Pb — FIND THE SUCCESSIVE APPROXIMATION ADC OUTPUT FOR A 4 BIT CONVERTER TO A 3.217 V INPUT IF THE REFERENCE IS 5V.

INPUT = 3.217 V   SET → N = 1

REF = 5V

I

$$V_f = V_{ref} \times 2^{-n} = 5 \times 2^{-1} = \frac{5}{2} = 2.5V$$

$V_{IN} = 3.217V$, $V_f = 2.5V$

$V_{IN} > V_f \longrightarrow b_1 = 1$

II

INPUT = 3.217V,   SET $n = 2$

REF = 5V

$$V_f = \left(V_{ref} \times 2^{-n} + \frac{V_{ref}}{2}\right) = 5 \times 2^{-2} + \frac{5}{2} = 3.75V$$

COMPARE V_{IN} 3.217 V WITH V_f 3.75V

$V_f > V_{IN} \longrightarrow b_2 = 0$

III INPUT =

REF =

COMPAR

IV INPUT

REF

III INPUT = 3.217 V SET $n=3$

REF = 5V $\rightarrow V_f = V_{ref} \times 2^{-n} + \frac{V_{ref}}{2}$

$= 5 \times 2^{-3} + \frac{5}{2} = 3.125\,V$

COMPARE V_{IN} 3.217 V WITH V_f 3.125V

$V_{IN} > V_f \longrightarrow b_3 = 1$

b_1	b_2	b_3	b_4
1	0	1	0

$_2$

IV INPUT = 3.217 V SET $n=4$

REF = 5V

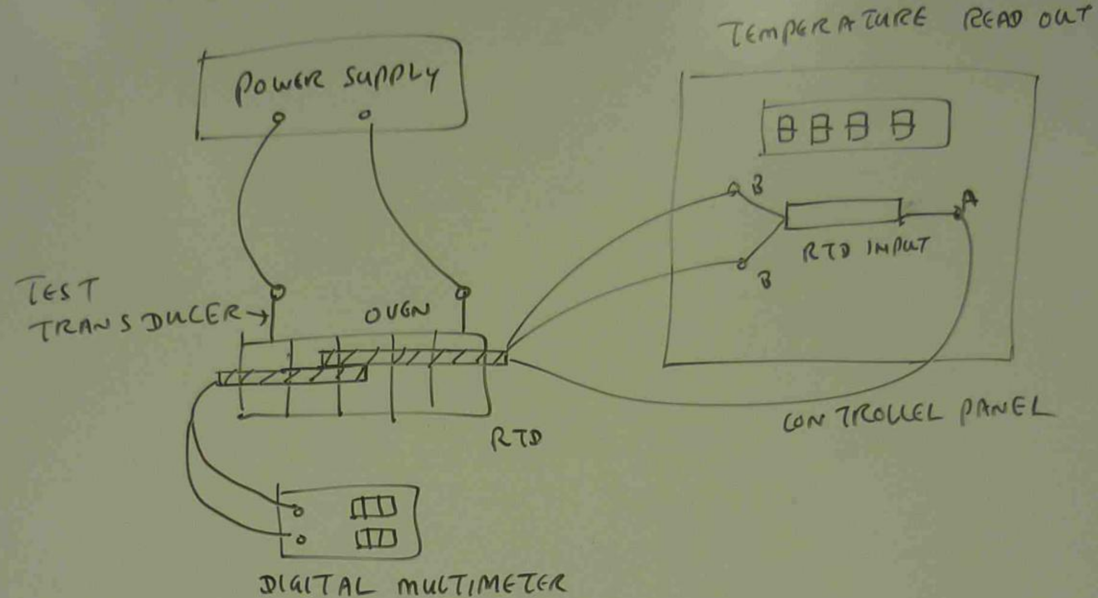
$V_f = V_{ref} \times 2^{-n} + \frac{V_{ref}}{2}$

