CHAPTER 1

INTRODUCTION

Counting similar objects which are in large number is tedious and time consuming. Automation of such counting process is very much essential to reduce the manual effort and time.

A counting device based on microcontroller is suggested here. This method uses the equivalent weight of the items (which are assumed to be of similar in weight) to find the count. An LCD display is used for displaying the count. The project uses a cantilever beam type of load cell, instrumentation amplifier, 12-bit ADC and 8-bit 8051 which is flash ROM version of microcontroller and LCD display.

The load cell converts the weight into equivalent analog voltage. The voltage varies linearly with the weight applied on the load cell. The output of the load cell is very low, and hence it is necessary to amplify it to the desired level. An instrumentation amplifier is used for the purpose. It is a differential amplifier whose gain can be varied using a variable resistor to get desired output.

The analog voltage from the output of instrumentation amplifier is converted in to digital value using a 12-bit ADC-1674, which has a resolution of 2.44 mV. The microcontroller uses the digital equivalent obtained from the ADC to find the count of the objects. A flash ROM version of 8051 microcontroller (89C51) is used here. Finally the count is displayed on an LCD display.

This device has many applications other than counting. A modified version of this can be used for weighing purpose. This device is more flexible and reliable to use in various fields.

CHAPTER 2

BLOCK DIAGRAM

In this chapter a breif explaination of the counting device is given. The block diagram along with details of each block is presented.

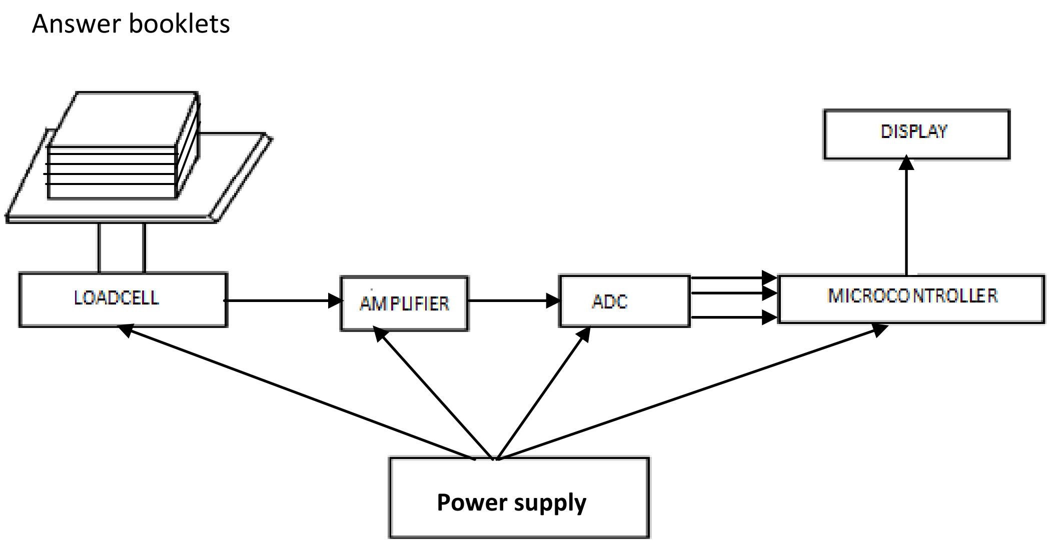

Figure (3.1): Block Diagram of Microcontroller Based Counting Device

Figure 3.1 shows the block diagram of microcontroller based counting device. The various blocks are Load cell, Instrumentation amplifier, Analog to Digital Converter, Microcontroller & Display.

2.1 LOAD CELL

Load cell is a transducer which converts weight in to electrical output. Cantilever beam type of load cell is used in this project. When weight is applied on load cell, a proportional electrical voltage will be produced at its output terminals.

2.2 INSTRUMENTATION AMPLIFIER

Instrumentation amplifier is a high input impedance, differential amplifier. Input to the amplifier is the output of load cell, which is a low level signal. To amplify the low level output signal of load cell to desirable level, we use instrumentation amplifier. It uses operational amplifiers.

2.3 ANALOG TO DIGITAL CONVERTER

Analog to Digital Converter is used to convert analog voltage obtained from instrumentation amplifier to digital value, which can be fed to microcontroller. A 12- bit ADC- 1674 is used, which has a resolution of 2.44mV.

2.4 MICROCONTROLLER

An 8-bit microcontroller 89C51 is used, which is flash ROM version of 8051. It uses digital value obtained from ADC to calculate the count.

