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Embedded Systems: 8085 Microprocessor Based Parcel Price Calculator

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ABSTRACT

Delivery of packages from one place to another over short to long distances has always been an important part of business enterprises. With the rise of online shopping and e-commerce, the delivery business has expanded. It is essential to standardize the cost of delivering packages and calculate the price easily, accurately and quickly. This requires digitisation and automation. This paper discusses the design of a digital embedded parcel price calculator based on an8-bit micro processor 8085. The price of delivering aparcel depends on the weight of the package, the volume and the delivery distance. Hence, this embedded system has two components- digital electronic weight machine and length (hence volume) measurement using an ultrasonic sensor. The weight machine employs a load cell, which measures the weight with great accuracy and speed. The digitisation of the analog signals from the load cell pressure sensor is done using an easily interfaced 8-bit ADC. The price due to the weight and the volume is computed separately in the microprocessor. The total price, that is the sum of the two is seen on an LCD display. The paper concludes by discussing a few enhancements in the design of the system for industrialapplications.

Keywords- 8085, 8-bit ADC, embedded systems, instrumentation amplifier, load cell, microprocessor, ultrasonic sensor

I. INTRODUCTION

Couriers are distinguished from ordinary mail services by features such as speed and swift delivery times and their use is limited to packages. With a rise in the courier services, it is important that the price is computed quickly, accurately and with minimum efforts. Also, it is essential that the price is standardised based on reasonable parameters. These parameters are the weight and volume of the package and the delivery distance. Hence,there needs to be asystemin place which easily and accurately measures the weight and the volume of the package and computes a price corresponding to that. The system must be easy to handle and use. Such a system would save manpower as well as time for the courier companies. Further, stand ardisation of the cost of delivery would be advantageous for the customers. The proposed system uses a highly sensitive straight rectangular bar load cell and an easily interfaced 8-bit ADC 0804 to measure weight accurately. Precision can be improved using 24-bit ADCs, which are comparatively difficult to interface. Also, ultrasonic module, HC-SR04 is reasonably accurate for length measurements and hence reliable for correct volume calculations.

II. EMBEDDED SYSTEMDESCRIPTION

2.1 Electronic Weight Machine

8085 Microprocessor based electronic weighing machine is used for measuring the weight of the parcel and

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indicating it ona digital display.

The itemto be weight displaced on a platform. The weight is determined by the machine and displayed on a LCD display. Microprocessor based electronic balance consists of rectangular bar load cell, instrumentation amplifier, 8-bit analog to digital converter and a LCD.

The electronic balance has a load cell pressure transducer. It converts the weight in to a proportional electrical signal.ThesensingresistanceintheloadcellformsaWheatstonebridge.Withnoloadontheplatform,thebridge is balanced. On placing the load, the resistance of one arm will change. This produces an output of the order of few millivolts. The small signal is amplified by an instrumentation amplifier. This amplifier provides an output signal to the required level of analog to digitalconverter.

The load cell can have a max load of 10kg. It will produce 5mv output for a 10kg load. Hence, the output voltage produced for 100g load= 5mV/100=50uV.

The ADC converts the analo gvol tagein to a digitals ignal as needed by the micro processor. Through anI/Oport, output of the ADC is connected to the micro processor.The micro processor reads the data, and internally compares it with 8 bit words stored in the memory to deicide the weight and compute the corresponding price. TABLE1

The price and the measured weight is displayed on LCD display with a resolution of 2 decimal places (i.e.50g). The weight machine would display maximum 5kg.

Weight	Price(INR)
50g-200g	20
200g-500g	30
500g-1.5kg	50
1.5kg-3.5kg	70
3.5kg-5.00kg	90

Table 1. Price Chart for Weight

2.2 VOLUME MEASUREMNT USING ULTRASONICSENSOR

An Ultrasonic sensor is a device that can measure the distance to an object by using sound waves. It measures distance by sending out a sound wave at a specific frequency and listening for that sound wave to bounce back. By recording the elapsed time between the sound wave being generated and the sound wave bouncing back, it is possible to calculate the distance between the sonar sensor and the object.

