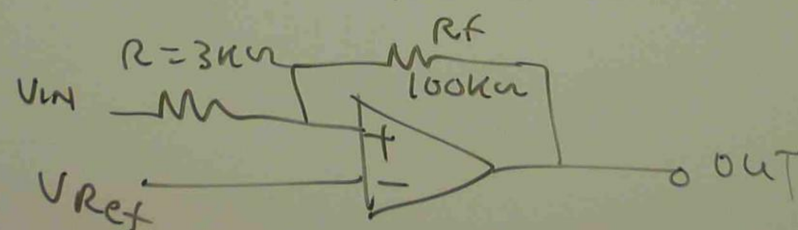
$$\frac{R}{R_f} \times 5 = 150 \times 10^{-3}$$

$$\frac{R}{R_f} = \frac{150 \times 10^{-3}}{5} = 0.03$$

IF $R_f = 100k\Omega$

$R = 0.03 \times 100k\Omega = 3k\Omega$





$$V_L = V_{Ref} - \frac{R}{R_f} V_O$$

$V_H = V_{Ref}$