$= 5 \times 2^{-4} + \frac{5}{2} = 3.437\,V$

COMPARE V_{IN} 3.217 V WITH V_f 3.437V

$V_f > V_{IN} \rightarrow b_4 = 0$

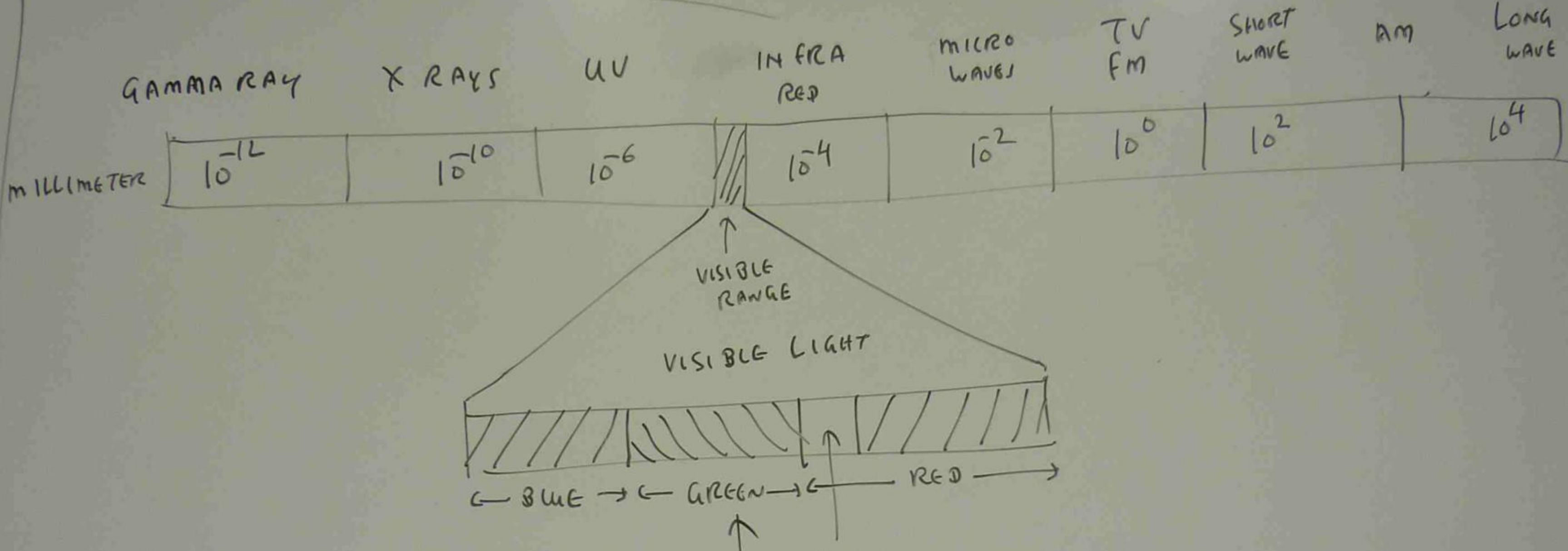
TEMPERATURE MEASUREMENT



EQUIPMENT

- TEMPERATURE TRANSDUCER (RTD, THERMISTOR, THERMOCOUPLE)
- DIGITAL MULTIMETER
- HEATING OVEN
- UNIVERSAL CONNECTING BLOCK
- DC POWER SUPPLY - 2A
- TEMPERATURE CONTROL PANEL
- CONNECTION LEAD - 4mm BANANA LEAD

LIGHT AND LIGHT TRANSDUCERS



HUMAN EYE PEAK RESPONSE

560mm

VISIBLE SPECTRUM

AM LONG WAVE

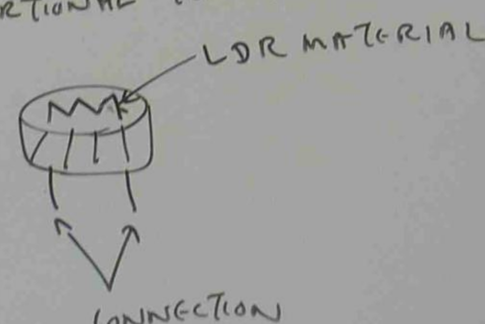
10^4

LDR (LIGHT DEPENDENT RESISTOR) → PHOTO CONDUCTIVE CELL

($0.6\phi \times 15$mm)

OPERATION

LIGHT FALLING ON THE SURFACE OF LDR CAUSES A DECREASE IN RESISTANCE THAT IS PROPORTIONAL TO THE AMOUNT OF LIGHT



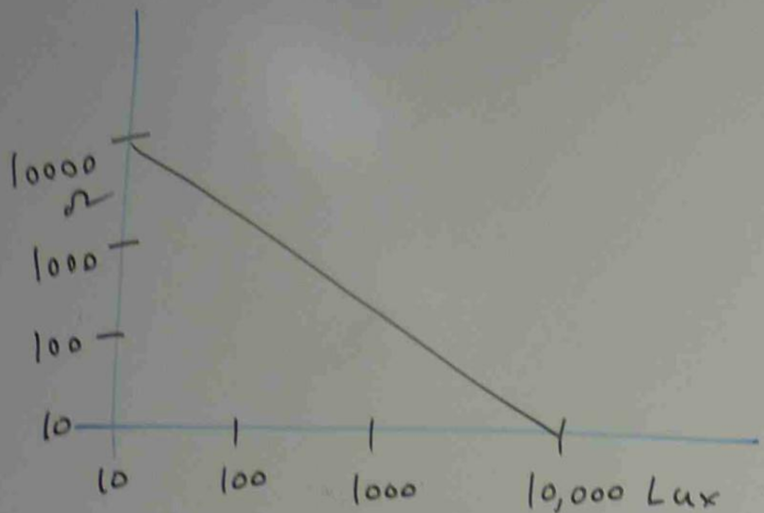
DARK VALUE R_D = MINIMUM 10MΩ (TOTAL DARKNESS)