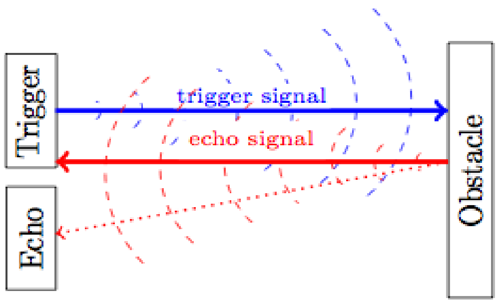

Fig.1 Basic ultrasonic sensor operation

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Since it is known that sound travels through air at about 344 m/s, the time taken for the sound wave to return, multiplied 344 gives the total round-trip distance of the sound wave. Round-trip means that the sound wave travelled2timesthedistancetotheobjectbeforeitwasdetectedbythesensor;itincludesthe'trip'fromthesonar sensor to the object AND the 'trip' from the object to the Ultrasonic sensor (after the sound wave bounced off the object). To find the distance to the object, simply divide the round-trip distance in half[1].

(1) Distance= (Time Elapsed*Speed of Sound) /2

The three dimensions (length,width,height) of the pack age are determined using the ultrasonics ensorbyplacing it on the platform in three different orientations. And the volume is determined using theformula-

(2) Volume=Length*Height*Width

The length of the side to be measured is placed opposite to the ultrasonic sensor against the back wall of the casing. To determine the length, the reading of the sensor from the front face is subtracted from reading from the back wall of the casing touching the back face of the package.

The volume is computed by the microprocessor by using the above formula and the price corresponding to the calculated volume is displayed in accordance with a pre-defined chart.

TABLE 2

Dimensions(cm)	Volume(cm3)	Price(INR)
4x4x4	64	50
8x8x8	512	50
10x10x10	1000	70
11x11x11	1331	100
12x12x12	1728	120
13x13x13	2197	145
14x14x14	2744	170
15x15x15	3375	185
16x16x16	4096	210
17x17x17	4913	235
18x18x18	5832	260
	>5832	320

Table 2. Price Chart for Volume

The formula to calculate the total price of delivery wouldbe-

(3) Total Price= Price due to weight + Price due tovolume

This price would be the base price which can be multiplied by a factor for the delivery distance.

