DOMESTIC GAS MONITORING DEVICE

By

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FINAL PROJECT REPORT

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CERTIFICATION OF APPROVAL

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A project dissertation submitted to the
Electrical & Electronics Engineering Programme
Universiti Teknologi PETRONAS
in partial fulfillment of the requirement for the
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Approved by,

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Project Supervisor

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

June 2008

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

HAZERINA BINTI JAFFAR

ABSTRACT

The goal of this project is to monitor the content of Liquified Petroleum Gas (LPG) in a cooking gas cylinder / LPG cylinder and alert user to replace the LPG cylinder when it is almost finish. This is to ensure that user would not be stuck in between cooking / heating / drying / grilling when the gas runs out. Based on Hooke's Law, the project will use compression spring to measure the weight of the LPG. The decreasing content of LPG in the LPG cylinder will affect the movements of the compression spring. A sensor which is a potentiometer is used to detect the decreased in weight of the LPG content. As the weight decreases, the potentiometer will rotate according to the spring movements. The signal from the sensor will be sent to the programming circuit via wireless Radio Frequency (RF) transmission and displayed the result on Portable display consists of Liquid Crystal Display (LCD), Light Emitting Diode (LED) and Buzzer. The buzzer will be used to alert the user once the LPG reached the minimum level.

ACKNOWLEDGEMENTS

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

LPG	Liquefied Petroleum Gas
LCD	Liquid Crystal Display
GMD	Gas Monitoring Device
PIC	Programmable Integrated Circuit
RF	Radio Frequency
ADC	Analog to Digital Converter
PC	Personal Computer
I/O	Input/Output
DC	Direct Current
PCB	Printed Circuit Board

CHAPTER 1
INTRODUCTION

1.1 Background of Study

Liquefied Petroleum Gas (LPG) is a mixture of propane, butane and other chemicals. The LPG is widely used in domestic, commercial, industrial and agricultural. It plays an important role in providing gas to user for cooking, heating, drying and grilling [2]. Domestic Gas Monitoring Device (GMD) is designed to give information to user on the volume of gas left inside the cooking gas cylinder / LPG cylinder. It will also be able to alert user to replace the gas cylinder before finish so that user would not be stuck in between cooking / heating / drying / grilling when the gas runs out.

There are three categories of domestic LPG cylinder in Malaysia which are the 12kg, 14kg and 50kg. However, this project will concentrate on the 12kg and 14kg domestic LPG cylinder.

Currently in the market, the volume of gas inside the LPG cylinder is monitored using LPG gas regulator which uses the concept of gas pressure. For this project, a different concept will be implemented to monitor the content of LPG in the LPG cylinder. The Domestic GMD in this project will make use of compression of spring to monitor the weight of the LPG. Domestic GMD that is reliable, cost-effective and user-friendly will be designed. The Domestic GMD will be able to give information on the content of gas left on a Portable display consists of Liquid Crystal Display (LCD), Light Emitting Diode (LED) and Buzzer. The buzzer will be used to alert the user once the LPG reached the minimum level.

1.2 Problem Statement

LPG or cooking gas is an important element in cooking, heating, drying and grilling. Without it, living would not be as easier as before. It is like going back to ancient times where you have to make your own fire using woods.

User often gets frustrated as they get stuck in between cooking when the gas runs out. These is because, currently there are no mechanism to alert the user when the LPG reaches its minimum level. This will reduce the quality of food cooked because some of the food such as rice, stew and cakes need proper and constant heating.

Bakeries, cake houses and even pizza outlets used LPG to fire their baking ovens. The same problem will occur if the gas runs out in between the cooking. For bakeries and cake houses, the cakes will be spoiled which results in loss.

Currently, there are two types of gas monitoring device in the market. First type is the conventional gas monitoring which consist of a head / regulator and a hose. It is cheap but it is not able to give information to user on the content of LPG left inside the cooking gas cylinder. Second type is the gas monitoring using pressure regulator with indicator. Although it is able to give information to user on the content of LPG left inside the cooking gas cylinder, it is expensive, cannot alert user when the LPG has reached the minimum level and is placed on top of the LPG cooking gas cylinder. This is not feasible for the user to monitor since most of them placed their cooking gas cylinder inside their kitchen cabinet or below their stove oven. Therefore, it is not convenient for them to check the content of LPG left in their cooking gas cylinder.

1.3 Objectives and Scope of Study

The main objectives of the project are to design and build prototype of a GMD for domestic cooking gas cylinders that:

1. Gives information on the content / weight of LPG
2. Alerts user when the LPG reach the minimum level
3. Provides wired and portable display
4. Costs less than RM 100

The devices that will be used are sensors, radio frequency transmitter and receiver for portable display, Programmable Integrated Circuit (PIC) and Liquid Crystal Display (LCD). The scope of study for this project is the 12kg and 14kg domestic cooking gas cylinder.

CHAPTER 2

LITERATURE REVIEW

2.1 Monitoring device

The project will use spring to monitor the content of LPG in the cooking gas cylinder. There are a few types of springs which are compression spring, extension spring and torsion spring [5]. Compression spring which is an open-coil, helical spring that offers resistance to compressive loading is chosen for this project.

Spring follows the Hooke's Law which stated that elasticity is an approximation that states that the amount by which a material body is deformed (the strain) is linearly related to the force causing the deformation (the stress). Therefore, for compression spring, when content of LPG in cooking gas is decreased, the spring will go upward because the load is directly proportional to deformation of spring. For systems that obey Hooke's Law:

$$\vec{F} = -k\vec{x}$$

Where,

x = the distance by which the material is elongated [usually in meters]
F = the restoring force exerted by the material [usually in Newtons]
k = the force constant (or spring constant). The constant has units of force per unit length [usually in Newtons/metre]

[Source from http://en.wikipedia.org/wiki/Hooke's_law]

When this holds, the behavior is said to be linear. Elastic materials are objects that quickly regain their original shape after being deformed by a stress, with the molecules or atoms of their material returning to the initial state of stable equilibrium. Hooke's Law only holds for some materials under certain loading conditions. Steel exhibits linear-elastic behavior in most engineering applications.

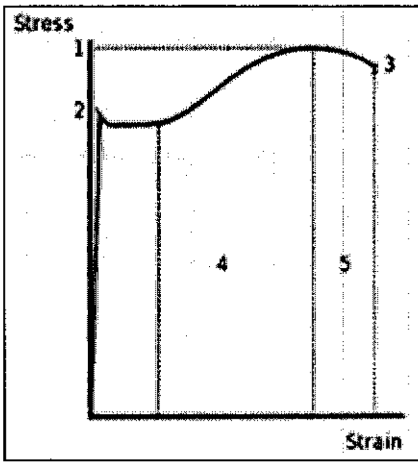
Hooke's Law is valid for it throughout its elastic range (i.e, for stresses below the yield strength). For some other materials, such as aluminium, Hooke's Law is only valid for a portion of the elastic range [3]. Common spring materials and properties are shown in Table 2.1 below:

Table 2.1 – Common Spring Materials and Properties

Common Spring Materials and Properties				
Material	Tensile Strength min. (psi x 103)	Modulus of Elasticity (psi x 106)	Modulus in Torsion (psi x 106)	Maximum Design Temperature (deg F)
Music wire	229 – 300	30	11.5	250
Chrome Vanadium	190 – 300	30	11.5	425
Stainless Steel 302	125 – 350	28	10	550
Stainless Steel 17-7 (313)	235 – 335	29.5	11	600

[Table 2.1 adapted from http://www.engineersedge.com/spring_general.htm]

For these materials, a proportional limit stress versus stain curve for low-carbon steel is defined on Figure 2.1 below (errors associated with the linear approximation are negligible) [3]. Hooke's Law is only valid for the portion of the curve between the origin and the yield point.



1. Ultimate strength
2. Yield strength-corresponds to yield point
3. Rupture
4. Strain hardening region
5. Necking region

Figure 2.1 – Graph of the spring equation

[Figure 2.1 from http://en.wikipedia.org/wiki/Hooke's_law]

For compression spring, the equation is:

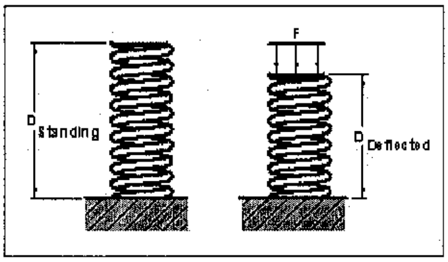


Figure 2.2 – Compression spring

Force (F) = k ($D_{Standing} - D_{Deflected}$)

Where;

F = Force exerted by spring
$D_{Standing}$ = Free length of spring
$D_{Deflected}$ = Length of spring with force applied
k = Spring constant determined by experiment or calculation

[Source from http://www.engineersedge.com/spring_comp_calc.htm]

The spring rate can be measured by taking the difference in force at 80% maximum deflection and 20% minimum deflection and dividing by the difference in deflection. The spring rate tends to be constant over the central 60% of the deflection range. Because of end coil effects, the first 20% of range has a considerably lower spring rate. The final 20% of deflection shows considerably higher spring rate. When designing for a particular spring, design for critical loads and rates to be within the central 60% deflection range [5].

2.2 Sensor

For the sensor part, variable resistor is proposed as the sensor to detect the movements of springs due to weight changes on the LPG cooking gas cylinder. According to [7], variable resistor is a device which its resistance can be changed. Variable resistors consist of a resistance track with connections at both ends and a wiper which moves along the track as the spindle is turned (Refer Figure 2.3). The track may be made from carbon, cermet (ceramic and metal mixture) or a coil of wire (for low resistances) and is usually rotary [7], [8].

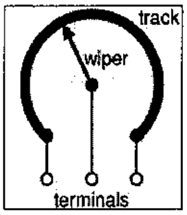


Figure 2.3 – Construction of a variable resistor

There are three types of variable resistor which are Rheostat, Potentiometers and Preset. Each type has a different way of working:

1. Rheostat: In this type of resistor conducting wire is wound around a drum. There are two terminals and one of them is fixed while the other slider moves forward and backward. When the slider is moved, the number of conducting coils increases or decreases thus decreasing or increasing the current resistance. An example of varying current is to control the brightness of lamp.

2. Potentiometers: This type has three terminals, all connected. As the terminal moves in or out, the resistance changes. The potentiometer is normally used to vary voltage. An example of varying voltage is to control the volume (loudness) in an amplifier circuit. If the terminals at the ends of the track are connected across the power supply, then the wiper terminal will provide a voltage which can be varied from zero up to the maximum of the supply.

3. Presets: They are mounted on the PCB and usually the resistance can be adjusted using a screwdriver or similar tool. An example of application using preset is to set the frequency of an alarm tone or the sensitivity of a light-sensitive circuit.

   Multiturn presets: Similar to preset but a very precise adjustments must be made. The screw must be turned many times (10+) to move the slider.

For this project, the proposed variable resistor type to be used is potentiometer. This is because the weight of the gas left is calculated from the varying voltage. The microcontroller will then convert these voltage signals into values that are easy for the user to understand.

Pictures and symbols of each type of the variable resistors are shown in Figure 2.4 and Figure 2.5 below:

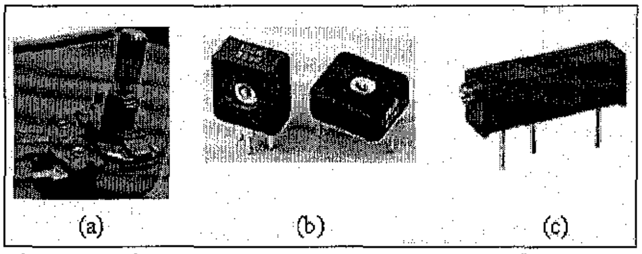


Figure 2.4 – (a) Potentiometer / Rheostat, (b) Preset and (c) Multiturn Preset

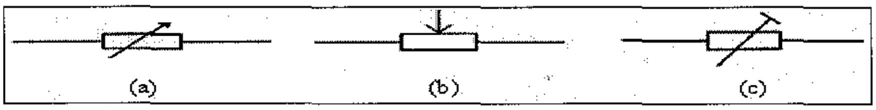


Figure 2.5 – (a) Rheostat Symbol, (b) Potentiometer Symbol and (c) Preset Symbol

[Figures 2.3-2.5 from http://www.flickr.com/photos/stibbons/172729198/ and http://www.kpsec.freeuk.com/components/vres.htm]

2.3 Microcontroller

Microcontroller is needed to control the Gas Monitoring Device system. A microcontroller is a computer-on-a-chip. It is a type of microprocessor emphasizing high integration, low power consumption, self-sufficiency and cost-effectiveness, in contrast to a general-purpose microprocessor (the kind used in a PC). Microcontroller consume relatively small power (milliwatts), and generally have the ability to turn into sleep mode. User can wake them up manually (by pressing button) or automatically (triggered when sensor sent signals). The power consumption while in sleep mode may be just nano watts, which makes it ideal to be use in the Gas Monitoring Device system which requires low power and long lasting battery applications [9].

For the purpose of this project, a microcontroller containing internal on-chip Analog to Digital Converter (ADC) is chosen. This is because the potentiometer, which will act as the sensor operates in analogue mode. This analogue signal needs to be converted into digital signal to enable it to display digital values on the Liquid

Crystal Display (LCD). Disadvantages of Internal ADC are it does not have high accuracy conversions and speed. Since this project does not require both high accuracy conversions and speed, Internal ADC is the best choice because of its simplicity, cost effective and less consumption of space.