LIGHT VALUE $R_L = 75 - 300\Omega$ (MEASURED AT 1000 LUX)

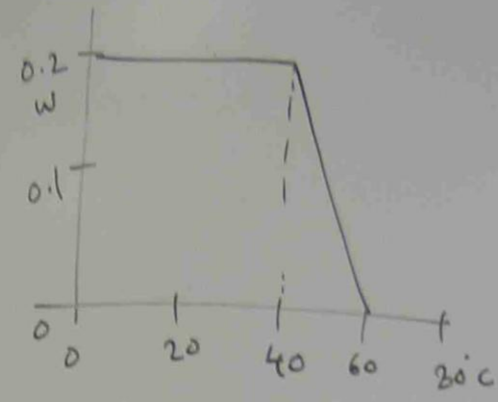
PERMISSIBLE VOLTAGE = $E_{MAX} = 150V$

AMBIENT TEMPERATURE = $-20 \rightarrow +60^\circ C$

CAPACITANCE 6 pF



RESISTANCE VALUE AS FUNCTION OF LIGHT INTENSITY



DERATING CURVE

TWO TYPES OF LDRs ARE AVAILABLE AND THEIR RESPONSES ARE AS FOLLOWS

CADMIUM SELENIDE Cdse = 735mm (INFRARED)

CADMIUM SULPHIDE CdS = 530mm TO 600 mm (EYE)

DIGITAL TO ANALOG CONVERTORS (DACS)

$$V_{out} = V_R \left[b_1 2^{-1} + b_2 2^{-2} + \cdots + b_n 2^{-n} \right]$$

V_{out} = ANALOG OUTPUT VOLTAGE

V_R = REFERENCE VOLTAGE

$b_1, b_2 \cdots b_n$ = n BIT BINARY WORD

$$V_{out} = \frac{N}{2^n} V_{ref}$$

Pb WHAT IS THE OUTPUT VOLTAGE OF A 10 BIT DAC WITH A 10 V REFERENCE IF THE INPUT IS (a) 001 0110101

(b) 20FH

WHAT INPUT IS NEEDED FOR 6.5 V OUTPUT

(a) $V_{OUT} = V_{REF} \left(b_1 2^{-1} + b_2 2^{-2} + \cdots b_n 2^{-n} \right]$

$= 10 \left(0 \times 2^{-1} + 0 \times 2^{-2} + 1 \times 2^{-3} + 0 \times 2^{-4} + 1 \times 2^{-5} + 1 \times 2^{-6} + 0 \times 2^{-7} + 1 \times 2^{-8} + 0 \times 2^{-9} + 1 \times 2^{-10} \right]$

$= 10 \times 0.1767$

$= 1.767$ VOLT

(b) $20FH = 2 \times 16^2 + 0 \times 16^1 + 15 \times 16^0 = 527_{10}$

$\underset{2}{\uparrow}\underset{1}{\uparrow}\underset{0}{\uparrow}$

$V_{OUT} = \frac{N}{2^n} V_{ref} = \frac{527}{2^{10}} \times 10 = 5.14648\ V$

$V_{OUT} = \frac{N}{2^n} V_{ref}$

$6.5 = \frac{N}{2^{10}} \times 10$

$N = \frac{6.5 \times 2^{10}}{10} = 665.6\ V$

$$\Delta V_{OUT} = V_r \times 2^{-n}$$

ΔV_{OUT} = SMALLEST OUTPUT CHANGE

V_r = REFERENCE VOLTAGE

n = NUMBER OF BITS IN THE WORD.

pb 5 BIT D/A CONVERTER, 10V REFERENCE

$$\Delta V_{OUT} = V_r \times 2^{-n}$$

$$\Delta V_{OUT} = 10 \times 2^{-5} = 0.3125 \text{ V/BIT}$$

Ph FIND THE SUCCESSIVE APPROXIMATION ADC OUTPUT FOR A 4 BIT CONVERTER TO A 3.217 V INPUT IF THE REFERENCE IS 5V.