The following block diagram describes the 8085 based Embedded System. Fig.2

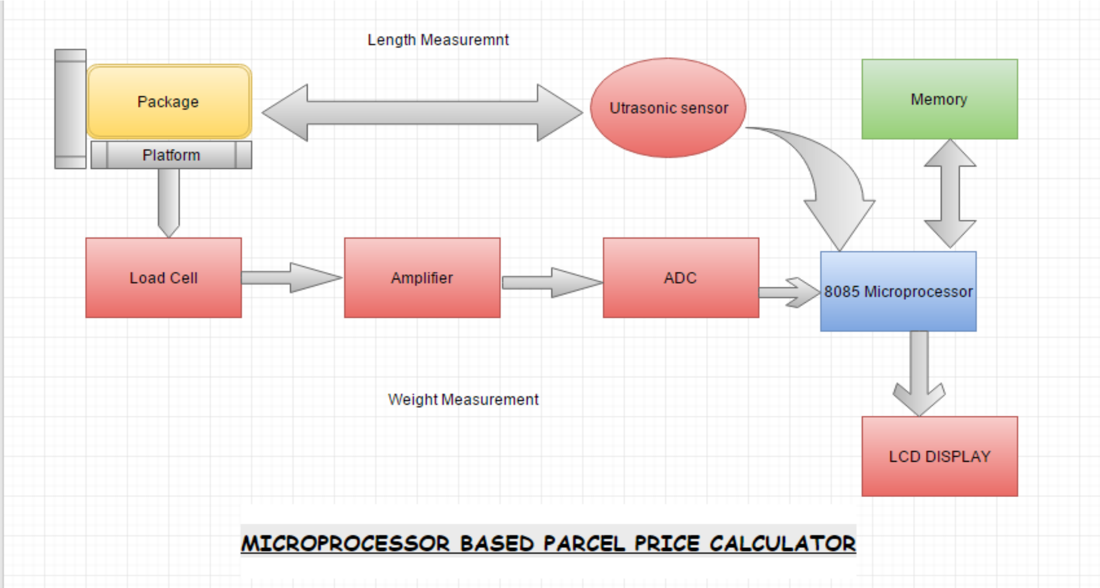

Fig.2 Block Diagram of the Embedded System

III. HARDWARE DESCRIPTION

3.1 The Clock

This system runs at a frequency of 2MHz.The source being a 4MHz Quartz Crystal, having 22 pF ceramic capacitor at the X2 terminal of 8085. This capacitor provides enough loading for the crystal to build up oscillations.

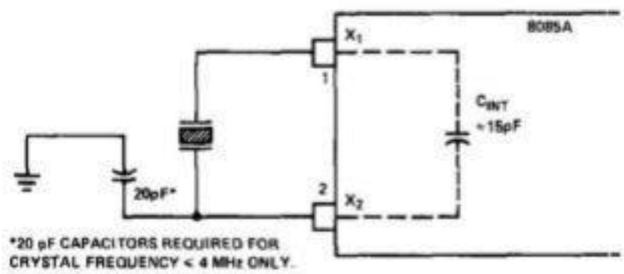

Fig.3 Quartz Crystal clock driver

3.2 Reset Switch

It brings back the system to the default stage that is when pressed, it starts the execution from the beginning of the program stored in the ROM of the system.

3.3 Memory Interfacing

The system has a 32K EEPROM with address range from 0000H to7FFFH. This is a non-volatile and electronically erasable memory which contains the machine code. The system also consists a 32K RAM with address range from 8000H to FFFF H. It is volatile and holds variable and other processing data. The data is lost on reset or power off.

8085 has a 16-bit address bus which means that there are 64K memory address locations. Since, the program running the system should stay in the memory even when the power is turned off, it is stored in a non-volatile memory that is ROM. Also, at the time of powering up, the Program counter has the value 0000H corresponding to

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first memory location.This is the default state of any system.Thus,the execution starts from the location 0000H when the system is reset. This justifies the selected address range for theROM.

To reduce the address decoding circuitry, the 64K memory locations are divided into two halves. First 32K memory locations correspond do 28C256, a 32 KEEPRO Mand the next 32K memory locations were allocated to 62256, a 32KRAM. Any of the 32K locations is addressed using A0-A14 address lines. To distinguish between RAM and ROM as used in this system, only one address line is required. Hence, the A15 of the address bus is connected to the active low Chip Enable input of the ROM IC and an inverted A15* signal is generated which is connected to active low chip enable of the RAM IC. When A15 would be zero, ROM will be enabled and when A15 would be 1, RAM will beselected.

To generate read/write signals for memory and I/O a 3 to 8 decoder, 74HCT138 is used. Input to the decoder are RD*, WR*and IO/M* lines from the 8085 microprocessor IC. Decoding all these signals, four useful signals- IOW*, IOR, MEMR*, MEMW* are generated to enable the IO and memory peripherals as and when required.