2.5 LCD DISPLAY

A 16 characters, 2 lines LCD display is used to display the count of the objects kept on the load cell. Count required for display is obtained from microcontroller.

CHAPTER 3

SYSTEM HARDWARE

In this chapter, the details of each block of microcontroller based counting device are explained. Design specifications with details of each block are given.

3.1 LOAD CELL:

A load cell is a transducer which converts weight into electrical output. This conversion is indirect and happens in two stages. Through mechanical arrangements, the force being sensed deforms a strain gauge which converts the deformation (strain) to electrical signals. Different types of load cell available are Pancake load cell, S Beam load cell, Load button load cell, Single point load cell. Cantilever beam type of load cell is used which belongs to pancake type.

In the cantilever beam type of load cell one end is fixed and another end is movable as shown in figure 3.1. Weight is applied at the movable end, which causes beam to bend resulting in generation of strain. From principle of strain we know that when a beam is bent, strain generated at fixed end is larger compared to that of movable end. A resistive transducer is attached to fixed end.

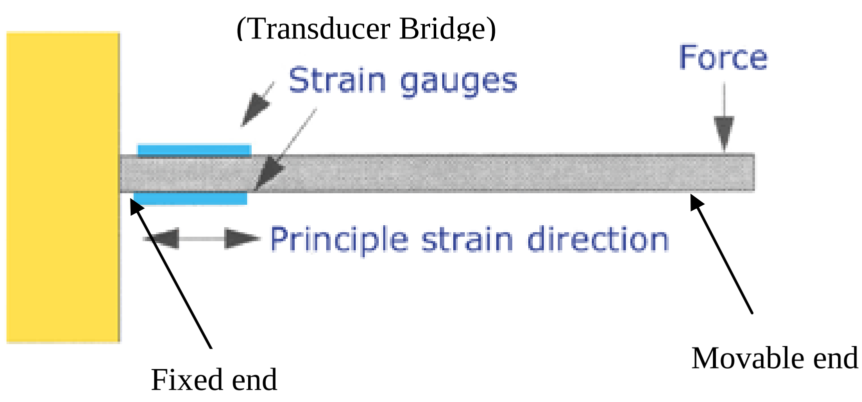

Fig 3.1: Block diagram of Cantilever Beam type Load cell

A strain gauge is a resistive transducer whose resistance changes due to elongation or compression of beam when an external stress is applied.

Figure 3.2 shows the circuit diagram of transducer bridge, which consists of a resistive transducer (R_T) and three resistors (R_A, R_B, R_C), which are arranged in the form of wheatstone network. DC bias voltage is applied across the terminal C & D, where as output is measured across terminal A & B. The DC voltage ranges from 6V-12V depending on the requirement. A 12V DC voltage is used in this project for load cell.