There are many microcontrollers containing internal on-chip ADCs such as Atmel Atmega series and Microchip microcontrollers. For this project PIC16F877 from Microchip has been chosen as the controller [Refer Figure 2.6]. The full datasheet of PIC16F877 is attached in Appendix G.

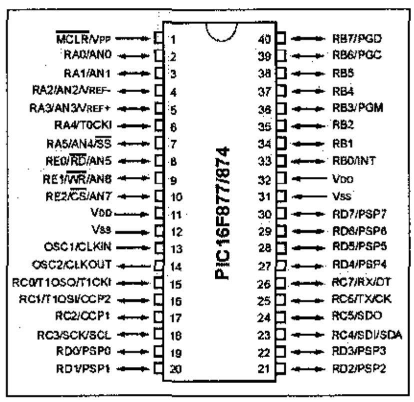


Figure 2.6 – PIC16877 40-Pins diagram

[Figure 2.6 from http://www.microchip.com/downloads/en/DeviceDoc/30292c.pdf]

2.3.1 PIC16F877

PIC16F877 is a microcontroller which has 8K x 14-bit words of Flash program memory, 368 bytes of data RAM, 256 bytes of data EEPROM and an 8-level x 13 bit wide hardware stack. The Program Counter (PC) of this Programmable Integrated Circuit (PIC) is 13 bits wide, thus making it possible to access all 8K x 14 addresses [11].

This PIC has five digital I/O ports (A,B,C,D,E) each between 3 and 8 bits wide. Each port is mapped into the register space, and may be read and written to like any other register. The circuitry is such that it is not possible to physically input to and output from a particular pin simultaneously. For most ports, the I/O pins direction controls the direction of PORT<x>. A '1' in the TRIS bit corresponds to that pin being an input, while a '0' corresponds to that pin being an output. An easy way to remember is that a '1' looks like an I (input) and a '0' looks like an O (output) [12].

The port register is the latch for the data to be output. When the port is read, the device reads the levels present on the I/O pins (not the latch). This means that care should be taken with read-modify-write commands on the ports and changing the direction of a pin from an input to an output. The pins on the PIC are multiplexed so that one of several functions may be selected (e.g. pin 2 may be used as either bit 0 of I/O port A, or as channel 0 of an A/D converter). The TRIS registers control the direction of the port pins, even when they are being used as analog pins [12].

The TRIS bits must be maintained set when using the pins as analog inputs. The A/D allows conversion of an analog input signal to a corresponding 8-bit digital number. The output of the analog 'sample and hold' is the input into the converter which generates the result via successive approximation. The analog reference voltage is software selectable to either the positive supply voltage (5V) [12].

2.4 Wireless Transmission

Several technologies have been taken into consideration. Table 2.2 shows different wireless technologies and their brief descriptions.

Table 2.2 – Wireless Technologies currently available [16]

Wireless Technologies	Description
Bluetooth	Operates in the unlicensed 2.4 GHz spectrum and can operate over a distance of 10 meters or 100 meters depending on the Bluetooth device class. Bluetooth wireless technology are able to penetrate solid objects and the cost of Bluetooth chips is under $3.

Ultra-Wideband (UWB)	Transmit digital data over a wide spectrum of frequency bands with a very low power. It can transmit data at a very high data rates. However, UVB products are slow to come to market due to the disagreements over the standard and the lack of global regulatory approval.
Wi-Fi (IEEE 802.11)	Stands for Wireless Fidelity and is used to define any of the wireless technology in the IEEE 802.11 specification. Wi-Fi Alliance is the body responsible for promoting the term and its association with various wireless technology standards. Wi-Fi boasts faster data transfer speeds and range compare to Bluetooth, making it a good replacement for Ethernet systems while Bluetooth requires less power and is therefore more prominent in small appliance such as PDA.
WiBro (Wireless Broadband)	Provides high data rate wireless internet access with Personal Subscriber Station (PSS) under the stationary of mobile environment, anytime and anywhere. It uses the frequency of 2.3-2.4 Ghz using channel bandwidth of 10 Mhz. The system supports mobile users at a velocity of up to 60 km/h.
Infrared (IrDA)	Provides wireless connectivity for devices that normally use cable to connect. It is a point-to-point device and designed to operate over a distance of 0 to 1 meter at sped of 9600 bps to 16 Mbps. Disadvantages of IrDa is it is not able to penetrate solid objects.
Radio Frequency (RF)	Provides wireless connectivity to many applications such as cordless phones, radar, ham radio, GPS and radio and television broadcasts. RF waves are electromagnetic waves which propagate at the speed of light, or 186,000 miles per second (300,000 km/s). Every device that uses RF waves must conform to the Federal Communication Commission's (FCC) regulations.
ZigBee (IEEE 802.15.4)	Operates at 250 kbps at 2.4 GHz, 40 kbps at 915 Mhz and 20 kbps at 868 MHz. Its purpose is to become a wireless standard for remote control in the industrial field. Zigbee technology is targeting the control applications industry which does not require high data rates but must have low power, low cost and ease of use.

For this project, RF transmission is chosen to transmit the signal from sensor to the portable display. The advantages of RF compare to other technologies:

- Simple technology but very effective in wide field of industry
- Able to penetrate solid object
- Cheap (less than RM100)
- Frequency can be adjusted to suit the environments
- Range of RF signal can be as far as hundred kilometers depending on the design of circuit.

The transmitter and receiver chosen as shown in Figure 2.7 are TLP 434 and RLP 434 respectively. The full datasheet is attached in Appendix H.

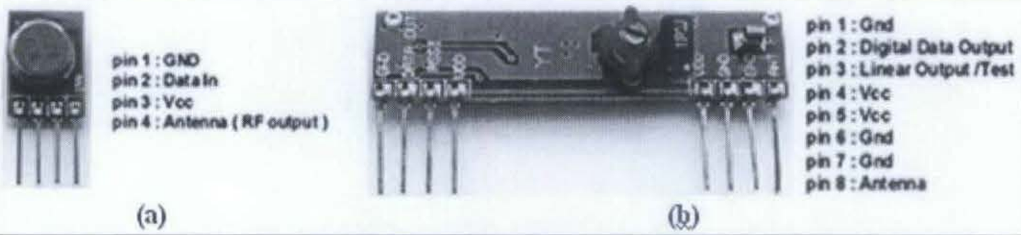


Figure 2.7 – (a) TLP 434 (RF Transmitter); (b) RLP 434 (RF Receiver)

[Figures from http://www.laipac.com/easy_434a_eng.htm]

RF in electromagnetic spectrum is usually crammed with noise and other interference signals. Thus, when using a wireless RF transmission, it is desirable to filter out unwanted / noise signals to prevent incorrect data signals from being received and interpreted. The method is to use an encoder IC (CIP-8E) at the transmitter and decoder (CIP-8D) at the receiver side [Refer Appendix I for full datasheet]. These ICs are able to generate multiple serial codes and should be decoded and matched with the address bits on the decoder before data signals are received, recognized and verified. Otherwise, without implementing the approach, wireless RF transmissions would trigger themselves at the receiver when it receives data signals which are mixed with noise and interferences [14].

2.5 LCD Display

The other important characteristic for this project is the display. The type of display that is chosen to display the amount of gas left inside the LPG cooking gas cylinder is a 2 x 20 serial LCD display. The display should be suitable with the microcontroller in order to be able to display the value and some wordings. The datasheet of the LCD display is attached in Appendix J.

LCD is a thin, flat display device made up of any number of color or monochrome pixels arrayed in front of a light source or reflector. It is often utilized in battery-powered electronic devices because it uses small amounts of electric power [13].

Each pixel of an LCD typically consists of a layer of molecules aligned between two transparent electrodes, and two polarizing filters, the axes of transmission of which are (in most of the cases) perpendicular to each other. With no liquid crystal between the polarizing filters, light passing through the first filter would be blocked by the second (crossed) polarizer [13].

The surface of the electrodes that are in contact with the liquid crystal material are treated so as to align the liquid crystal molecules in a particular direction. This treatment typically consists of a thin polymer layer that is unidirectionally rubbed using, for example, a cloth. The direction of the liquid crystal alignment is then defined by the direction of rubbing [13].

Before applying an electric field, the orientation of the liquid crystal molecules is determined by the alignment at the surfaces. In a twisted nematic device (still the most common liquid crystal device), the surface alignment directions at the two electrodes are perpendicular to each other, and so the molecules arrange themselves in a helical structure, or twist. Because the liquid crystal material is birefringent, light passing through one polarizing filter is rotated by the liquid crystal helix as it passes through the liquid crystal layer, allowing it to pass through the second polarized filter. Half of the incident light is absorbed by the first polarizing filter, but otherwise the entire assembly is transparent [13].

When a voltage is applied across the electrodes, a torque acts to align the liquid crystal molecules parallel to the electric field, distorting the helical structure (this is resisted by elastic forces since the molecules are constrained at the surfaces). This reduces the rotation of the polarization of the incident light, and the device appears gray. If the applied voltage is large enough, the liquid crystal molecules in the center of the layer are almost completely untwisted and the polarization of the incident light is not rotated as it passes through the liquid crystal layer. This light will then be mainly polarized perpendicular to the second filter, and thus be blocked and the pixel will appear black. By controlling the voltage applied across the liquid crystal layer in each pixel, light can be allowed to pass through in varying amounts thus constituting different levels of gray [13].

The liquid crystal material and the alignment layer material contain ionic compounds. If an electric field of one particular polarity is applied for a long period of time, this ionic material is attracted to the surfaces and degrades the device performance. This is avoided either by applying an alternating current or by reversing the polarity of the electric field as the device is addressed (the response of the liquid crystal layer is identical, regardless of the polarity of the applied field) [13].

When a large number of pixels is required in a display, it is not feasible to drive each directly since then each pixel would require independent electrodes. Instead, the display is multiplexed. In a multiplexed display, electrodes on one side of the display are grouped and wired together (typically in columns), and each group gets its own voltage source. On the other side, the electrodes are also grouped (typically in rows), with each group getting a voltage sink. The groups are designed so each pixel has a unique, unshared combination of source and sink. The electronics, or the software driving the electronics then turns on sinks in sequence, and drives sources for the pixels of each sink [13].

Important factors to consider when evaluating an LCD display include resolution, viewable size, response time (sync rate), matrix type (passive or active), viewing angle, color support, brightness and contrast ratio, aspect ratio, and input ports (e.g DVI or VGA) [13].

Figure 2.8 below shows LCD display of the GMD. For this project, the display will show the weight of gas left in kilograms. From the figure, "TANK: VERY LOW" means that the content of LPG is in between 1 to 3 kg.

Figure 2.8 – 2 x 20 serial LCD display

2.6 Domestic GMD proposed design

The proposed design of the domestic GMD is shown in Figure 2.9 below. The GMD consists of four compression springs, rack and pinion gears, sensor, RF Transmitter and Receiver circuit, programming circuit, portable LCD display, buzzer, spring holder and roller.

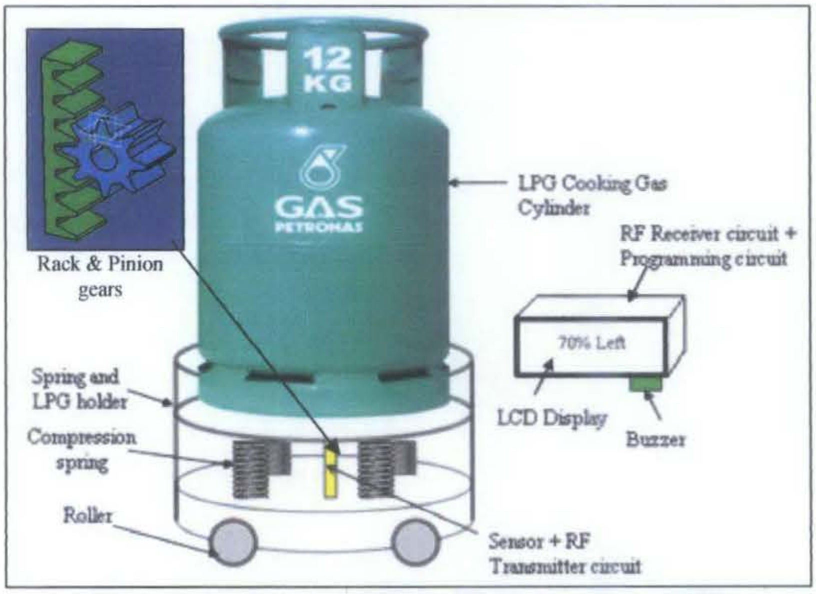


Figure 2.9 – Proposed design of the Domestic GMD

CHAPTER 3
METHODOLOGY

3.1 Project Flowchart

In ensuring the smoothness of project execution, a project flowchart is constructed as shown in Figure 3.1 below. The figure outlines the main approaches use in completing the project.