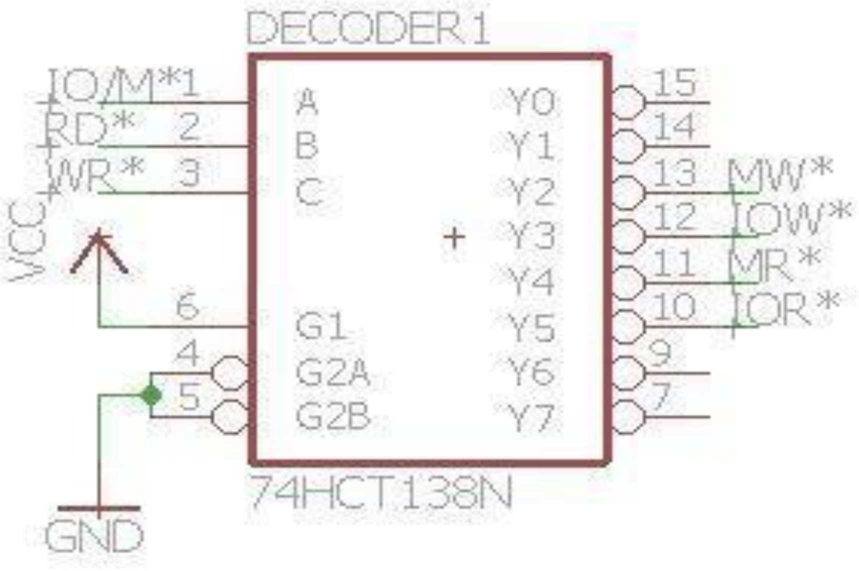

Fig.4 Decoding of the IO/M, RD, WR signals from 8085

3.4. Analog to Digital Conversion (ADC0804)

ADC0804 is an 8-bit analog to digital convertor. It is a single channel IC, *i.e.*, it can take only one analog signal as input. The digital outputs vary from 0 to a maximum of 255. Step Size of an ADC is the input analog voltage level which would cause a change of one bit in the digital output. The step size can be adjusted by setting the reference voltage at pin 9 of 0804 [2]. To obtain a full-scale output voltage at 5V that is, 255 ,5/2= 2.5V is given at V ref.

Hence the step size is 255/5=19.53 mV ADC 0804 needs a clock to operate. The time taken to convert the analog value to digital value is dependent on this clock source. A suitable RC circuit is connected between the Clock IN and Clock R pins to use the internal clock. The values of resistance and capacitance can be chosen for a desired time-period[2].

In this system, the ADC is used in the continuous mode. This means that the ADC is continuously doing analog to digital conversion soft hevoltage satits input. For continuous mode CS*and RD*are grounded and WR*and INTR are shorted.

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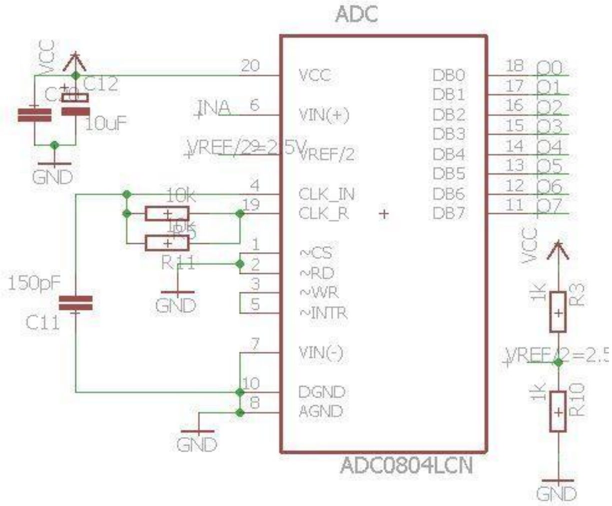

Fig. 5 Analog to Digital conversion of voltage signal using ADC 0804

3.5. AD620 Instrumentation Amplifier

Instrumentation amplifier accepts a differential voltage signal and generates a single amplified output voltage. TheAD620,withitshighaccuracyof40ppm(maximum)nonlinearity,lowoffsetvoltageof50µV(maximum), and offset drift of 0.6 µV/°C (maximum), is ideal for use in precision data acquisition systems such as weigh scales and trans ducer interfaces.

Gainis set with One External Resistor with in the range from1to10,000.AD620 hasa wide Power Supply Range (±2.3 V to ±18 V) and offers higher performance than three Op Amp IA Designs. This instrumentation amplifier is available in 8-Lead DIP and SOIC Packaging. Also, AD620 consumes low power, 1.3 mA max Supply. The gain and the external resistance are selected in accordance with the following equations[3]-

(4) Gain= (49.4 K Ohms/R) +1

(5) R= 49.4 K Ohms/(Gain-1)

For this system, the differential input voltage to AD620 comes from the load cell. The differential input voltage isoftheorderofafewmicrovolts.Thegainissettoapproximately500usinganexternalresistanceof100Ohms. The single end ed amplified analog output voltage (fewmilli Volts) is the nfed to the 8bit ADC0804.The amplifier takes in a dual power supply from two 9Vbatteries.