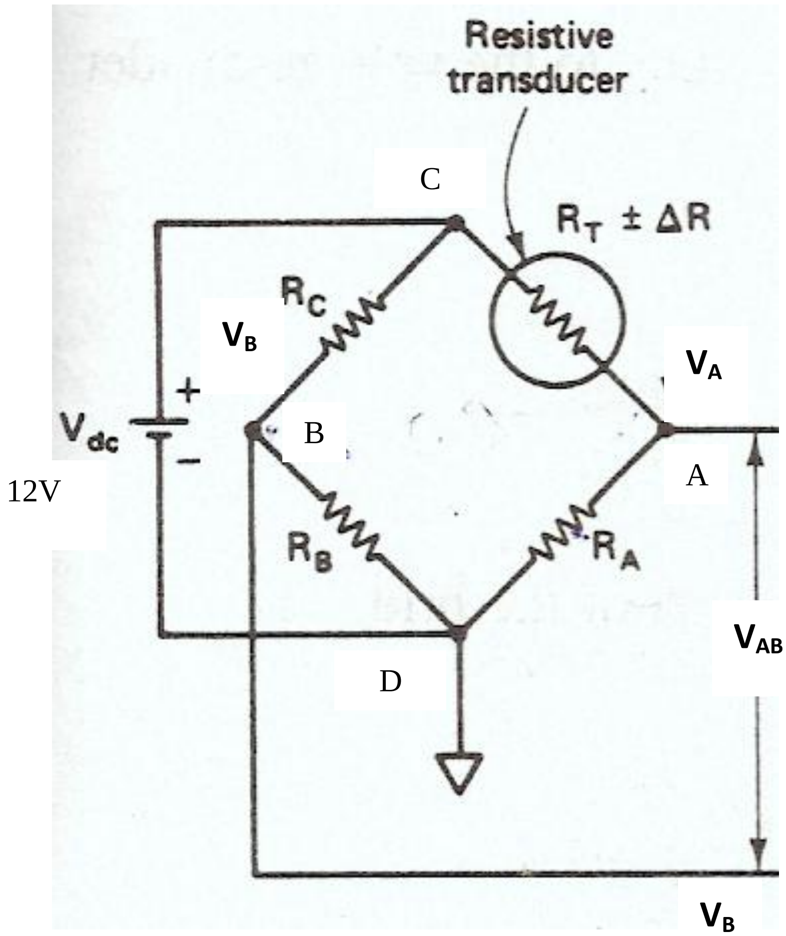

Fig 3.2: Transducer bridge

There may be one or more resistive transducers in a wheatstone network. The figure shown in 3.2 has only one resistive trasducer. If there is no strain then the bridge is balanced and if strain varies bridge will be unbalanced resulting in voltage across terminal A and B.

On application of a force *f* through weight at the movable end of the cantilever beam load cell, a bending moment proportional to force is developed in the beam, resulting in generation of large strain at the fixed end. A Strain gauge which is attached at the fixed end senses the stress which in turn varies the resistance of the resistive transducer, resulting in small voltage (V_{AB}) at the terminals A & B.

When no weight is applied on load cell i.e. (*f*=0). The resistive transducer R_T will not vary.

$$V_A = V_B \tag{3.1}$$

$$\text{i.e. } \frac{R_C}{R_B} = \frac{R_T}{R_A} \tag{3.2}$$

where R_T is transducer resistance.

After applying weight on load cell by keeping objects, the transducer bridge will be unbalanced $\text{i.e.}\, V_A \neq V_B$.

By applying voltage divider rule to Wheatstone bridge which is shown in figure 3.2,

$$V_A = \frac{R_A * V_{dc}}{(R_A + (R_T + \Delta R))} \tag{3.3}$$

$$V_B = \frac{R_B * V_{dc}}{(R_B + R_C)} \tag{3.4}$$

Output voltage of Load Cell is given by

$$V_{AB} = V_A - V_B \tag{3.5}$$

By substituting Eq.(3.3) and Eq.(3.4) in Eq.(3.5) and by setting $R_A = R_B = R_C = R_T = R$

$$V_{AB} = \frac{(\Delta R * V_{dc})}{(2 * (2R + \Delta R))} \tag{3.6}$$

From Eq.(3.6) we can notice that voltage V_{AB} varies if there is any change in resistance ΔR., which inturn depends on weight applied on load cell.

3.2 INSTRUMENTATION AMPLIFIER

An instrumentation amplifier is a type of differential amplifier. The characteristics of instrumentation amplifier are very low DC offset, low drift, low noise, very high open loop gain, very high common-mode rejection ratio, and very high impedance.

The output of the load cell is low, which needs to be amplified before further processing. An instrumentation amplifier designed using 3- operational amplifier is shown in figure 3.3