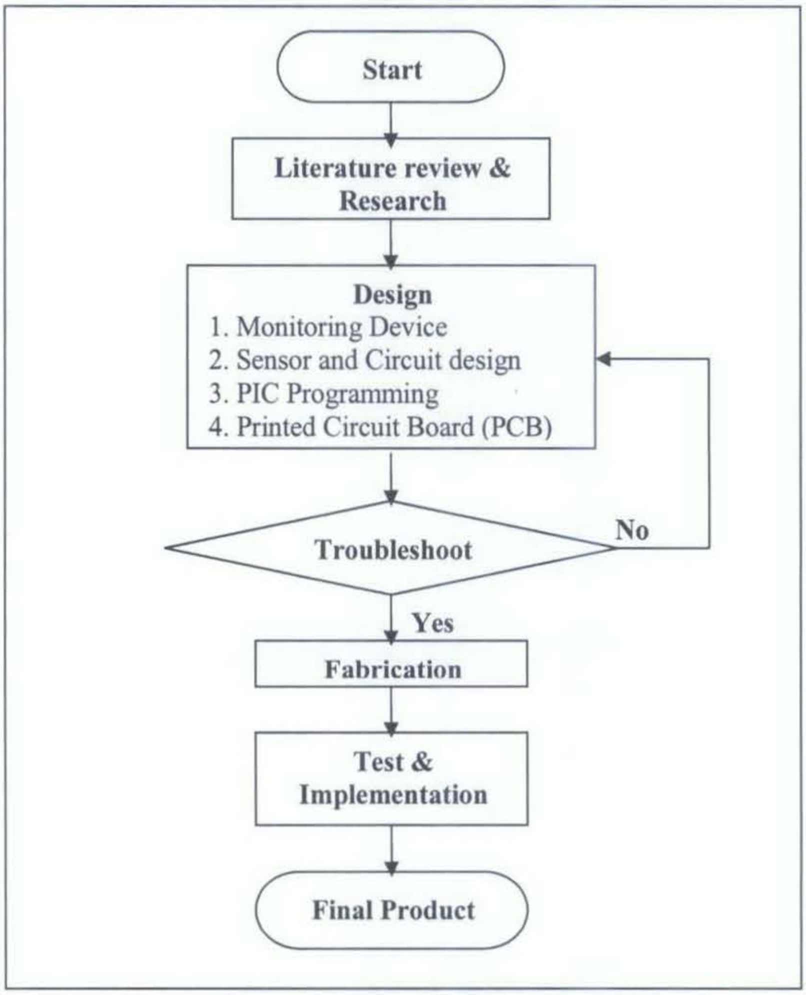


Figure 3.1 – Project Flowchart

3.2 Experimental / Laboratory Work

The experimental work is sub-groups into four parts which are Monitoring device, Sensor and Circuit design, PIC programming and PCB Design;

3.2.1 Monitoring device

The main component in the Monitoring Device is Compression Spring. Spring testing experiment is done to determine the right spring size and constant for the project. All the equipments necessary for spring testing is available at the Geotechnical Lab located at New Academic Complex Block 14.

3.2.2 Sensor and Circuit design

During this stage, the input and output to be integrated on Domestic GMD are determined. The input will be from the potentiometer as sensor, the outputs are Portable display consists of LCD, LEDs and Buzzer. Before the circuits were produced on normal breadboard, they were designed in PSpice software and simulated. The purpose of simulation design is to design the circuit virtually before the real circuit is constructed.

3.2.2.1 Voltage Regulator circuit

The Microcontroller (PIC16F877) needs a supply voltage of 5V. Therefore, a voltage regulator circuit needs to be constructed to supply a regulated 5V DC supply. Figure 3.2 below shows a schematic diagram of Voltage Regulator circuit.

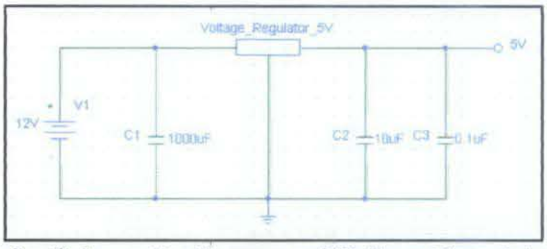


Figure 3.2 – Schematic diagram of Voltage Regulator circuit

3.2.2.2 Sensor circuit

The sensor (Potentiometer) is connected to the output of Voltage Regulator circuit as shown in Figure 3.3. The sensor output (in analogue mode) will be the input to the Microcontroller. The analog reference voltage will be selected as 5V.

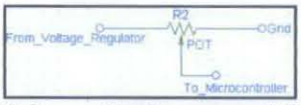


Figure 3.3 – Schematic diagram of Sensor circuit

3.2.2.3 Block diagram of overall circuit

The overall circuit is break down into two parts as shown in Figure 3.4; the first part consists of a sensor, microcontroller and transmitter circuit while the second part consists of receiver circuit, microcontroller and the output display.

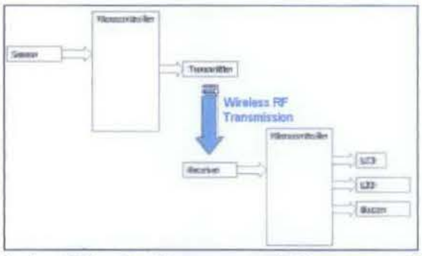


Figure 3.4 – Block diagram of the overall circuit

3.2.3 PIC Programming

The programming part is done at Microprocessor Lab located at New Academic Complex Block 22. A few procedures need to be followed in order to program the PIC. The ADC value will be calculated by using the formula below;

$$\mathbf{V_{in} = (V_{fullscale} \times ADC\ value) / (2^8 - 1)}$$

where;

Vfullscale = 5V

ADC value = Variable resistor input

[Equation from Embedded C Programming and the Microchip PIC book by Barnett Cox & O'Cull]

3.2.3 PCB Design

Once the schematic of the overall circuit is finalized, the circuit is design using Eagle 4.13 software to be printed on the Printed Circuit Board (PCB). A PCB is a piece of plastic/fiber material on which electronic components can be mounted for mechanical support, and which also electrically interconnects all the equipments it supports by means of a pattern metal tracks on it outer surfaces and sometimes on inner layers.

Almost all electronic equipment, from large computers and radar systems down to pocket transistor radios, uses printed circuit boards as the main component support and interconnection system.

Printed circuit interconnections take up less space than ordinary insulated wiring and the plastic substrate also support all the components it interconnects and no other panel or frame is required.

The advantages of printed circuit boards over other forms of packing or wiring can be summarized as:

- Predictability.
- Repeatability.
- Reliability.
- Low Cost.
- Light Weight.
- Low Volume.
- Easy Assembly and Servicing.
- Ease of Cooling.
- Ability to Use Mass Soldering Techniques.

Figure 3.5 below is the procedure that needs to be followed in order to produce a PCB.

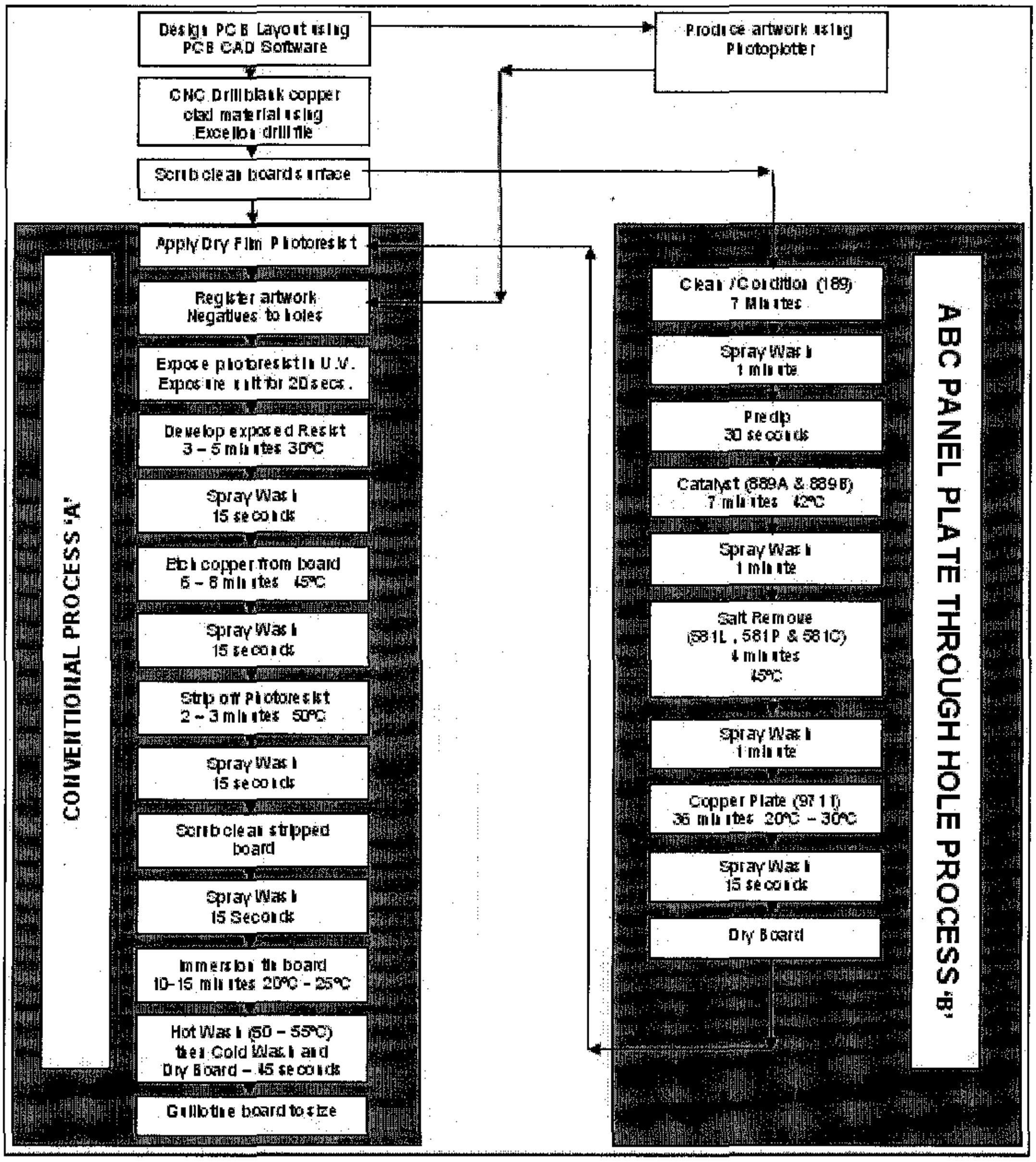


Figure 3.5 – Flowchart of producing PCB

3.3 Tools and Equipments

The tools and equipments used during this project are divided into three sub-groups as below;

3.3.1 List of Equipments

- Multimeter
- DC Power supply
- Digimatic Caliper
- PIC Development Programmer
- Computer Numerical Control (drill PCB)
- UV exposure unit (PCB)
- Photo Plotter (PCB)
- Brush Cleaning Machine (PCB)

3.3.2 List of Softwares

- PSPICE (Circuit Simulation)
- EAGLE 4.13 (PCB Design)
- CCS Compiler (PIC Programming)
- Warp 13 (PIC Uploader)

3.3.3 List of Components

- Spring
- Gear
- Potentiometer
- PIC16F877 Microcontroller
- TLP 434 RF Transmitter & RLP 434 RF Receiver
- CIP-8E Encoder
- CIP-8D Decoder
- LCD Display

CHAPTER 4

RESULTS AND DISCUSSION

4.1 LPG Gas Cylinder calibration

During research, calibration on the weight of three LPG gas cylinders for each 12 kg and 14 kg is done. Petronas' LPG gas cylinder is chosen. Table 4.1 below shows the result of the calibration:

Table 4.1 – Calibration result for 12 kg and 14 kg Petronas' LPG gas cylinder

Category	Type	Empty gas Cylinder (kg)			Full gas cylinder (kg)		
		1	2	3	1	2	3
12 kg	Domestic Cylinder	15.83	15.86	15.81	27.78	27.65	27.70
14 kg	Domestic Cylinder	16.51	16.62	16.55	30.39	30.40	30.35

The ideal weight for each empty 12 kg and 14 kg gas cylinder is 15.8 kg and 16.5 kg. The ideal weight for each full 12 kg and 14 kg gas cylinder is 27.8 kg and 30.5 kg. From the result shown above, both 12 kg and 14 kg gas cylinders gave an approximate of less than ± 150 gram error when calibration is done on different cylinders. Since the error is small, concept of weight can be used to monitor the content of LPG inside the cooking gas cylinder.

4.2 Monitoring device

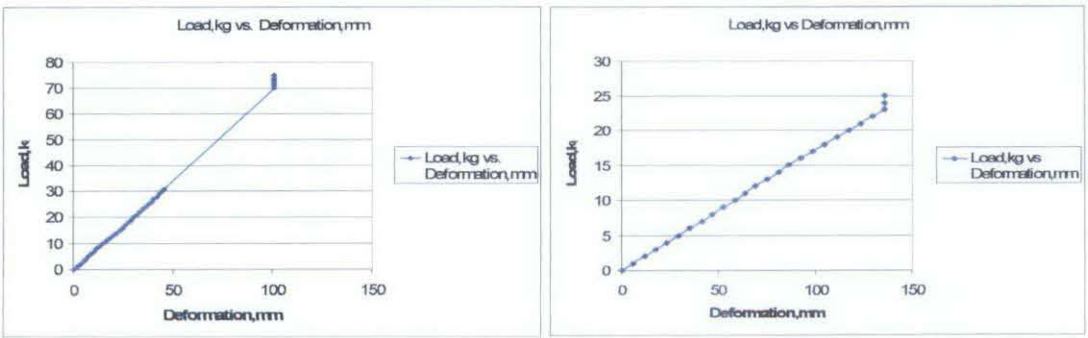
4.2.1 Spring Testing experiment

Two experiments are conducted using different compression spring constant. These experiments as shown in Figure 1 are conducted to verify the suitability of using spring and to find the suitable spring constant for the system.

Figure 4.1 – Picture on the experiment conducted

The first experiment is conducted using three compression spring while the second experiment is conducted using four compression spring. Results are attached in Appendix C and D respectively. The deformation of spring is measured using Digimatic Caliper, an equipment which gives a precise reading.