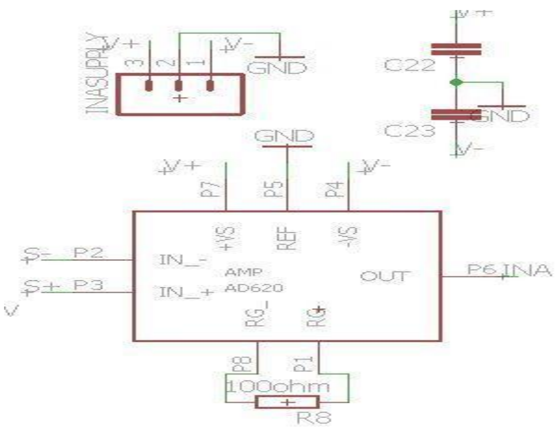

Fig.6 Amplification of differential voltage signal from load cell using INA AD620

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3.6. Load Cell

The system uses a 10kg straight bar load cell. This straight bar load cell (sometimes called a strain gauge) can translate upto 10kg of pressure (force) into an electrical signal. Eachload cell can measure the electrical resistance that changes in response to, and proportional of, the strain (e.g. pressure or force) applied to the bar. The straight bar load cell is made from an aluminium-alloy and has four strain gauges that are hooked up in a Wheatstone bridge formation. The bridge is balanced and the output voltage is zero in case of no load. The load cell hasfour wires. The colour code on the wiring is as follows: red = E+, green = O+, black = E-, and white = O- [4]. E+ is connected to a 5V supply, E- is connected to ground of the system. O+ and O- are the differential output voltage signals produced in response of the weight on the load cell.

This differential analog voltage is a few micro volts, hence need to be amplified by an instrumentation amplifier to a voltage level suitable for input to the 8-bit ADC. O+ and O- are inputs to the instrumentation amplifier.

3.7. I/O Inter Facing

3.7.1. Ultrasonic Sensor

The input pulses from the ultrasonic sensor are coming on the SID pin of the micro processor where they are counted to calculate the distance.The Systemuses HC-SR04,anul transonic ranging module powered by 5V supply that provides 2 cm to 400 cm non-contact measurement function. How does it measure distances? The module has 4 pins- 5V supply, Trigger Pulse Input, Echo Pulse Output, 0V Ground. The trigger is connected to the SOD and the Echo is connected to the SID pins of the 8085microprocessor.

First a 10us high pulse is given to the trigger input via the SOD pin to start ranging. The module then sends out a neight-cycle bursto fultra soundat 40kH zandraise the echo. The echore main shigh till an echo signalis received back after reflection from an object. Thus, the distance is givenby- (6) DISTANCE= (time elapsed) x (speed of sound/2)

Using the formula, the time elapsed for 1cm distance is 58 microseconds.

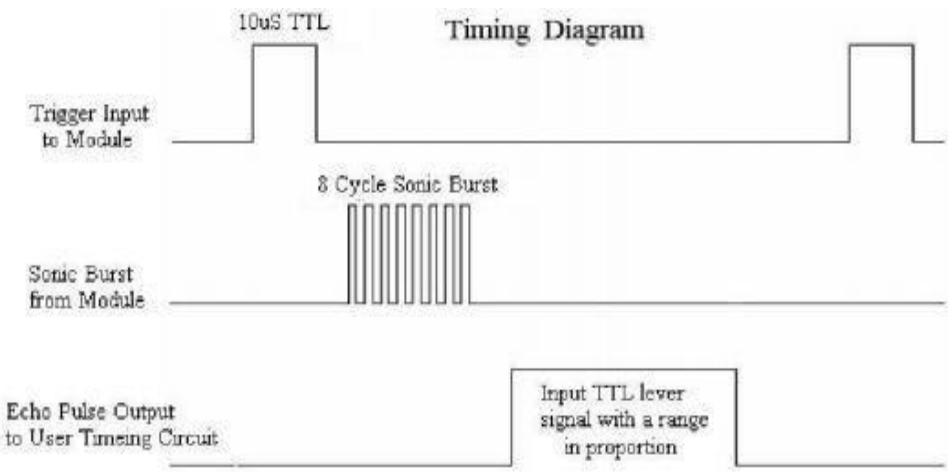

Fig.7 Timing diagram of Ultrasonic Sensor HC-SR04 [1].