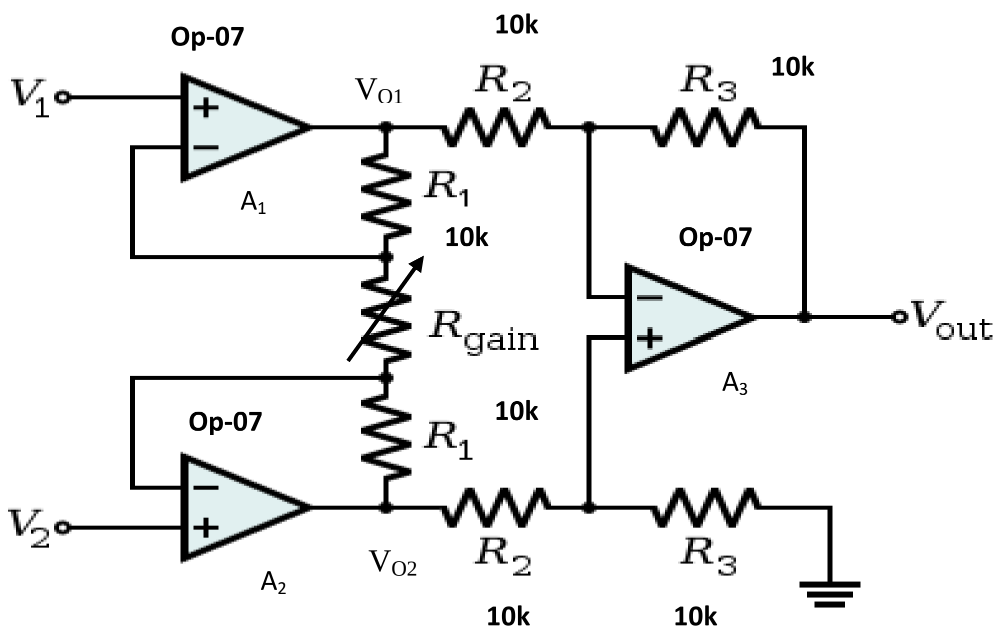

Figure 3.3 Instrumentation amplifier circuit

The instrumentation amplifier has two stages namely gain stage and difference stage. Circuit shown in figure 3.3 uses three operational amplifiers for the implementation of gain stage and difference stage. Each amplifier has a specific function. With circuit combination as shown in figure 3.3, two of the three operational amplifiers i.e. A_1 & A_2 are used to provide gain to the two input signals and to provide impedance matching. The third amplifier A_3 subtracts the two gained input signals, thereby providing a difference stage, and thus producing an amplified output at the output terminal of A_3 op-amp.

Design :

By virtual ground concept and superposition theorem, output voltage at Op-amp A_1 and A_2 is given by

$$V_{O1}= \left(1+\frac{R_1}{R_{GAIN}}\right)*V_1-\left(\frac{R_1}{R_{GAIN}}\right)*V_2 \qquad (3.7)$$

$$V_{O2}= \left(1+\frac{R_1}{R_{GAIN}}\right)*V_2-\left(\frac{R_1}{R_{GAIN}}\right)*V_1 \qquad (3.8)$$

From figure 3.3, $$V_{OUT}=\frac{R_3}{R_2}*(V_{O2}-V_{O1}) \qquad (3.9)$$

The gain of instrumentation amplifier is obtained by substituting Eq.(3.7) and Eq.(3.8) in Eq.(3.9).

$$V_{OUT}=\frac{R_3}{R_2}*\{\left(1+\frac{R_1}{R_{GAIN}}\right)*V_2-\left(\frac{R_1}{R_{GAIN}}\right)*V_1-\left(1+\frac{R_1}{R_{GAIN}}\right)*V_1+\left(\frac{R_1}{R_{GAIN}}\right)*V_2\} \qquad (3.10)$$

$$V_{OUT}=\{\left(1+\frac{2R_1}{R_{GAIN}}\right)*V_2-\left(1+\frac{2R_1}{R_{GAIN}}\right)*V_1\}*\left(\frac{R_3}{R_2}\right) \qquad (3.11)$$

$$V_{OUT}=\left(1+\frac{2R_1}{R_{GAIN}}\right)*\left(\frac{R_3}{R_2}\right)*(V_2-V_1) \qquad (3.12)$$

by setting $R_3=R_2=R_1$ in Eq.(3.12)

$$V_{OUT}=A*(V_2-V_1) \qquad (3.13)$$

where $$A=1+\frac{2R_1}{R_{GAIN}}$$

The basic idea behind this project is for an object kept on load cell we must get an output of 38mV to 39mV from the instrumentation amplifier for counting the objects accurately. To get the required output, the variable gain resistor (R_{GAIN}) of the amplifier is adjusted suitably.

3.3 ANALOG TO DIGITAL CONVERTOR

The voltage signal obtained from the output of the instrumentation amplifier circuit is to be digitized in order to be fed to a microcontroller. For this purpose a 12 bit ADC-1674 is used.

Features of ADC 1674

- Complete monolithic 12- Bit ADC .
- Sampling rate of ADC is 10 μs.
- It has optional analog multiplexer to enable the one of the eight different analog sources.
- On board Sample and Hold Amplifier
- Industry Standard Pinout
- 8 and 16 Bit Microprocessor and Microcontroller Interface
- AC and DC specified and tested
- Analog source can be unipolar (0- 10V, 0- 20V) or bipolar Inputs (±5V, ±10V).
- Resolution of ADC is 2.44 mV for input range of 0 to 10 mV.