From the results obtained, graph of Load versus Deformation is plotted for each experiment. Both graphs shown in Figure 2 results in a linear straight line which proved that the load is proportional to the deformation of spring.



(a) (b)

Figure 4.2 – (a) Graph of Experiment 1: Load versus Deformation; (b) Graph of Experiment 2: Load versus Deformation

For experiment 1, the spring constant calculated is 6.615 N/mm. The system can sustained load up to 70 kg which is suitable to monitor the LPG cooking gas cylinder but since the sensor is very sensitive (maximum rotation of potentiometer is 20 mm, therefore 1.43 mm changes of spring height for each kilograms), a higher spring constant is needed. For experiment 2, four springs are used and the calculated spring constant for the system is 1.668 N/mm. The system can sustained load up to 23 kg which is lower than the maximum weight of a 14 kg LPG cooking gas cylinder (Weight of a full 14 kg cylinder is 30.5 kg). Therefore, the spring constant is not suitable for the system. Based on both experiment done, a maximum of four springs will be used for stability purposes.

4.2.2 Calculations

Based on the results obtained, the spring constant for both experiments are calculated. From the experiment, the suitable spring constant for the system is obtained as below:

<u>Experiment 1:</u>

Spring constant for the system, K

$= \Delta F / \Delta X_{equi} = (264.87 - 68.67) / (39.75 - 10.09) = \underline{6.615\ N/mm}$

<u>Experiment 2:</u>

Spring constant for the system, K

$= \Delta F / \Delta X_{equi} = (215.82 - 19.62) / (129.41 - 11.755) = \underline{1.668\ N/mm}$

<u>The suitable spring constant for the system:</u>

Spring used: 4

Sensor rotation = 20 mm

Spring constant for the system, K $= (30.5\ kg \times 9.8) / (20\ mm / 14\ kg \times 30.5\ kg)$

$= \underline{6.97\ N/mm}$

Deformation of the spring, X $= 43.57\ mm / 30.5\ kg$

$= \underline{1.43\ mm\ \text{for each}\ 1\ kg\ \text{load}}$

4.3 Sensor and Circuit design

The sensor and circuit design is break down into two parts; the first part consists of a sensor, microcontroller and transmitter circuit while the second part consists of receiver circuit, microcontroller and the output display [Refer Figure 4.3 and 4.4].

The microcontroller will be the brain of the overall controller circuit where it regulates the overall process according to set points given. The input (sensor) would be from the variable resistor. The outputs are the LCD, buzzer and LED; all controlled by the microcontroller.

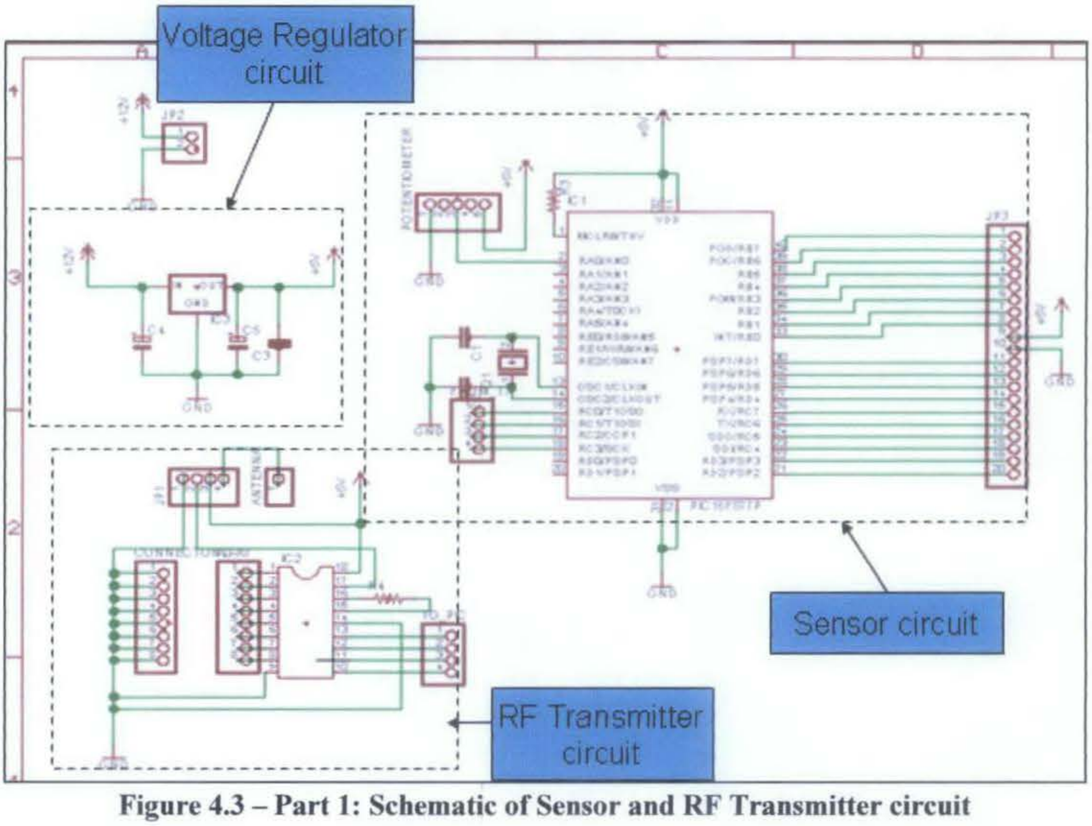


Figure 4.3 – Part 1: Schematic of Sensor and RF Transmitter circuit

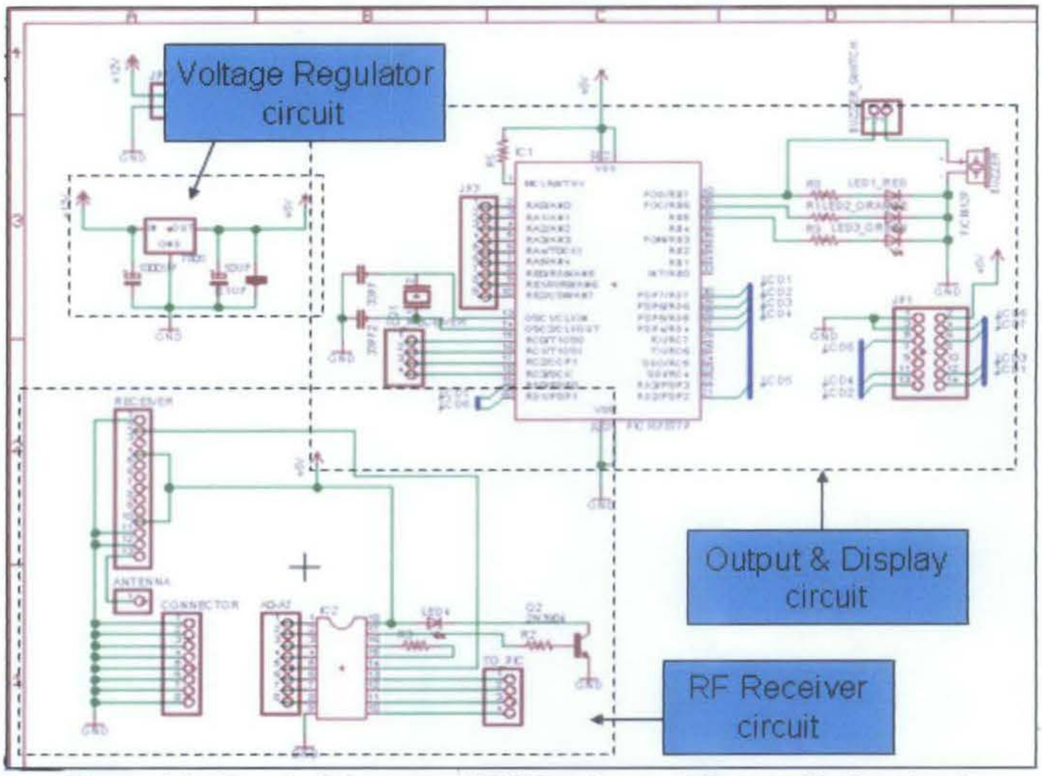


Figure 4.4 – Part 2: Schematic of RF Receiver and Output display circuit

4.3.1 Construction of the overall circuit

Based on Part 1 and Part 2 schematic diagram, the circuit is constructed on normal breadboard as shown in Figure 4.5 to test the workability. All components are put onto the breadboard temporarily to see if the desired results can actually come out. The voltage regulator circuit results in a perfect 5V output from input of 9V. When the input from the sensor is connected to the Controller circuit, result is displayed on the LCD. Based on the programming set in the microcontroller, the outputs will display:

Table 4.2: Output display

Weight (kg)	LED light	Buzzer	Display
≥ 5	Green	Off	TANK: OK
$3 \leq$ Weight < 5	Orange	Off	TANK: LOW
$1 \leq$ Weight < 3	Orange (blinking)	Off	TANK: VERY LOW
<1	Red	On	TANK: REPLACE NOW

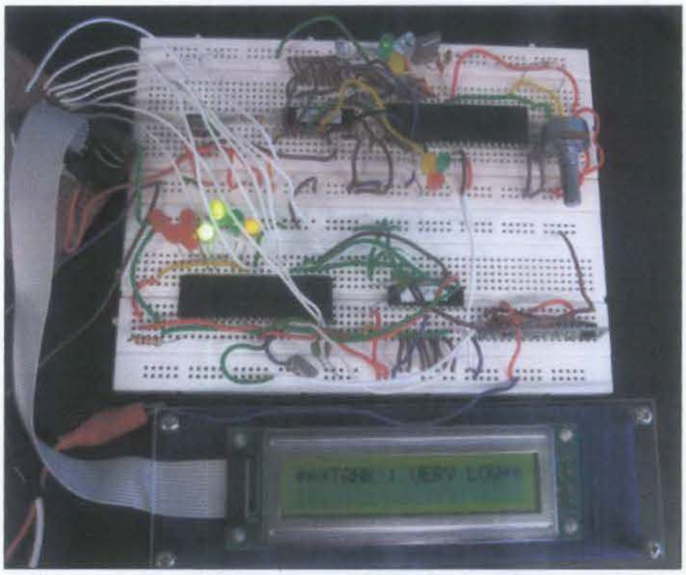


Figure 4.5 – Construction of Part 1 and Part 2 circuit on normal breadboard

4.4 PIC Programming

The microcontroller (PIC16F877) needs to be programmed before it can start functioning. The C Program is divided into 2 main parts; Part 1: ADC and transmitter and Part 2: Receiver and Output display [Refer Appendix E]. The C programs are compiled using PICC Compiler. This compiler is used to convert the C file into Hex file [Refer Figure 4.6].

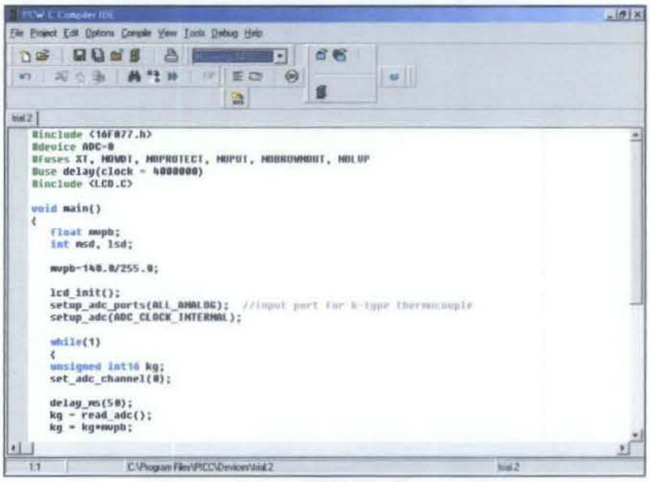


Figure 4.6 – PICC Compiler

Once the program is successfully compiled and converted into Hex file, it is downloaded to Warp-13, and then uploaded onto PIC using PIC Development Programmer [Refer Figure 4.7 and 4.8].

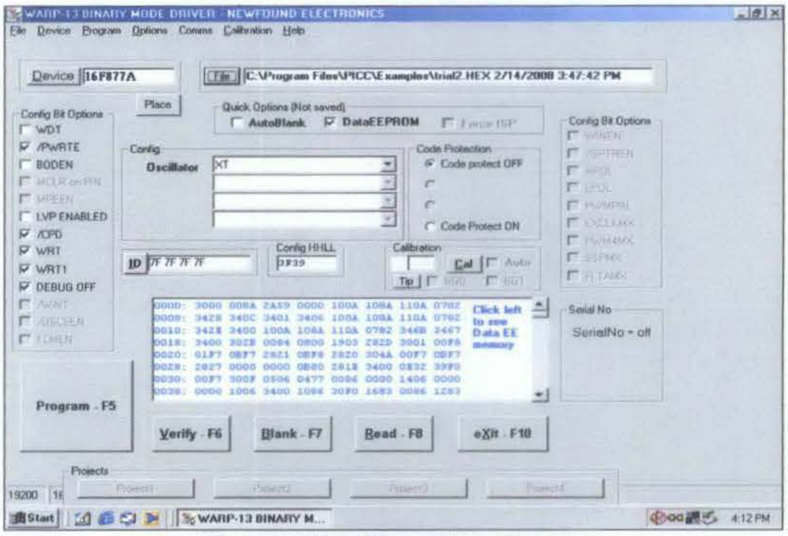


Figure 4.7 – Warp-13 software

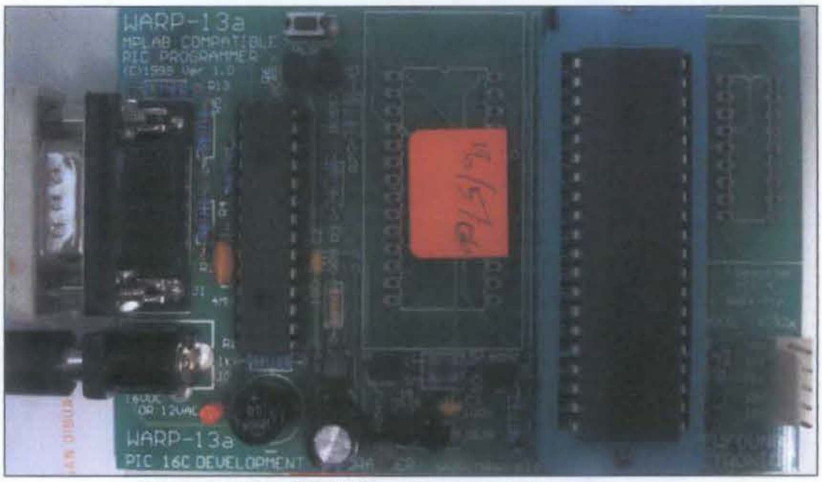


Figure 4.8 – PIC Development Programmer

4.5 PCB Design

The PCB design is constructed using eagle 4.13 software once the sensor and circuit design is finalized. Procedure that needs to be followed to produce PCB is shown in Methodology. The PCB layouts are attached in Appendix F. Figure 4.9 and 4.10 below are the produced PCB from both Part 1 and Part 2 circuit.