(V_{in}) I/P = 3.217V   SET $n=1$

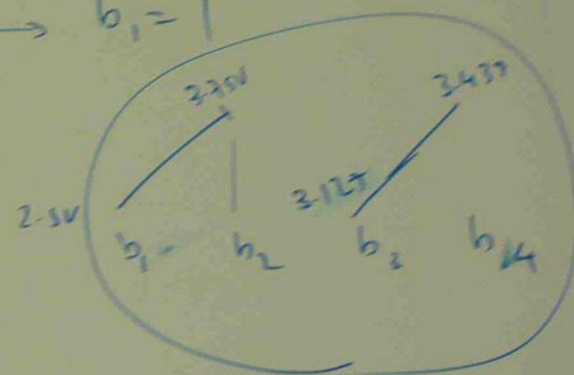
REF = 5V

$$V_f = V_{REF} \times 2^{-n} = 5 \times 2^{-1} = \frac{5}{2} = 2.5V$$

V_{in} COMPARES WITH V_f

$V_{in} > V_f \longrightarrow b_1 = 1$

3.217   2.5



II SET $n=2$

$$V_f = V_{ref} \times 2^{-n} + \frac{V_{ref}}{2}$$

$$= 5 \times 2^{-2} + \frac{5}{2}$$

$$= 3.75V$$

V_{in} COMPARES WITH V_f $V_{in} < V_f \rightarrow b_2 = 0$

3.217   3.75

III SET $n = 3$

$$V_f = V_{ref} \times 2^{-n} + \frac{V_{ref}}{2}$$

$$= 5 \times 2^{-3} + \frac{5}{2}$$

$$= 3.127 \text{ V}$$

V_{IN} COMPARES WITH V_f $V_{IN} > V_f \longrightarrow b_3 = 1$

3.217 3.127

IV SET $n = 4$

$$V_f = V_{REF} \times 2^{-n} + \frac{V_{REF}}{2}$$

$$= 5 \times 2^{-4} + \frac{5}{2}$$

$$= 3.437 \text{ V}$$

V_{IN} COMPARES WITH V_f $V_{IN} < V_f \rightarrow b_4 = 0$

3.217 3.437

b_1	b_2	b_3	b_4
1	0	1	0

RAMP A/D (RAMP ANALOG TO DIGITAL CONVERTER)

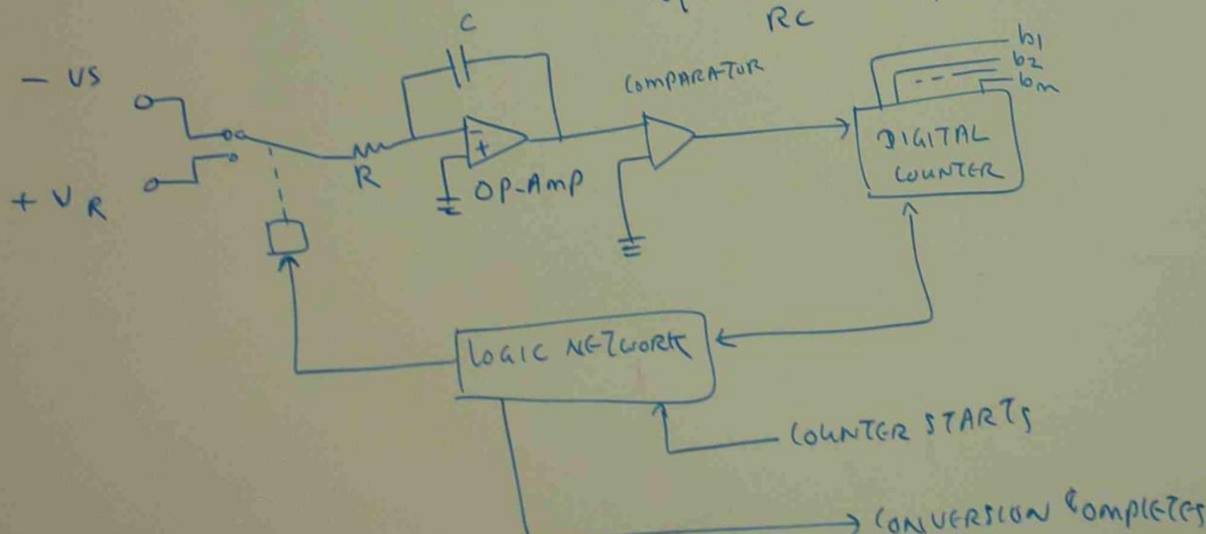
THE RAMP TYPE A/D CONVERTERS ESSENTIALLY COMPARE THE INPUT VOLTAGE AGAINST A LINEARLY INCREASING RAMP VOLTAGE.

DUAL SLOPE A/D

THE INPUT SIGNAL TO DRIVE THE INTEGRATOR FOR A FIXED TIME (T_1)

GENERATING OUTPUT $V_1 = \frac{1}{RC} \int V_x \, dt$

$$V_1 = \frac{1}{RC} T_1 V_x$$



A DUAL SLOPE ADC WAS AN OP-AMP INTEGRATOR, COMPARATOR AND ASSOCIATED DIGITAL CIRCUITS.

DIGITAL TO ANALOG CONVERTORS (DACS)

$$V_{out} = V_R \left[b_1 2^{-1} + b_2 2^{-2} + \cdots + b_n 2^{-n} \right]$$

V_{out} = ANALOG OUTPUT VOLTAGE

V_R: REFERENCE VOLTAGE

$b_1, b_2 \cdots b_n$ = n BIT BINARY WORD

$$V_{out} = \frac{N}{2^n} V_{ref}$$

Pb WHAT IS THE OUTPUT VOLTAGE OF A 10 BIT DAC WITH A 10 V REFERENCE IF THE INPUT IS (a) 001 0110101

(b) 20FH

(c) WHAT INPUT IS NEEDED FOR 6.5 V OUTPUT

(a) $V_{out} = V_{REF} (b_1 2^{-1} + b_2 2^{-2} + \cdots b_n 2^{-n})$

$= 10 (0\times 2^{-1} + 0\times 2^{-2} + 1\times 2^{-3} + 0\times 2^{-4} + 1\times 2^{-5} + 1\times 2^{-6} + 0\times 2^{-7} + 1\times 2^{-8} + 0\times 2^{-9} + 1\times 2^{-10})$