Resolution of ADC-1674 is given by

$$\mathrm{RESOLUTION} = \frac{\mathrm{V_{REF}}}{2^{\mathrm{N}-1}} \tag{3.14}$$

Where N is the number of bits. For N=12 and $\mathrm{V_{REF}}$=10V, $\mathrm{RESOLUTION} = 2.44\ m\mathrm{V}$

The instrumentation amplifier is designed to give the output voltage in steps of 38mV for every booklet kept on load cell. Output of instrumentation amplifier is fed to the ADC-1674 which has resolution of 2.44 mV and thus the desired output is obtained. The digital output of ADC is as shown in table 3.1.

Change in digital value per booklet $= \left(\frac{38\ \mathrm{mV}}{2.44\ \mathrm{mV}}\right)$=16 (Theoretical value)

\

Table 3.1. Digital output of ADC for corresponding increse in input in steps of 38mV

Analog input in mV	Digital output (D_{11}-D_0)	In hexadecimal
0	000000000000	000
38	000000010000	010
76	000001001100	020
114	000001110010	030
152	000010011000	040

From table 3.1, we can observe that the hexadecimal values in the last colum increses by 0X10 (16_D) value for corresponding increase in ADC input value by 38 mV. Hence instrumentation amplifier is designed such that the change in voltage for increse in 1 booklet kept on load cell must be equal 38 mV.

3.4 POWER SUPPLY

The various blocks in the project needs DC supply for the operation. Regulated power supply with various ratings is designed.

3.4.1 BLOCK DIAGRAM OF POWER SUPPLY

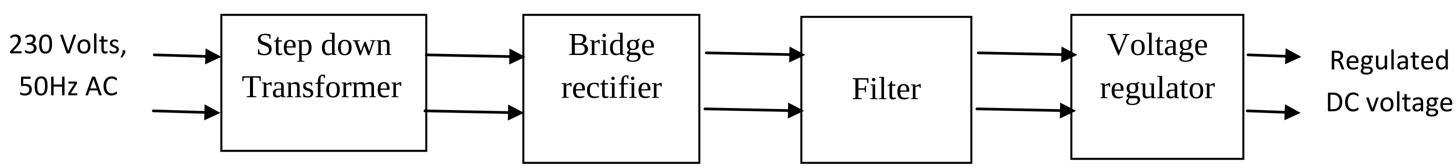

Figure 3.4: Block diagram of power supply

Transformer:

A step down transformer is used to reduce the voltage level from 230V to required voltage level (depending on DC supply voltage required for various components of circuit).

Rectifier and Filter:

Rectifier is used to convert AC to pulsating DC. Bridge rectifier is preferred over full wave rectifier as it requires no centre tap, it has higher transformer utilization factor and the PIV (peak inverse voltage) of a diode in a bridge rectifier is half the PIV of a diode in full wave rectifier. Further, the AC ripple is removed using a filter. A capacitor filter is used for the purpose.

Regulator:

A regulator IC is used to get the required DC voltage. A regulated DC output of required voltage is obtained from the unregulated DC. Different regulator ICs are available for various DC voltage levels.