The time till which the echo remains high is calculated in the microprocessor by setting up a counter. The micro processor is programmed to measure distances with a precision of 1cm. This is achieved by checking the Status of SID (echo) pin every 58micro seconds and incrementing the count if it’s still high or stop counting when it goes

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low. The distance in cm equals the count.

3.7.2.Load Cell

The voltage variation from the load cell corresponding to the weight/load is input to the INA which amplifies the differential voltage and generates a single ended voltage. This output voltage is given to the ADC0804 which is continuously doing analog to digital conversions. The digital output is taken as input to the microprocessor via a **tristatebuffer** which is I/O mappedwithaddress**00H**.Theactivelowoutputenableiscontrolledbytheaddress lines and the **IOR*signal.**

3.7.3. LCD

LCD is used in 4-bit mode. It is I/O mapped with address **00H**. The LCD is interfaced with the microprocessor using and output latch. The output Enable of the latch is always grounded. The active high latch enable is controlled using the address and the **IOW* signal.**

IV. SOFTWARE- HEART OF THE SYSTEM

A microcomputer performs a task by reading and executing the set of instructions written in its memory. Each instruction in the program is a command, in binary, to the microprocessor to perform an operation. The instructions set of 8085 can be classified into five groups of instructions – Data Transfer, Arithmetic, Logical, Branch and Machine Control. The microprocessor is programmed using Assembly Language. An Assembly Language Program includes memory address, hexadecimal code from the instruction set, mnemonics for the instructions and optional comments. The microprocessor only understands machine language that is, binary. The instructions to run this system are stored in the EEPROM starting from the address 0000H. A flowchart is first prepared which is a pictorial representation of the steps necessary to write a program. Fig. 8,9. It helps in understanding the sequence of steps and guides in writing the instructions. The program was assembled and compiled into machine codes using 8085 Simulator IDE and the source file was written in the EEPROM.