$= 10 \times 0.1767$

$= 1.767$ VOLT

(b) $20FH = 2\times 16^2 + 0\times 16^1 + 15\times 16^0 = 527_{10}$

2 1 0

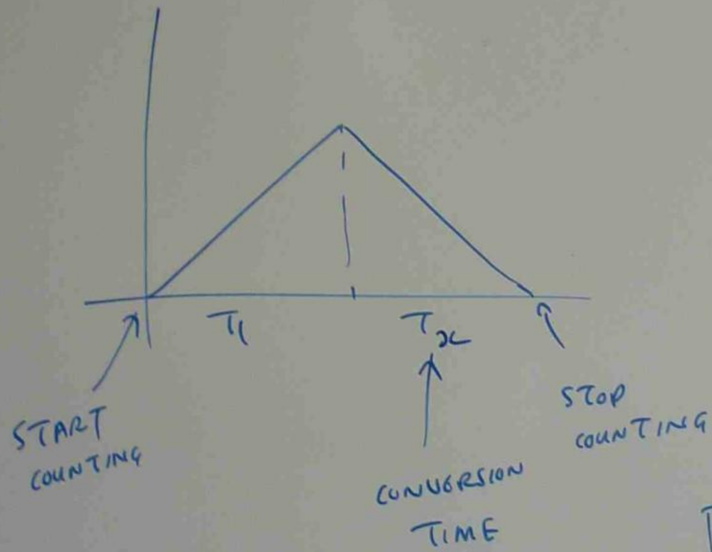
$$V_{out} = \frac{N}{2^n} V_{ref} = \frac{527}{2^{10}} \times 10 = 5.14648\ V$$

(c) $V_{out} = \frac{N}{2^n} V_{ref}$

$$6.5 = \frac{N}{2^{10}} \times 10$$

$$N = \frac{6.5 \times 2^{10}}{10} = 665.6 \simeq 665_{10}$$

Pb — A DUAL SLOPE ADC AS SHOWN IN FIGURE HAS $R = 100\,k\Omega$, $C = 0.01\,\mu F$. THE REFERENCE IS 10 V AND THE FIXED INTEGRATION TIME IS 10 ms. FIND THE CONVERSION TIME FOR 6.8 V INPUT.



$$\boxed{V_1 = \frac{1}{RC} T_1 V_x}$$

$$V_1 = \frac{1}{100\times10^{3} \times 0.01\times10^{-6}} \times 10\times10^{-3} \times 6.8$$

$$V_1 = 6.8\,V$$

$$\boxed{t_x = \text{CONVERSION TIME} = \frac{T_1 \times V_1}{V_R}}$$

$$= \frac{10\times10^{-3} \times 6.8}{10}$$

$$= 6.8\,ms$$

GENERAL CHARACTERISTICS

(1) INPUT   COMMON LEVEL $0 \to 10$, $0 \to 5$ V, $-10 \to +10$ V

(2) OUTPUT

A PARALLEL (OR) SERIAL BINARY WORD THAT IS ENCODING OF THE ANALOG INPUT

(3) REFERENCE

A STABLE, LOW RIPPLE SOURCE AGAINST WHICH THE CONVERSION IS PERFORMED

(4) POWER SUPPLY

GENERALLY A BIPOLAR ± 12 V TO ± 18 V SUPPLY IS REQUIRED FOR THE ANALOG AMPLIFIERS AND COMPARATORS AND a $+5$ V SUPPLY FOR DIGITAL CIRCUITRY

(5) DIGITAL SIGNAL

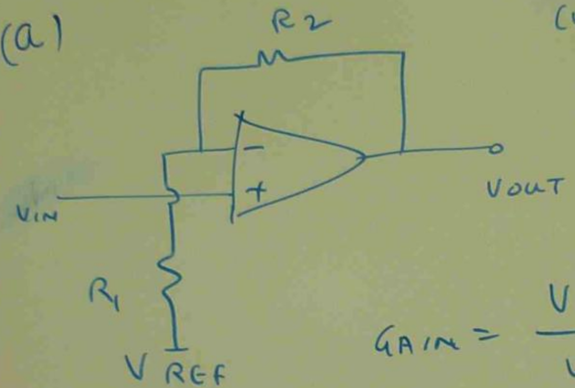
THE ADC USUALLY PROVIDES A HIGH LEVEL ON ANOTHER LINE AS AN INDICATOR.

pb

A MEASUREMENT OF TEMPERATURE USING A SENSOR THAT OUTPUTS 6.5 mV/°C MUST MEASURE TO 100°C. A 6 BIT ADC WITH A 10 V REFERENCE IS USED (a) DEVELOP AC CIRCUIT TO INTERFACE WITH THE SENSOR AND ADC

(b) FIND THE TEMPERATURE RESOLUTION.