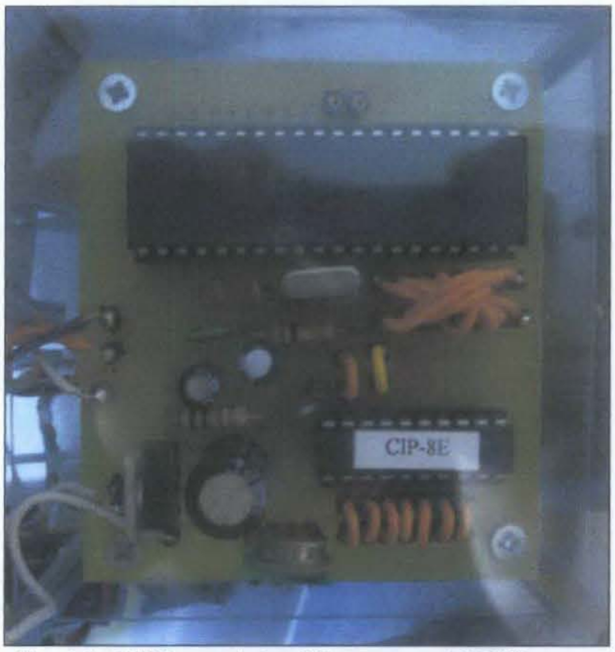


Figure 4.9 – Part 1: PCB consists of Sensor and RF Transmitter circuit

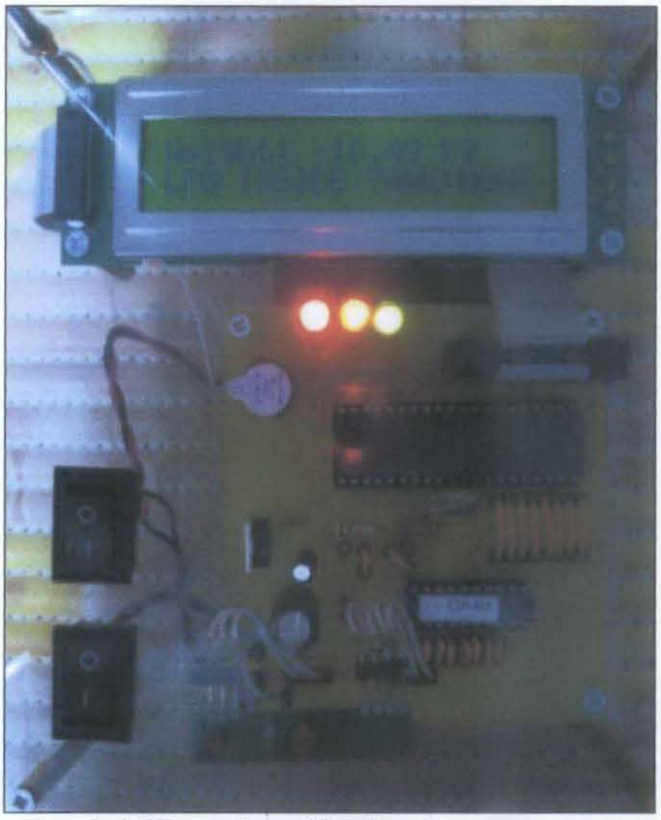


Figure 4.10 – Part 2: PCB consists of RF Receiver and output display circuit

4.6 Construction of Domestic GMD prototype

The construction of Domestic GMD is done at Building 22's lab. Figure 4.12 and 4.13 is the final product. A set of Rack and Pinion gears will be used to rotate the potentiometer. The dimension of the Rack and Pinion gears is attached in Appendix K.

Figure 4.11 – Final product

Figure 4.12 – Gear to rotate the potentiometer

4.7 Cost Analysis

The costing of the project as shown in Table 4.3 is done by referring to the State and Mayor companies' price at Pasir Putih.

Table 4.3: Cost for Domestic GMD

Components	Cost
Spring	RM 12.50
Microcontroller	RM 20.00
RF Transmitter & Receiver	RM 37.08
Encoder & Decoder	RM 8.00
Roller	RM 8.00
Miscellaneous	RM 10.00
Total	**RM 95.58**

CHAPTER 5
CONCLUSION & RECOMMENDATION

The project has shown that it is possible to monitor the content of LPG by using weight, other than pressure. The experiment conducted has shown that, spring could be used in this approach. This approach is simple and less expensive, but at the same time reliable and practical. A portable display that is able to display the weight of LPG and alert user is also developed. Besides using buzzer, LEDs of different colors are also used for this purpose.

Future recommendations for this project are to:

1. Include gas leakage detection
2. Use Bluetooth for wireless transmission instead of Radio Frequency
3. Carry out statistical analysis for reliability of the experimental results
4. Use load cell for a more accurate weight reading
5. Build an energy saving circuit so that the portable display can last long when it is switched on.

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APPENDICES

APPENDIX A:

GANTT CHART FYP I

APPENDIX A

GANTT CHART FYP I

No.	Detail/ Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	Selection of Project Topic	■	■														
2	Preliminary Research Work		■	■	■												
3	Submission of Preliminary Report				★												
4	Laboratory work																
	Design Monitoring device					■	■	■	■	■							
	Research on suitable sensor							■	■	■							
	Design sensor circuit										■	■	■		■		
5	Submission of Progress Report									★							
6	Seminar 1 (compulsory)										■						
7	Submission Draft Report												★				
8	Submission of Interim Report Final Draft															★	
9	Oral Presentation																★

★ Suggested milestone

■ Process

Hari Raya Holidays

APPENDIX B:

GANTT CHART FYP II

APPENDIX B

GANTT CHART FYP II

No.	Detail/ Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	Project work continue																
	Programming	■	■	■													
2	Submission of Progress Report 1				★												
3	Laboratory work																
	RF Transmitter and RF Receiver circuit				■	■	■	■									
	Troubleshooting						■	■		■	■	■	■				
	Build GMD prototype										■	■	■				
4	Submission of Progress Report 2									★							
5	Seminar 1									■							
6	Poster exhibition											★					
7	Seminar 2													■			
7	Submission of Dissertation (soft bound)													★			
8	Oral Presentation														★		
9	Submission of Project Dissertation (Hard Bound)															★	

★ Suggested milestone
■ Process
Mid Semester Break

APPENDIX C:
RESULT OF EXPERIMENT 1

Experiment 1

Total spring : 3
Maximum load : 70 kg
Apparatus : Load (1-75kg), Digimatic caliper

Table 4.2 – Result of Experiment 1

Load (kg)	Newton, N	Deflection, D (mm)			Deformation, X (mm)			Xequi (mm)
		Spring 1	Spring 2	Spring 3	Spring 1	Spring 2	Spring 3	
75.00	735.75	50.00	50.00	50.00	100.64	100.74	100.73	100.70
74.00	725.94	50.00	50.00	50.00	100.64	100.74	100.73	100.70
73.00	716.13	50.00	50.00	50.00	100.64	100.74	100.73	100.70
72.00	706.32	50.00	50.00	50.00	100.64	100.74	100.73	100.70
71.00	696.51	50.00	50.00	50.00	100.64	100.74	100.73	100.70
70.00	686.70	50.00	50.00	50.00	100.64	100.74	100.73	100.70
31.00	304.11	107.42	101.01	106.77	43.22	49.73	43.96	45.64
30.00	294.30	108.11	102.13	108.32	42.53	48.61	42.41	44.52
29.00	284.49	109.11	103.90	109.90	41.53	46.84	40.83	43.07
28.00	274.68	110.86	105.48	110.41	39.78	45.26	40.32	41.79
27.00	264.87	111.89	106.46	114.50	38.75	44.28	36.23	39.75
26.00	255.06	113.54	108.66	112.64	37.10	42.08	38.09	39.09
25.00	245.25	114.40	110.04	114.81	36.24	40.70	35.92	37.62
24.00	235.44	116.07	112.11	116.06	34.57	38.63	34.67	35.96
23.00	225.63	117.32	113.22	117.84	33.32	37.52	32.89	34.58
22.00	215.82	119.02	115.12	118.84	31.62	35.62	31.89	33.04
21.00	206.01	120.62	116.75	119.89	30.02	33.99	30.84	31.62
20.00	196.20	122.81	117.76	121.19	27.83	32.98	29.54	30.12
19.00	186.39	123.36	119.49	122.72	27.28	31.25	28.01	28.85
18.00	176.58	125.16	120.94	123.83	25.48	29.80	26.90	27.39
17.00	166.77	126.83	122.77	125.42	23.81	27.97	25.31	25.70
16.00	156.96	127.27	124.26	126.47	23.37	26.48	24.26	24.70
15.00	147.15	128.83	126.78	127.44	21.81	23.96	23.29	23.02
14.00	137.34	130.12	128.99	129.23	20.52	21.75	21.50	21.26
13.00	127.53	131.56	130.45	130.88	19.08	20.29	19.85	19.74
12.00	117.72	133.04	132.98	133.01	17.60	17.76	17.72	17.69
11.00	107.91	134.76	134.89	134.22	15.88	15.85	16.51	16.08
10.00	98.10	136.12	136.43	136.32	14.52	14.31	14.41	14.41
9.00	88.29	137.65	137.86	137.71	12.99	12.88	13.02	12.96
8.00	78.48	139.21	139.45	139.44	11.43	11.29	11.29	11.34
7.00	68.67	140.54	140.65	140.65	10.10	10.09	10.08	10.09
6.00	58.86	141.96	142.05	142.12	8.68	8.69	8.61	8.66
5.00	49.05	143.22	143.45	143.32	7.42	7.29	7.41	7.37
4.00	39.24	144.65	144.89	144.77	5.99	5.85	5.96	5.93
3.00	29.43	145.89	145.94	145.78	4.75	4.80	4.95	4.83
2.00	19.62	147.23	147.33	147.34	3.41	3.41	3.39	3.40
1.00	9.81	148.68	148.64	148.77	1.96	2.10	1.96	2.01
0.00	0.00	150.64	150.74	150.73	0.00	0.00	0.00	0.00

Deformation, X = Free length of spring - spring deflected
Average Deformation, $X_{equi} = (X_1 + X_2 + X_3 + X_4) / 4$
Constant, $K = \Delta F / \Delta X$

APPENDIX D:

RESULT OF EXPERIMENT 2

Experiment 2

Total spring : 4
Maximum load : 23 kg
Apparatus : Load (1-25kg), Digimatic caliper

Table 4.3 – Result of Experiment 2

Load (kg)	Newton, N	Deflection, D (mm)				Deformation, X (mm)				Xequi (mm)
		Spring 1	Spring 2	Spring 3	Spring 4	Spring 1	Spring 2	Spring 3	Spring 4	
25.00	245.25	50.00	50.00	50.00	50.00	135.68	135.30	135.68	135.32	135.50
24.00	235.44	50.00	50.00	50.00	50.00	135.68	135.30	135.68	135.32	135.50
23.00	225.63	50.00	50.00	50.00	50.00	135.68	135.30	135.68	135.32	135.50
22.00	215.82	56.01	56.11	56.14	56.08	129.67	129.19	129.54	129.24	129.41
21.00	206.01	62.04	62.13	62.06	62.03	123.64	123.17	123.62	123.29	123.43
20.00	196.20	68.13	68.34	68.24	68.19	117.55	116.96	117.44	117.13	117.27
19.00	186.39	74.23	74.34	74.41	74.35	111.45	110.96	111.27	110.97	111.16
18.00	176.58	80.88	80.93	80.91	80.84	104.80	104.37	104.77	104.48	104.61
17.00	166.77	87.04	87.13	87.23	87.15	98.64	98.17	98.45	98.17	98.36
16.00	156.96	93.12	93.32	93.22	93.14	92.56	91.98	92.46	92.18	92.30
15.00	147.15	99.23	99.33	99.43	99.21	86.45	85.97	86.25	86.11	86.20
14.00	137.34	105.76	104.38	104.48	104.28	79.92	80.92	81.20	81.04	80.77
13.00	127.53	111.43	110.12	110.75	110.22	74.25	75.18	74.93	75.10	74.87
12.00	117.72	117.35	116.79	116.05	116.45	68.33	68.51	69.63	68.87	68.84
11.00	107.91	123.17	121.64	121.33	121.59	62.51	63.66	64.35	63.73	63.56
10.00	98.10	127.51	127.10	127.25	127.52	58.17	58.20	58.43	57.80	58.15
9.00	88.29	133.16	133.40	133.07	133.63	52.52	51.90	52.61	51.69	52.18
8.00	78.48	139.59	138.26	139.31	138.95	46.09	47.04	46.37	46.37	46.47
7.00	68.67	144.40	144.87	143.82	144.16	41.28	40.43	41.86	41.16	41.18
6.00	58.86	151.21	150.48	150.25	150.21	34.47	34.82	35.43	35.11	34.96
5.00	49.05	156.16	156.30	156.03	156.03	29.52	29.00	29.65	29.29	29.37
4.00	39.24	162.16	162.20	162.34	162.22	23.52	23.10	23.34	23.10	23.27
3.00	29.43	167.95	168.43	167.94	168.38	17.73	16.87	17.74	16.94	17.32
2.00	19.62	173.78	173.85	173.34	173.99	11.90	11.45	12.34	11.33	11.76
1.00	9.81	180.47	180.05	179.40	179.42	5.21	5.25	6.28	5.90	5.66
0.00	0.00	185.68	185.30	185.68	185.32	0.00	0.00	0.00	0.00	0.00