3.4.2 POWER SUPPLY CIRCUIT

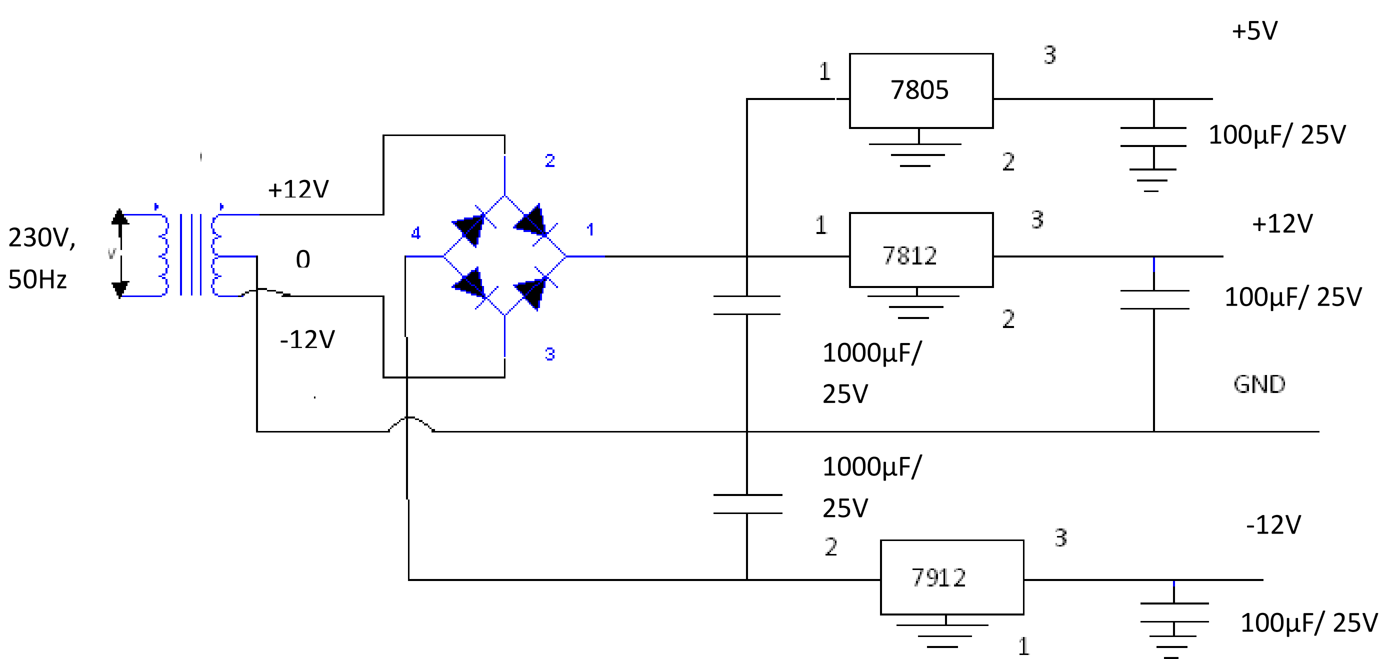

Figure 3.5: Circuit diagram of power supply

DESIGN:

1) For unregulated voltage, V_{dc}=16V, I_{dc}=125 mA, γ=0.02.

$$\therefore R_L = \frac{V_{dc}}{I_{dc}} = 128\Omega \qquad (3.15)$$

Ripple factor is given by

$$\gamma = \frac{1}{4\sqrt{3}fCR_L} \Rightarrow C = 1070\ \mu F \qquad (3.16)$$

We know that, for a full wave rectifier with filter

$$V_m = V_{dc} + \frac{I_{dc}}{4fC} \qquad (3.17)$$

$$V_m = 16.66V$$

Choose C=1000 μF / 25V

V_{rms} is given by

$$V_{rms} = \frac{V_m}{\sqrt{2}} \qquad (3.18)$$

$$V_{rms} = 11.78V$$

A 12-0-12 transformer is used.

CHAPTER 4

SYSTEM SOFTWARE

This project is implemented in KEIL µVISION3 using Windows XP in an Intel Core 2 Duo CPU @ 2.2GHz.

Software part includes initialization of LCD display and converting digital value to count, converts hexadecimal. In this chapter flowchart and ALP program is given.