(a)



$$GAIN = \frac{RF}{R1}$$

$$GAIN = \frac{VOUT}{VIN}$$

$V_{IN} = V/°C \times$ TEMPERATURE MEASURE

$= 6.5 \times 10^{-3} \times 100$

$= 0.65\,V$

$V_{OUT} = V_R(a_1 2^{-1} + a_2 2^{-2} + a_3 2^{-3} + \cdots a_6 2^{-6})$

$a_1 = 1,\ a_2 = 1,\ a_3 = 1 \cdots a_6 = 1$

$V_{OUT} = V_R(1 \times 2^{-1} + 1 \times 2^{-2} + \cdots 1 \times 2^{-6})$

$= 10\left(\frac{1}{2} + \frac{1}{2^2} + \frac{1}{2^3} + \frac{1}{2^4} + \frac{1}{2^5} + \frac{1}{2^6}\right)$

$= 9.84375\,V$

$$\text{GAIN} = \frac{V_{OUT}}{V_{IN}} = \frac{9.84375}{0.65} = 15.14$$

$$\text{GAIN} = \frac{R_F}{R_1}$$

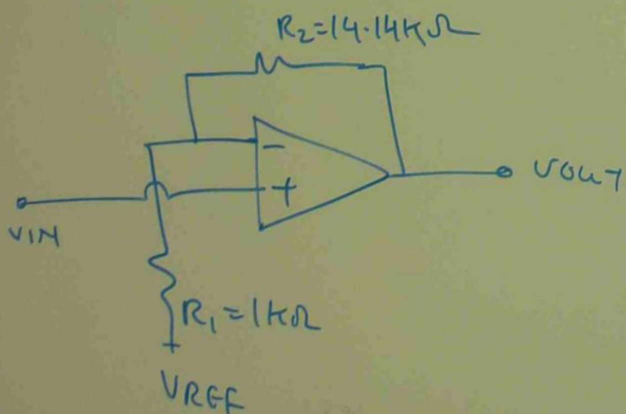
$$R_F = R_1 + R_2$$

$$15.14 = R_1 + R_2$$

SET $R_1 = 1\,k\Omega$

$$15.14 = 1 + R_2$$

$$R_2 = 14.14\,k\Omega$$



(b)

TEMPERATURE RESOLUTION

$$\boxed{\Delta T = \frac{\Delta V_T}{V/^\circ C}}$$

$$V/^\circ C = 6.5\,mV/^\circ C$$

$$\Delta V_T = ?$$

$$\boxed{\Delta V_T = \frac{\Delta V}{\text{GAIN}}}$$

$$\boxed{\Delta V = V_R \times 2^{-n}}$$

$$\Delta V = V_R \times 2^{-n}$$

$$\Delta V = 10 \times 2^{-6}$$

$$= 0.15625V$$

15.14 (b)