Deformation, X = Free length of spring - spring deflected
Average Deformation, Xequi = $(X_1 + X_2 + X_3 + X_4) / 4$
Constant, $K = \Delta F / \Delta X$

APPENDIX E:

C PROGRAM

```
'//////////////////////////////////////////////////////
' NAME              : HAZERINA BINTI JAFFAR            //
' ID                : 5727                             //
' PROJECT TITLE     : DOMESTIC GAS MONITORING DEVICE   //
' SUPERVISOR        : DR AFZA BINTI SHAFIE             //
'//////////////////////////////////////////////////////

'C PROGRAM FOR PART 1

include <16F877.h>
levice ADC=8
fuses XT, NOWDT, NOPROTECT, NOPUT, NOBROWNOUT, NOLVP
use delay(clock = 4000000)
include <LCD.C>


oid main()


  set_tris_d(0x00);     //output port to encoder
  setup_adc_ports(ALL_ANALOG); //input port for variable resistor
  setup_adc(ADC_CLOCK_INTERNAL);

  while(1)
  {
  int8 kg;
  set_adc_channel(0);

  delay_ms(50);
  kg = read_adc();


  delay_ms(100);
  output_d(kg); //all on

  }
```

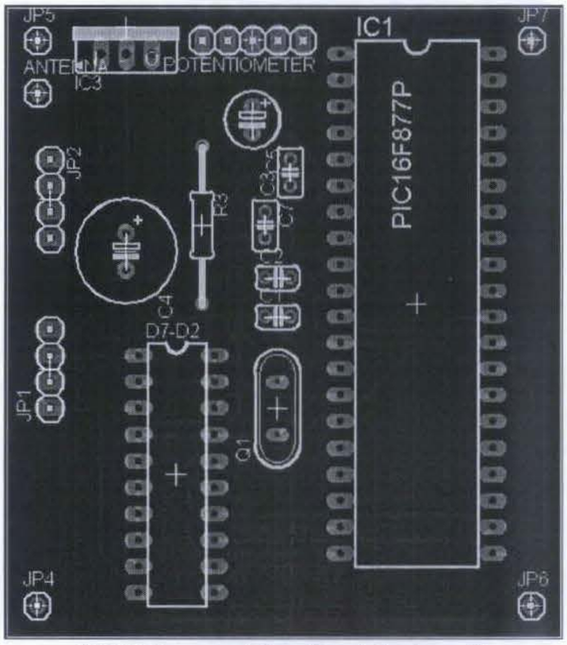
```
'///////////////////////////////////////////////////
' NAME            : HAZERINA BINTI JAFFAR            //
' ID              : 5727                             //
' PROJECT TITLE   : DOMESTIC GAS MONITORING DEVICE   //
' SUPERVISOR      : DR AFZA BINTI SHAFIE             //
'///////////////////////////////////////////////////

'C PROGRAM FOR PART 2

nclude <16F877A.h>
'uses XT, NOWDT, NOPROTECT, NOPUT, NOBROWNOUT, NOLVP
ıse delay(clock = 4000000)
nclude <LCD.C>


ıid main()

 set_tris_d(0x00);     //output port for lcd
 lcd_init();
 set_tris_c(0xFF);
 set_tris_b(0x00);


 while(1)
 {

 float mvpb;
 float result;
 float result2;
 int8 kg;
 mvpb=30.5/255.0;
 delay_ms(100);
 lcd_gotoxy(1,1);
 kg = input_c();
 result = kg*mvpb-16.5;
 result2 = 1.095*result + 2.9992;

 if ((result2 >= 5) && (result2 <=14.5 ))
 {
            printf(lcd_putc,"Weight: %5.2f kg \n",result2);
            lcd_putc("*****TANK : OK******");
                output_low(PIN_B6);
                        output_low(PIN_B7);
           output_high(PIN_B5);

 }
 else if ( (result2 >= 3) && (result2 < 5) )
 {
            printf(lcd_putc,"Weight: %5.2f kg \n",result2);
            lcd_putc("*****TANK : LOW*****");
                output_low(PIN_B5);
           output_low(PIN_B7);
           output_high(PIN_B6);

 }
 else if ( (result2 >= 1) && (result2 < 3) )
 {

            printf(lcd_putc,"Weight: %5.2f kg \n",result2);
            lcd_putc("**TANK : VERY LOW***");
                output_low(PIN_B5);
           output_low(PIN_B7);
```

```
          output_high(PIN_B6);
           delay_ms(100);
           output_low(PIN_B6);

}
else if ( (result2 >=0 ) && (result2 < 1) )
{
           printf(lcd_putc,"Weight: %5.2f kg \n",result2);
           lcd_putc("**TANK: REPLACE NOW*");
          output_low(PIN_B5);
           output_low(PIN_B6);
               output_high(PIN_B7);

}
else
{
           printf(lcd_putc,"Weight: 0.0 kg \n");
           lcd_putc("LPG INSIDE TANK:NONE");
               output_high(PIN_B5);
           output_high(PIN_B7);
               output_high(PIN_B6);
               delay_ms(100);
           output_low(PIN_B5);
               output_low(PIN_B7);
               output_low(PIN_B6);
               delay_ms(100);

}

delay_ms(1000);

}
```

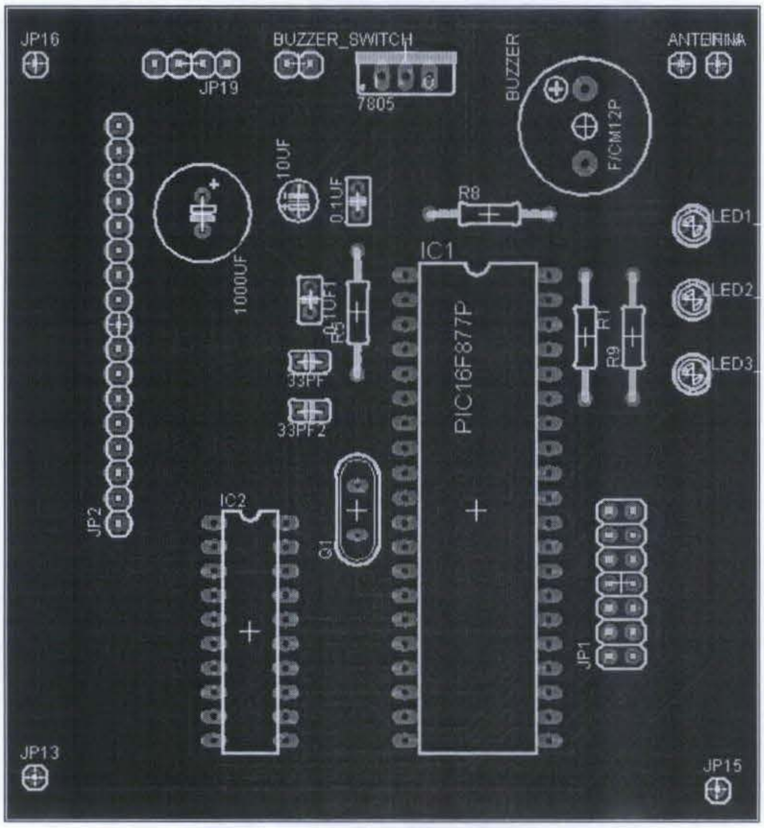
APPENDIX F:

PCB LAYOUT

APPENDIX F



PCB Layout for Part 1 circuit



PCB Layout for Part 2 circuit

APPENDIX G:

16F877 DATASHEET

PIC16F87X Data Sheet

28/40-Pin 8-Bit CMOS FLASH Microcontrollers

DNV Certification, Inc. USA

DNV MSC The Netherlands Accredited by the RvA

ISO 9001 / QS-9000 REGISTERED FIRM

Microchip received QS-9000 quality system certification for its worldwide headquarters, design and wafer fabrication facilities in Chandler and Tempe, Arizona in July 1999. The Company's quality system processes and procedures are QS-9000 compliant for its PICmicro® 8-bit MCUs, KEELOQ® code hopping devices, Serial EEPROMs and microperipheral products. In addition, Microchip's quality system for the design and manufacture of development systems is ISO 9001 certified.

PIC16F87X

28/40-Pin 8-Bit CMOS FLASH Microcontrollers

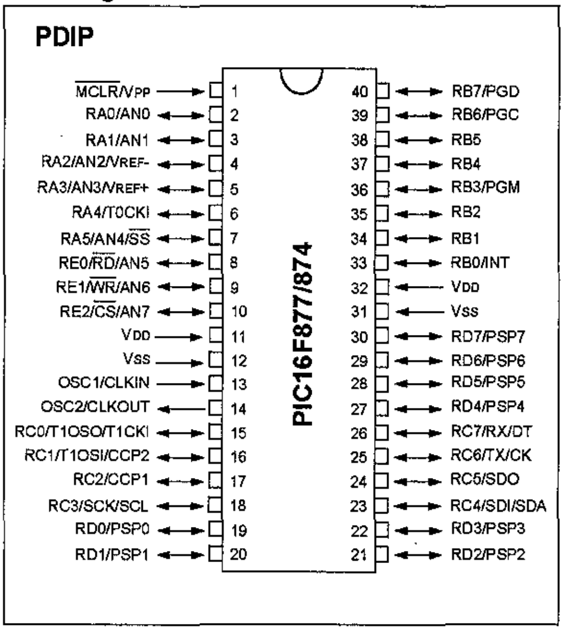
Devices Included in this Data Sheet:

- PIC16F873
- PIC16F874
- PIC16F876
- PIC16F877

Microcontroller Core Features:

- High performance RISC CPU
- Only 35 single word instructions to learn
- All single cycle instructions except for program branches which are two cycle
- Operating speed: DC - 20 MHz clock input
  DC - 200 ns instruction cycle
- Up to 8K x 14 words of FLASH Program Memory,
  Up to 368 x 8 bytes of Data Memory (RAM)
  Up to 256 x 8 bytes of EEPROM Data Memory
- Pinout compatible to the PIC16C73B/74B/76/77
- Interrupt capability (up to 14 sources)
- Eight level deep hardware stack
- Direct, indirect and relative addressing modes
- Power-on Reset (POR)
- Power-up Timer (PWRT) and Oscillator Start-up Timer (OST)
- Watchdog Timer (WDT) with its own on-chip RC oscillator for reliable operation
- Programmable code protection
- Power saving SLEEP mode
- Selectable oscillator options
- Low power, high speed CMOS FLASH/EEPROM technology
- Fully static design
- In-Circuit Serial Programming™ (ICSP) via two pins
- Single 5V In-Circuit Serial Programming capability
- In-Circuit Debugging via two pins
- Processor read/write access to program memory
- Wide operating voltage range: 2.0V to 5.5V
- High Sink/Source Current: 25 mA
- Commercial, Industrial and Extended temperature ranges
- Low-power consumption:
  - < 0.6 mA typical @ 3V, 4 MHz
  - 20 µA typical @ 3V, 32 kHz
  - < 1 µA typical standby current