4.1 FLOWCHART:

4.1a) TO CONVERT A SINGLE BYTE HEXADECIMAL NUMBER TO DECIMAL NUMBER

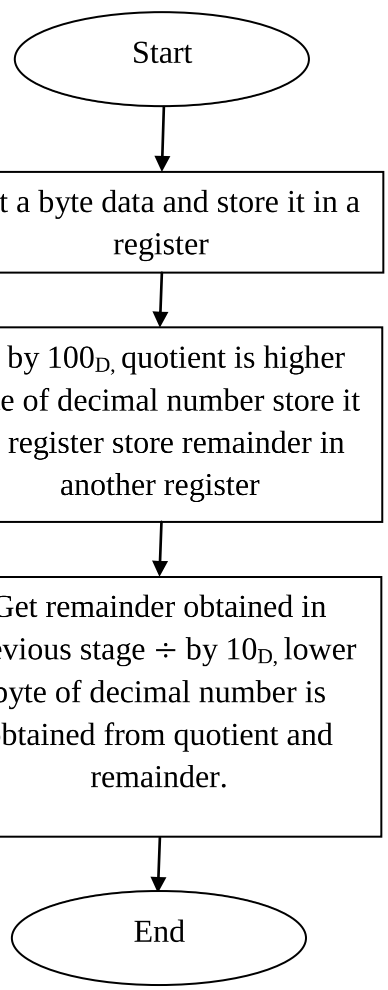

Figure 4.1: Flow chart to convert Hexadecimal number to Decimal number

4.1b) TO CONVERT DECIMAL NUMBER TO ASCII FORMAT

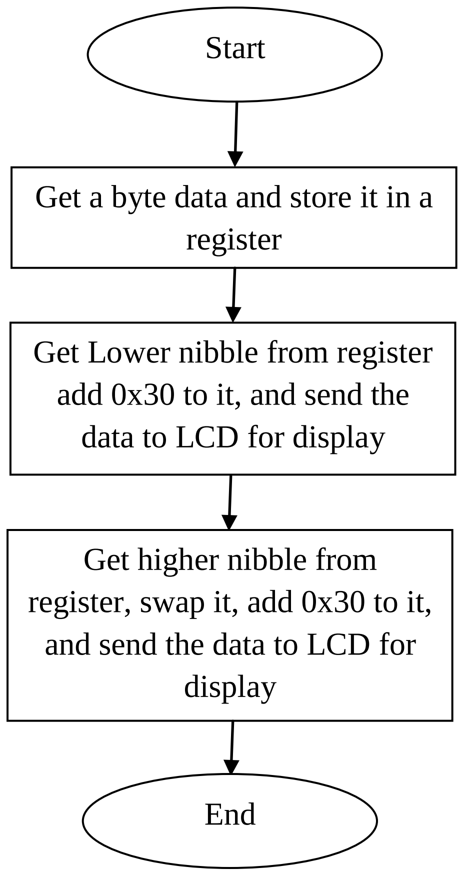

Figure 4.2: Flow chart to convert Decimal number to ASCII format

4.1c) TO CONVERT DIGITAL DATA FROM LCD TO COUNT AND DIPLAY IT ON LCD

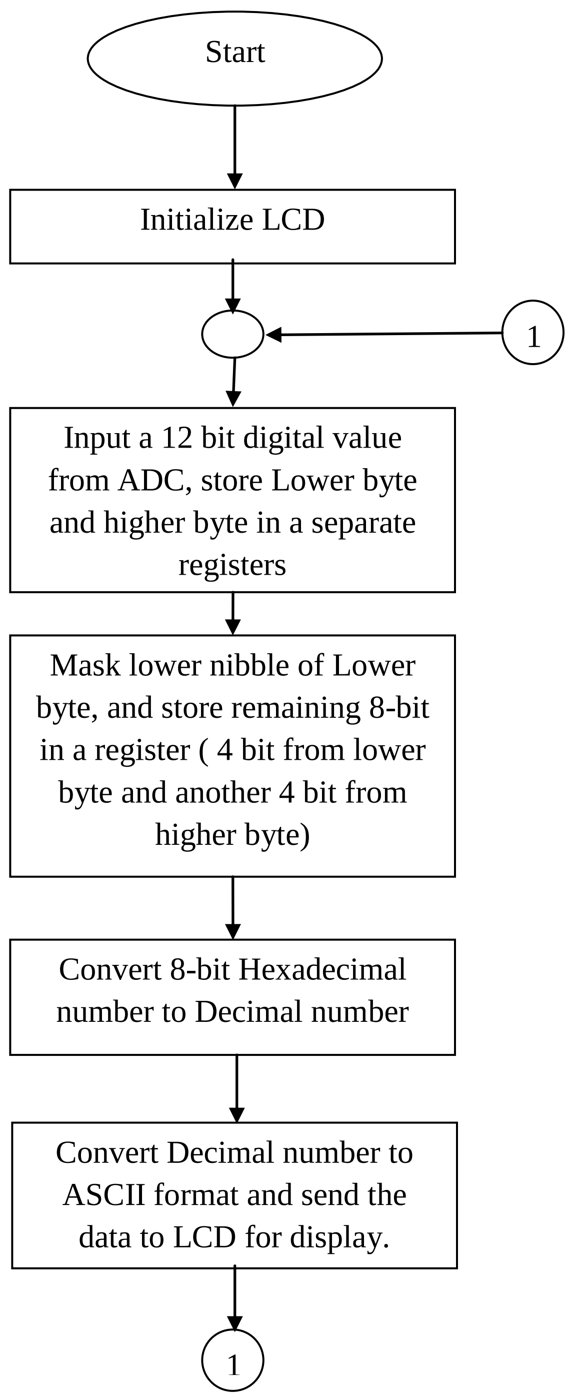

Figure 4.2: Flow chart to convert digital data from ADC to count and display it on LCD