TEMPERATURE RESOLUTION

$$\boxed{\Delta T = \frac{\Delta V_T}{V/^\circ C}}$$

$V/^\circ C = 6.5\ mV/^\circ C$

$\Delta V_T = ?$

$$\boxed{\Delta V_T = \frac{\Delta V}{GAIN}}$$

$$\boxed{\Delta V = V_R \times 2^{-n}}$$

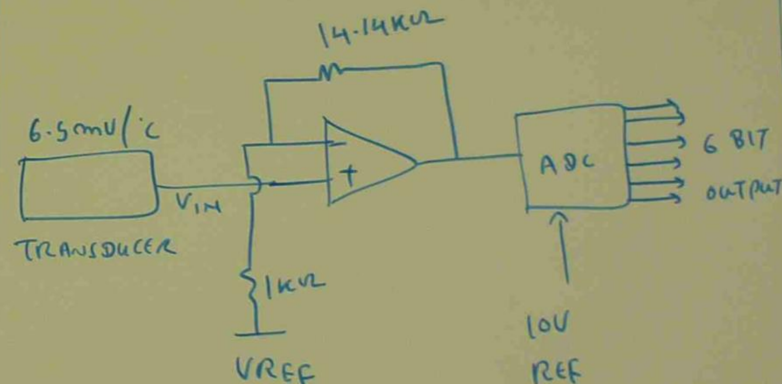
$\Delta V = V_R \times 2^{-n}$

$\Delta V = 10 \times 2^{-6}$

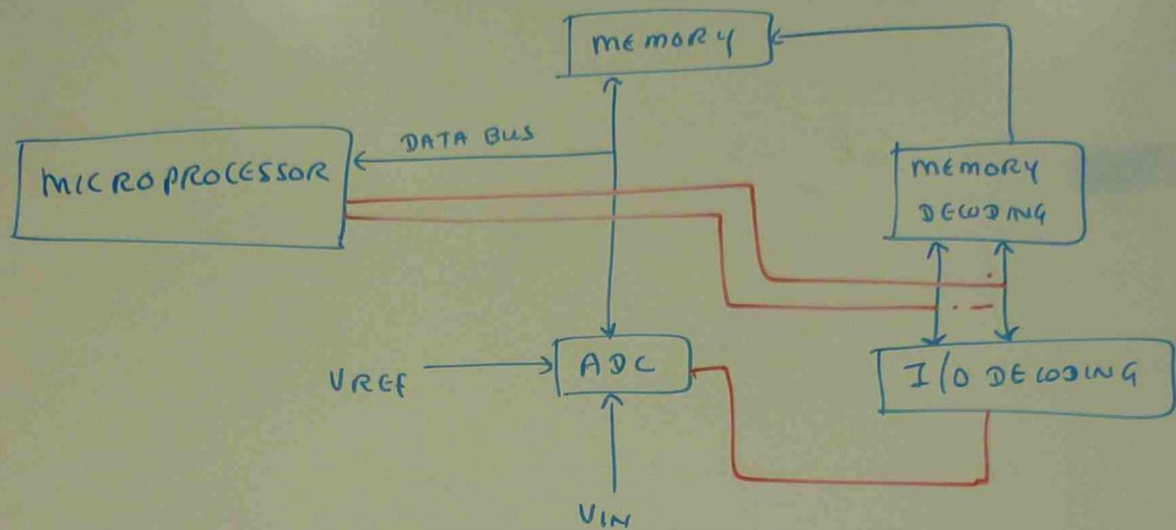
$= 0.15625 V$

$$\Delta V_T = \frac{\Delta V}{GAIN} = \frac{0.15625}{15.14} = 0.01012 V$$

$$\Delta T = \frac{\Delta V_T}{V/^\circ C} = \frac{0.01012}{6.5 \times 10^{-3}} = 1.5^\circ C$$



MICROPROCESSOR COMPATIBLE ADC



A WHOLE LINE OF ADC HAVE BEEN DEVELOPED THAT INTERFACE EASILY WITH MICROPROCESSOR BASED COMPUTERS.

THE ADCS HAVE BUILT IN TRISTATE OUTPUTS SO THAT THEY CAN BE CONNECTED DIRECTLY TO DATA BUS OF COMPUTER.

DATA FROM ADC IS ONLY PLACED ON DATA BUS LINES WHEN THE COMPUTER ISSUES AN APPROPRIATE ENABLE COMMAND (READ).

DATA INPUT BOARD

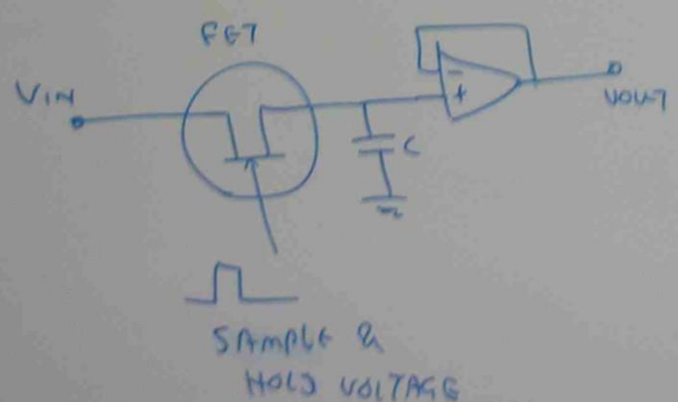
DATA INPUT BOARD, ADDRESSING, DECODING, BUS INTERFACE

REFERENCE FOR CONVERTERS.

SAMPLE AND HOLD

THE ADC REQUIRES A CERTAIN LENGTH OF TIME TO DETERMINE THE APPROPRIATE DIGITAL OUTPUT FROM AN ANALOG INPUT (TIME A FEW μS → ms)

DURING CONVERSION — IT IS NECESSARY TO FREEZE THE INPUT SIGNAL. THIS CAN BE DONE USING A SPECIAL OP-AMP CIRCUIT CALLED SAMPLE & HOLD



WHEN THE FET IS DRIVEN TO THE 'OPEN' STATE, THE VOLTAGE ON THE CAPACITOR WILL HOLD THE LAST VALUE BEFORE OPEN STATE OF FET OCCURS.