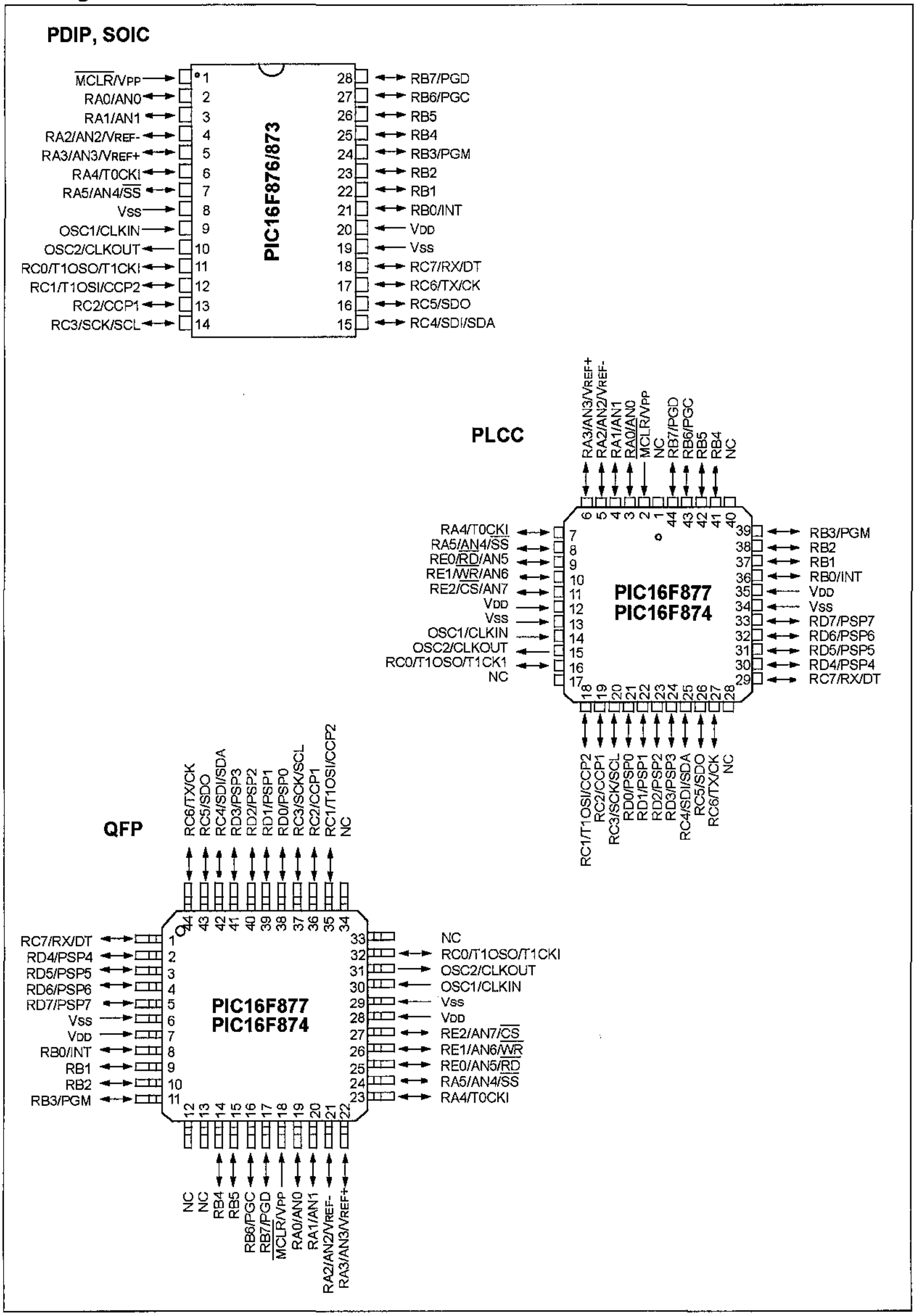
Pin Diagram



Peripheral Features:

- Timer0: 8-bit timer/counter with 8-bit prescaler
- Timer1: 16-bit timer/counter with prescaler, can be incremented during SLEEP via external crystal/clock
- Timer2: 8-bit timer/counter with 8-bit period register, prescaler and postscaler
- Two Capture, Compare, PWM modules
  - Capture is 16-bit, max. resolution is 12.5 ns
  - Compare is 16-bit, max. resolution is 200 ns
  - PWM max. resolution is 10-bit
- 10-bit multi-channel Analog-to-Digital converter
- Synchronous Serial Port (SSP) with SPI™ (Master mode) and I^2C™ (Master/Slave)
- Universal Synchronous Asynchronous Receiver Transmitter (USART/SCI) with 9-bit address detection
- Parallel Slave Port (PSP) 8-bits wide, with external RD, WR and CS controls (40/44-pin only)
- Brown-out detection circuitry for Brown-out Reset (BOR)

Pin Diagrams



Key Features PICmicro™ Mid-Range Reference Manual (DS33023)	PIC16F873	PIC16F874	PIC16F876	PIC16F877
Operating Frequency	DC - 20 MHz	DC - 20 MHz	DC - 20 MHz	DC - 20 MHz
RESETS (and Delays)	POR, BOR (PWRT, OST)	POR, BOR (PWRT, OST)	POR, BOR (PWRT, OST)	POR, BOR (PWRT, OST)
FLASH Program Memory (14-bit words)	4K	4K	8K	8K
Data Memory (bytes)	192	192	368	368
EEPROM Data Memory	128	128	256	256
Interrupts	13	14	13	14
I/O Ports	Ports A,B,C	Ports A,B,C,D,E	Ports A,B,C	Ports A,B,C,D,E
Timers	3	3	3	3
Capture/Compare/PWM Modules	2	2	2	2
Serial Communications	MSSP, USART	MSSP, USART	MSSP, USART	MSSP, USART
Parallel Communications	—	PSP	—	PSP
10-bit Analog-to-Digital Module	5 input channels	8 input channels	5 input channels	8 input channels
Instruction Set	35 instructions	35 instructions	35 instructions	35 instructions

Table of Contents

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1.0 DEVICE OVERVIEW

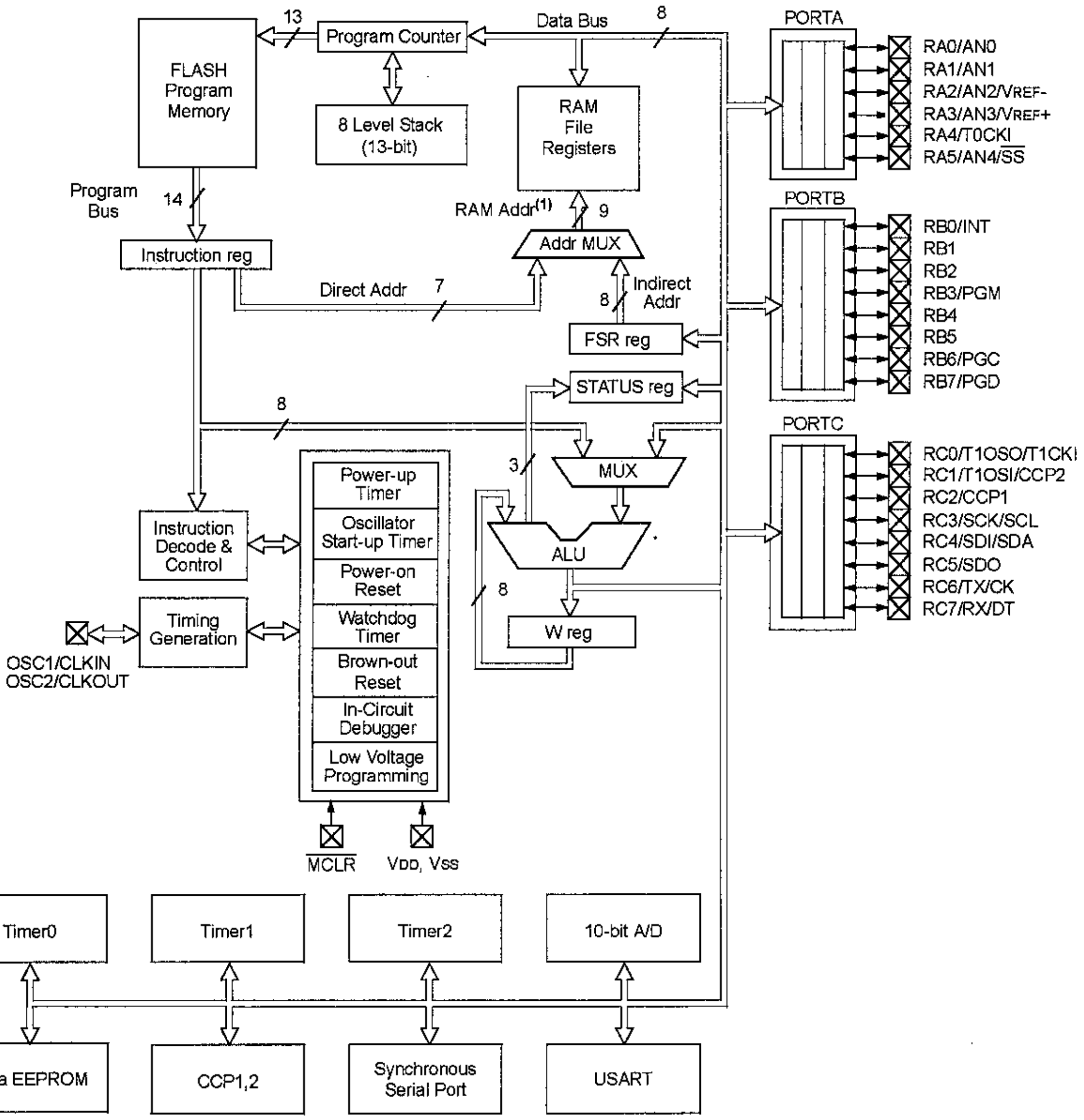
This document contains device specific information. Additional information may be found in the PICmicro™ Mid-Range Reference Manual (DS33023), which may be obtained from your local Microchip Sales Representative or downloaded from the Microchip website. The Reference Manual should be considered a complementary document to this data sheet, and is highly recommended reading for a better understanding of the device architecture and operation of the peripheral modules.

There are four devices (PIC16F873, PIC16F874, PIC16F876 and PIC16F877) covered by this data sheet. The PIC16F876/873 devices come in 28-pin packages and the PIC16F877/874 devices come in 40-pin packages. The Parallel Slave Port is not implemented on the 28-pin devices.

The following device block diagrams are sorted by pin number; 28-pin for Figure 1-1 and 40-pin for Figure 1-2. The 28-pin and 40-pin pinouts are listed in Table 1-1 and Table 1-2, respectively.

FIGURE 1-1: PIC16F873 AND PIC16F876 BLOCK DIAGRAM

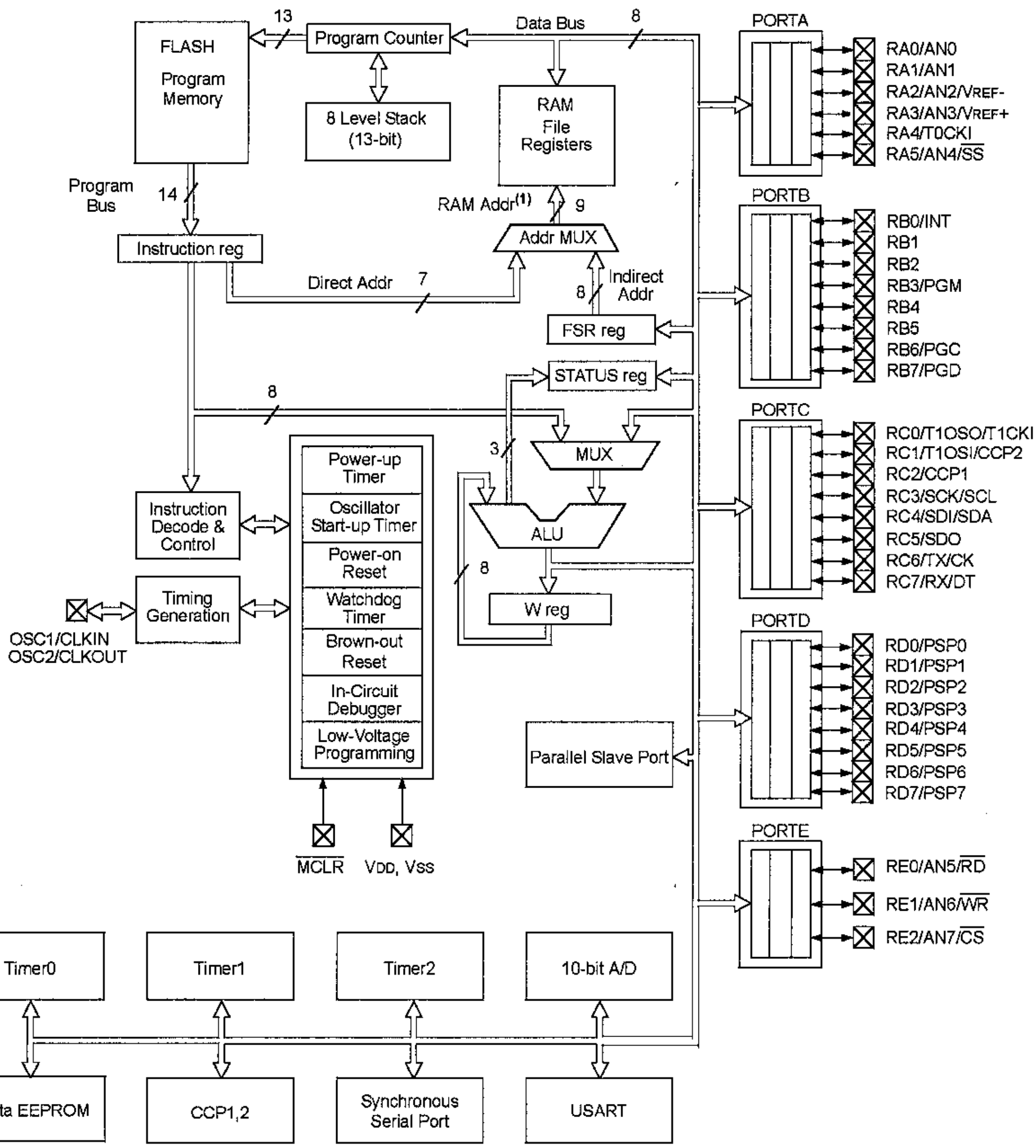
Device	Program FLASH	Data Memory	Data EEPROM
PIC16F873	4K	192 Bytes	128 Bytes
PIC16F876	8K	368 Bytes	256 Bytes



Note 1: Higher order bits are from the STATUS register.