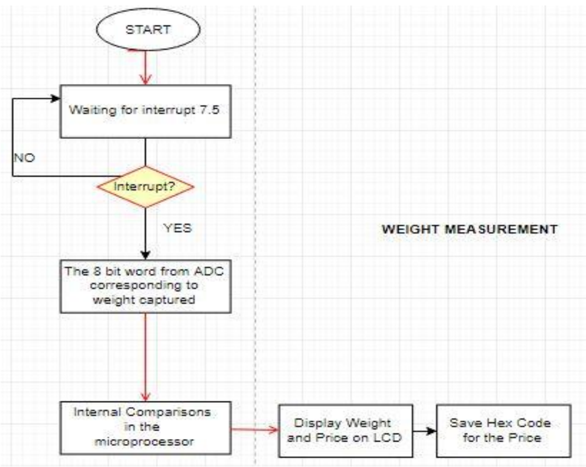

Fig.8 Flowchart for calculating price due to weight

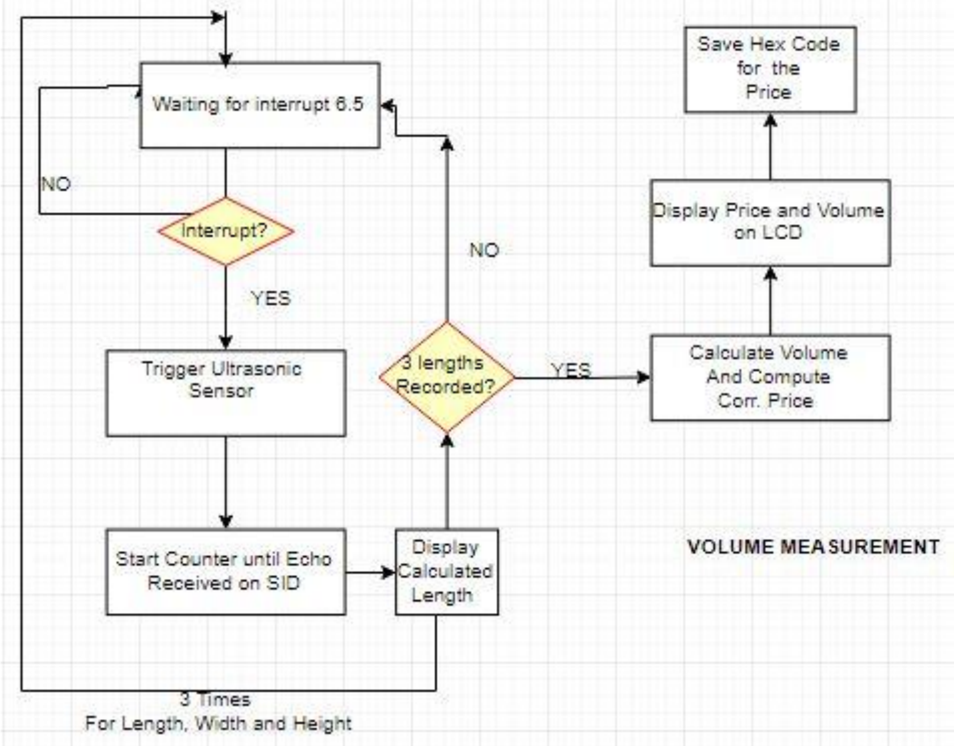

Fig.9 Flowchart for calculating price due to volume

4.1 Interrupt I/O

This system is programmed using interrupts. The Interrupt I/O is a process of data transfer whereby an external deviceoraperipheralcaninformthemicroprocessorthatitisreadyforcommunicationanditrequestsattention. The process is initiated by an external device and is asynchronous [5]. In this system, two buttons are used to interrupt the microprocessor at 7.5 and 6.5 vectored interrupts. One button takes the program execution to a subroutine which measures the weight of the parcel, computes the corresponding price and display them on a LCD Display. The other button interrupts the microprocessor to trigger the ultrasonic sensor to calculate the dimensions of the package, compute its volume and the price corresponding tothat.

V. CIRCUITDESIGNING

The circuit for the system was designed on EAGLE CAD. EAGLE is a scriptable electronic design automation application with schematic capture, printed circuit board layout, auto-router and computer-aided manufacturing features. EAGLE stands for Easily Applicable Graphical Layout Editor. EAGLE contains as chematic editor, for designing circuit diagrams.The PCB layouted it orallows back annotation to the schematic and auto-routing to automatically connect traces based on the connections defined in the schematic[6].Whiledesigningthecircuitofasystemitisimportanttofirsthaveaclearpictureofthecomponentsandhardware requirement. Different parts of the system must be first tested separately for desired outputs using a loose wired arrangement. After the trial and error phase, a schematic is prepared on EAGLE, connecting all the components. The final board layout isprinted on a PCB and the components are soldered keep in ginmind the polarity.

The motherboard houses all the ICs-8085 microprocessor, ADC 0804, INA-ad620, RAM, EEPROM, Latches, decoder, tri-state buffer, connect or sfor connecting batteries, load cell and ultrasonic sensor, the LCD, buttons and power LEDs.

VI. CONCLUSION

The embedded digital Parcel Price Calculator can find applications in business enterprises which need to quickly and accurately determine the delivery cost of packages. Since there is constant need to know the exact weight of items such as food, pharmacology, technology and chemistry, the system can find applications in varied sectors of economy. The precision and accuracy of the system can be improved using a higher resolution ADC and filters to remove noise in measurement. The system can be made cost effective using microcontrollers replacing 8085 and many peripherals. Also, some add-ons of the system can include generation of a receipt containing information about the weight, volume and the delivery address/ distance. Further, with the advent of IoT, this system can be connected to internet to maintain and update records of the delivery packages on a computer automatically.

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