DATA ACQUISITION SYSTEM

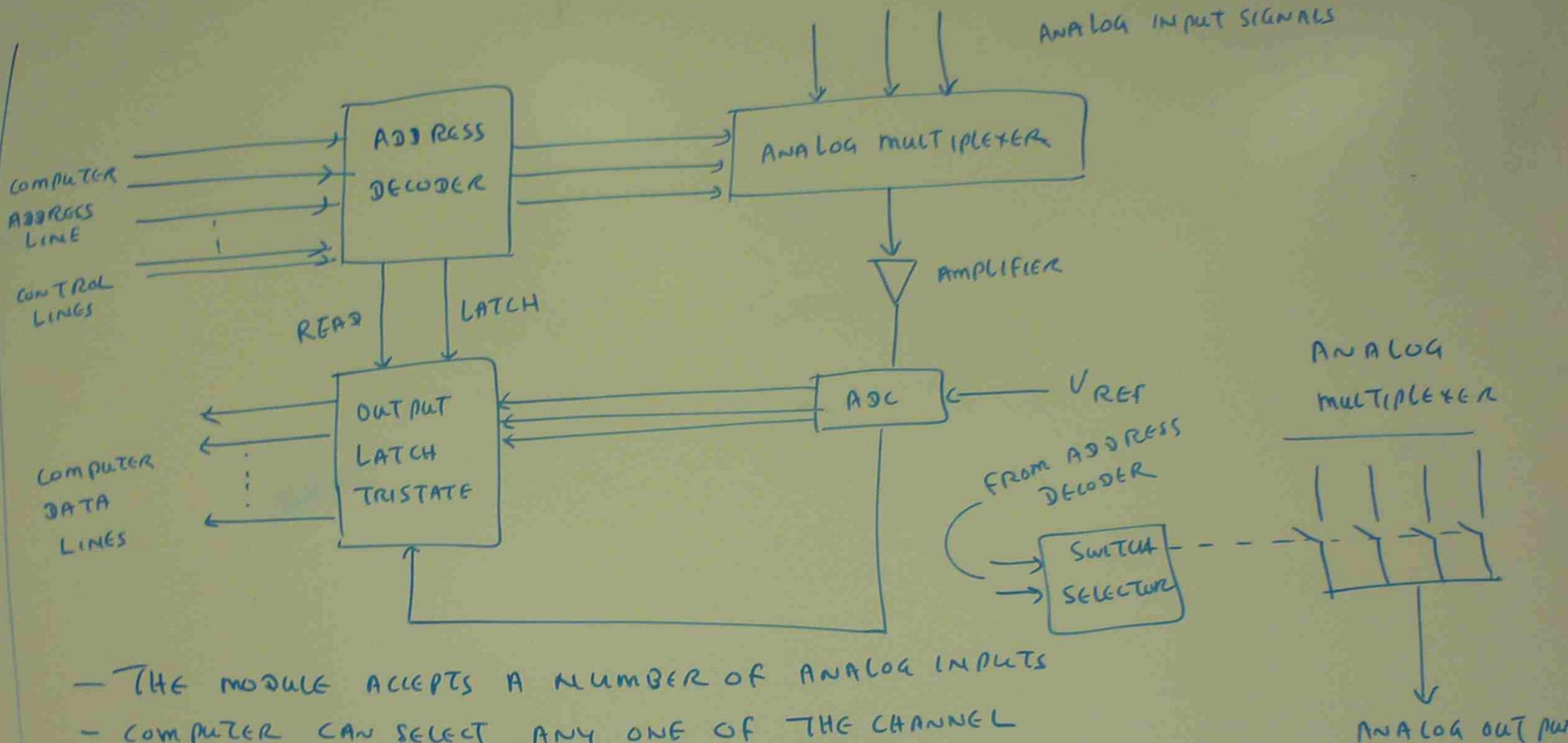
COMPUTER CONTROLS MANY VARIABLES.

COMPUTER PERIODICALLY SAMPLES THE VALUE OF A VARIABLE. EVALUATE IT ACCORDING TO PROGRAMMED CONTROL OPERATIONS AND OUTPUTS AN APPROPRIATE CONTROLLING SIGNAL TO THE FINAL CONTROL ELEMENT

(SAMPLE | EVALUATE (OUTPUT)

INTERFACE

NECESSARY AMPLIFIERS & WRITE THE PROGRAMS REQUIRED TO PUT TOGETHER AN INTERFACE TO SOME COMPUTERS FOR A PROCESS APPLICATION.



- THE MODULE ACCEPTS A NUMBER OF ANALOG INPUTS
- COMPUTER CAN SELECT ANY ONE OF THE CHANNEL UNDER PROGRAM CONTROL FOR INPUT DATA

- DAS (DATA ACQUISITION SYSTEM) ACCEPTS THE INPUT FROM THE COMPUTER VIA ADDRESS LINES.

AMPLIFIER

VARIABLE GAIN AMPLIFIER

ADC

THE ADC CONVERTER ACCEPTS THE VOLTAGES THAT SPAN A SPECIFIC RANGE AS PROVIDED BY THE PRECEEDING SIGNAL CONDITIONING

SAMPLE & HOLD

HOLD THE VALUE DURING THE CONVERSION.

HARDWARE PROGRAMMING

ADDRESS SELECTION, AMPLIFIER GAIN, DIFFERENTIAL SINGLE-ENDED OPERATION.

SELECT BY JUMPERS / PINS.

SOFTWARE PROGRAMMING

USE DATA MODULES.