4.2 PROGRAM

```
#DEFINE   LCDCLR        0X0E2F9
#DEFINE   LCDSTATUS     0X0E2D3
#DEFINE   LCDSTR        0X0E39E
#DEFINE   GOTOXY        0X0E380
#DEFINE   LCDDAT        0X0E2B4
#DEFINE   HEXASC        0X0E3B0
#DEFINE   DELAY         0X0E2EE
CDATA     DATA          0X64
CDATA1    DATA          0X66
CHA       DATA          0X60

          ORG       0000H
          SJMP      30H
          ORG       30H

          LCALL     LCDSTATUS
          LCALL     LCDCLR
          MOV       DPTR, #MSG
          LCALL     LCDSTR
          MOV       0F0H, #01H
          MOV       R0, #00H
          LCALL     GOTOXY
          MOV       DPTR, #MSG1        /* DISPLAY THE ABOVE STRING ON LCD*/
          LCALL     LCDSTR
          MOV       P0, #0FFh          /*INITIALIZE THE P0, P1 AS INPUT AND P2  AS   OUTPUT*/
          MOV       P1, #0FFH
          MOV       P2, #00H
          MOV       CHA, #00H
          MOV       CDATA, #00H
          MOV       CDATA1, #00H
```

```
NXTCHA:
        CALL     CONVERT
        CALL     DISCHAN_NO     /*GET THE CHANNEL NO. FOR  DISPLAYING*/
        MOV      0F0H, #01H
        MOV      R0, #08H
        LCALL    GOTOXY
        MOV      A, #00H
        LCALL    HEXASC
        LCALL    LCDDAT
        MOV      A, CDATA1
        LCALL    HEXASC
        LCALL    LCDDAT
        MOV      A, CDATA
        SWAP     A
        LCALL    HEXASC
        LCALL    LCDDAT
        MOV      A, CDATA
        LCALL    HEXASC
        LCALL    LCDDAT
        SJMP     NXTCHA
DISCHAN_NO:
        MOV      0F0H, #0H
        MOV      R0, #0EH
        LCALL    GOTOXY
        MOV      A, CHA
DISPCH:
        MOV      A, CHA
DISPCH1:
        SWAP     A
        LCALL    HEXASC
        LCALL    LCDDAT
```

```
        MOV     A, CHA
        LCALL   HEXASC
        LCALL   LCDDAT
        RET
```

CHAN_0:

```
        MOV     CHA, #00H
        MOV     P2, #00H
        SJMP    NXTCHA
```

CONVERT:

```
        MOV     A, #03H
        MOV     P2, A
        CLR     A
        MOVC    A, @A+DPTR
        ORL     A, #23H
        NOP
        MOV     P2, A
        NOP
        CLR     P2.1
        NOP
        SETB    P2.1
        NOP
        CLR     P2.0
        MOV     A, P0
        ANL     A, #0F0H
        SWAP    A
        MOV     R0, A
        MOV     A, P1
        ANL     A, #0FH
        SWAP    A
        ORL     A, R0
        MOV     B, #100
```

```
        DIV     AB
        MOV     R1, A
        MOV     A, B
        MOV     B, #10
        DIV     AB
        SWAP    A
        ORL     A, B
        MOV     CDATA, A
        MOV     A, R2
        MOV     CDATA1, A
        SETB    P2.0
        RET
MSG:
        DB ‘CHANNEL=’, 00
MSG1:
        DB ‘VALUE=’, 00
```

CHAPTER 5

CONCLUSION

A microcontroller based counting device is designed and tested successfully in this project. The weight of the objects is used to obtain the count. The device helps in fast counting of objects. The counting device is very flexible and reliable to be used in various forms not only in small scale but also in large scale industry too.

APPLICATIONS

- Slightly modified version of this device can be used as a weighing device.
- This device can also be used to count very small objects like tablets, coins etc.

LIMITATION

- The objects to be counted must be of same weight.

BIBLIOGRAPHY

1. Ramakanth A. Gayakwad, "Linear IC's and applications", Prentice- Hall of India , 1987- 1st Edition.
2. Douglas V.hall, "Microprocessor and Interfacing Programming ",Tata Mc Graw-Hill 1991- 7th Edition.
3. Muhammad Ali Mazidi "The 8051 Microcontroller and Embedded Systems", Pearson Education, 2008- 2nd Edition.
4. K.V. Ramanan "Functional Electronics", Tata Mc Graw-Hill.
5. www. Electronics4u.com.
6. www.loadcell.com.
7. www.analogelectroniccircuits.com.
8. www.wikipedia.com.