FIGURE 1-2: PIC16F874 AND PIC16F877 BLOCK DIAGRAM

Device	Program FLASH	Data Memory	Data EEPROM
PIC16F874	4K	192 Bytes	128 Bytes
PIC16F877	8K	368 Bytes	256 Bytes



Note 1: Higher order bits are from the STATUS register.

TABLE 1-1: PIC16F873 AND PIC16F876 PINOUT DESCRIPTION

Pin Name	DIP Pin#	SOIC Pin#	I/O/P Type	Buffer Type	Description
OSC1/CLKIN	9	9	I	ST/CMOS(3)	Oscillator crystal input/external clock source input.
OSC2/CLKOUT	10	10	O	—	Oscillator crystal output. Connects to crystal or resonator in crystal oscillator mode. In RC mode, the OSC2 pin outputs CLKOUT which has 1/4 the frequency of OSC1, and denotes the instruction cycle rate.
$\overline{\text{MCLR}}$/VPP	1	1	I/P	ST	Master Clear (Reset) input or programming voltage input. This pin is an active low RESET to the device.
					PORTA is a bi-directional I/O port.
RA0/AN0	2	2	I/O	TTL	RA0 can also be analog input0.
RA1/AN1	3	3	I/O	TTL	RA1 can also be analog input1.
RA2/AN2/VREF-	4	4	I/O	TTL	RA2 can also be analog input2 or negative analog reference voltage.
RA3/AN3/VREF+	5	5	I/O	TTL	RA3 can also be analog input3 or positive analog reference voltage.
RA4/T0CKI	6	6	I/O	ST	RA4 can also be the clock input to the Timer0 module. Output is open drain type.
RA5/$\overline{\text{SS}}$/AN4	7	7	I/O	TTL	RA5 can also be analog input4 or the slave select for the synchronous serial port.
					PORTB is a bi-directional I/O port. PORTB can be software programmed for internal weak pull-up on all inputs.
RB0/INT	21	21	I/O	TTL/ST(1)	RB0 can also be the external interrupt pin.
RB1	22	22	I/O	TTL	
RB2	23	23	I/O	TTL	
RB3/PGM	24	24	I/O	TTL	RB3 can also be the low voltage programming input.
RB4	25	25	I/O	TTL	Interrupt-on-change pin.
RB5	26	26	I/O	TTL	Interrupt-on-change pin.
RB6/PGC	27	27	I/O	TTL/ST(2)	Interrupt-on-change pin or In-Circuit Debugger pin. Serial programming clock.
RB7/PGD	28	28	I/O	TTL/ST(2)	Interrupt-on-change pin or In-Circuit Debugger pin. Serial programming data.
					PORTC is a bi-directional I/O port.
RC0/T1OSO/T1CKI	11	11	I/O	ST	RC0 can also be the Timer1 oscillator output or Timer1 clock input.
RC1/T1OSI/CCP2	12	12	I/O	ST	RC1 can also be the Timer1 oscillator input or Capture2 input/Compare2 output/PWM2 output.
RC2/CCP1	13	13	I/O	ST	RC2 can also be the Capture1 input/Compare1 output/ PWM1 output.
RC3/SCK/SCL	14	14	I/O	ST	RC3 can also be the synchronous serial clock input/output for both SPI and I^2C modes.
RC4/SDI/SDA	15	15	I/O	ST	RC4 can also be the SPI Data In (SPI mode) or data I/O (I^2C mode).
RC5/SDO	16	16	I/O	ST	RC5 can also be the SPI Data Out (SPI mode).
RC6/TX/CK	17	17	I/O	ST	RC6 can also be the USART Asynchronous Transmit or Synchronous Clock.
RC7/RX/DT	18	18	I/O	ST	RC7 can also be the USART Asynchronous Receive or Synchronous Data.
VSS	8, 19	8, 19	P	—	Ground reference for logic and I/O pins.
VDD	20	20	P	—	Positive supply for logic and I/O pins.

Legend: I = input O = output I/O = input/output P = power
— = Not used TTL = TTL input ST = Schmitt Trigger input

Note 1: This buffer is a Schmitt Trigger input when configured as the external interrupt.
2: This buffer is a Schmitt Trigger input when used in Serial Programming mode.
3: This buffer is a Schmitt Trigger input when configured in RC oscillator mode and a CMOS input otherwise.

TABLE 1-2: PIC16F874 AND PIC16F877 PINOUT DESCRIPTION

Pin Name	DIP Pin#	PLCC Pin#	QFP Pin#	I/O/P Type	Buffer Type	Description
OSC1/CLKIN	13	14	30	I	ST/CMOS[(4)]	Oscillator crystal input/external clock source input.
OSC2/CLKOUT	14	15	31	O	—	Oscillator crystal output. Connects to crystal or resonator in crystal oscillator mode. In RC mode, OSC2 pin outputs CLKOUT which has 1/4 the frequency of OSC1, and denotes the instruction cycle rate.
$\overline{\text{MCLR}}$/VPP	1	2	18	I/P	ST	Master Clear (Reset) input or programming voltage input. This pin is an active low RESET to the device.
						PORTA is a bi-directional I/O port.
RA0/AN0	2	3	19	I/O	TTL	RA0 can also be analog input0.
RA1/AN1	3	4	20	I/O	TTL	RA1 can also be analog input1.
RA2/AN2/VREF-	4	5	21	I/O	TTL	RA2 can also be analog input2 or negative analog reference voltage.
RA3/AN3/VREF+	5	6	22	I/O	TTL	RA3 can also be analog input3 or positive analog reference voltage.
RA4/T0CKI	6	7	23	I/O	ST	RA4 can also be the clock input to the Timer0 timer/counter. Output is open drain type.
RA5/$\overline{\text{SS}}$/AN4	7	8	24	I/O	TTL	RA5 can also be analog input4 or the slave select for the synchronous serial port.
						PORTB is a bi-directional I/O port. PORTB can be software programmed for internal weak pull-up on all inputs.
RB0/INT	33	36	8	I/O	TTL/ST[(1)]	RB0 can also be the external interrupt pin.
RB1	34	37	9	I/O	TTL	
RB2	35	38	10	I/O	TTL	
RB3/PGM	36	39	11	I/O	TTL	RB3 can also be the low voltage programming input.
RB4	37	41	14	I/O	TTL	Interrupt-on-change pin.
RB5	38	42	15	I/O	TTL	Interrupt-on-change pin.
RB6/PGC	39	43	16	I/O	TTL/ST[(2)]	Interrupt-on-change pin or In-Circuit Debugger pin. Serial programming clock.
RB7/PGD	40	44	17	I/O	TTL/ST[(2)]	Interrupt-on-change pin or In-Circuit Debugger pin. Serial programming data.

Legend: I = input O = output I/O = input/output P = power
— = Not used TTL = TTL input ST = Schmitt Trigger input

Note 1: This buffer is a Schmitt Trigger input when configured as an external interrupt.
2: This buffer is a Schmitt Trigger input when used in Serial Programming mode.
3: This buffer is a Schmitt Trigger input when configured as general purpose I/O and a TTL input when used in the Parallel Slave Port mode (for interfacing to a microprocessor bus).
4: This buffer is a Schmitt Trigger input when configured in RC oscillator mode and a CMOS input otherwise.

TABLE 1-2: PIC16F874 AND PIC16F877 PINOUT DESCRIPTION (CONTINUED)

Pin Name	DIP Pin#	PLCC Pin#	QFP Pin#	I/O/P Type	Buffer Type	Description
						PORTC is a bi-directional I/O port.
RC0/T1OSO/T1CKI	15	16	32	I/O	ST	RC0 can also be the Timer1 oscillator output or a Timer1 clock input.
RC1/T1OSI/CCP2	16	18	35	I/O	ST	RC1 can also be the Timer1 oscillator input or Capture2 input/Compare2 output/PWM2 output.
RC2/CCP1	17	19	36	I/O	ST	RC2 can also be the Capture1 input/Compare1 output/PWM1 output.
RC3/SCK/SCL	18	20	37	I/O	ST	RC3 can also be the synchronous serial clock input/ output for both SPI and I^2C modes.
RC4/SDI/SDA	23	25	42	I/O	ST	RC4 can also be the SPI Data In (SPI mode) or data I/O (I^2C mode).
RC5/SDO	24	26	43	I/O	ST	RC5 can also be the SPI Data Out (SPI mode).
RC6/TX/CK	25	27	44	I/O	ST	RC6 can also be the USART Asynchronous Transmit or Synchronous Clock.
RC7/RX/DT	26	29	1	I/O	ST	RC7 can also be the USART Asynchronous Receive or Synchronous Data.
						PORTD is a bi-directional I/O port or parallel slave port when interfacing to a microprocessor bus.
RD0/PSP0	19	21	38	I/O	ST/TTL(3)	
RD1/PSP1	20	22	39	I/O	ST/TTL(3)	
RD2/PSP2	21	23	40	I/O	ST/TTL(3)	
RD3/PSP3	22	24	41	I/O	ST/TTL(3)	
RD4/PSP4	27	30	2	I/O	ST/TTL(3)	
RD5/PSP5	28	31	3	I/O	ST/TTL(3)	
RD6/PSP6	29	32	4	I/O	ST/TTL(3)	
RD7/PSP7	30	33	5	I/O	ST/TTL(3)	
						PORTE is a bi-directional I/O port.
RE0/$\overline{RD}$/AN5	8	9	25	I/O	ST/TTL(3)	RE0 can also be read control for the parallel slave port, or analog input5.
RE1/$\overline{WR}$/AN6	9	10	26	I/O	ST/TTL(3)	RE1 can also be write control for the parallel slave port, or analog input6.
RE2/$\overline{CS}$/AN7	10	11	27	I/O	ST/TTL(3)	RE2 can also be select control for the parallel slave port, or analog input7.
VSS	12,31	13,34	6,29	P	—	Ground reference for logic and I/O pins.
VDD	11,32	12,35	7,28	P	—	Positive supply for logic and I/O pins.
NC	—	1,17,28, 40	12,13, 33,34		—	These pins are not internally connected. These pins should be left unconnected.

Legend: I = input O = output I/O = input/output P = power
— = Not used TTL = TTL input ST = Schmitt Trigger input

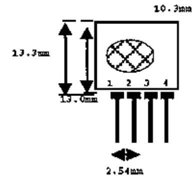
Note 1: This buffer is a Schmitt Trigger input when configured as an external interrupt.
2: This buffer is a Schmitt Trigger input when used in Serial Programming mode.
3: This buffer is a Schmitt Trigger input when configured as general purpose I/O and a TTL input when used in the Parallel Slave Port mode (for interfacing to a microprocessor bus).
4: This buffer is a Schmitt Trigger input when configured in RC oscillator mode and a CMOS input otherwise.

APPENDIX H:

RF TRANSMITTER AND RECEIVER MODULE DATASHEET

TLP434A Ultra Small Transmitter

Easy-Link Wireless



pin 1 : GND
pin 2 : Data In
pin 3 : Vcc
pin 4 : Antenna (RF output)

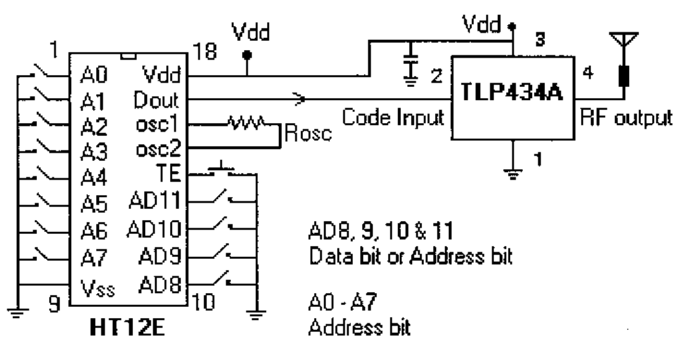
Frequency 315, 418 and 433.92 Mhz

Modulation : ASK
Operation Voltage : 2 - 12 VDC

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Vcc	Operating supply voltage		2.0	-	12.0	V
Icc 1	Peak Current (2V)		-	-	1.64	mA
Icc 2	Peak Current (12V)		-	-	19.4	mA
Vh	Input High Voltage	Idata= 100uA (High)	Vcc-0.5	Vcc	Vcc+0.5	V
Vl	Input Low Voltage	Idata= 0 uA (Low)	-	-	0.3	V
FO	Absolute Frequency	315Mhz module	314.8	315	315.2	MHz
PO	RF Output Power- 50ohm	Vcc = 9V-12V	-	16	-	dBm
		Vcc = 5V-6V	-	14	-	dBm
DR	Data Rate	External Encoding	512	4.8K	200K	bps

Notes : (Case Temperature = 25°C +- 2°C , Test Load Impedance = 50 ohm)

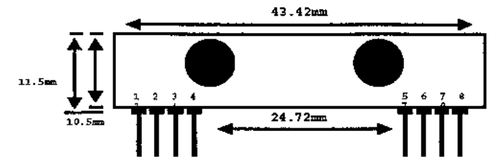
Application Circuit :
Typical Key-chain Transmitter using HT12E-18DIP, a Binary 12 bit Encoder from Holtek Semiconductor Inc.



Laipac Technology, Inc.
105 West Beaver Creek Rd, Unit 207 Richmond Hill Ontario L4B 1C6 Canada
Tel: (905)762-1228 Fax: (905)763-1737 e-mail: info@laipac.com

LAIPAC TECH

RLP434A SAW Based Receiver



pin 1 : Gnd
pin 2 : Digital Data Output
pin 3 : Linear Output /Test
pin 4 : Vcc
pin 5 : Vcc
pin 6 : Gnd
pin 7 : Gnd
pin 8 : Antenna

Frequency 315, 418 and 433.92 Mhz

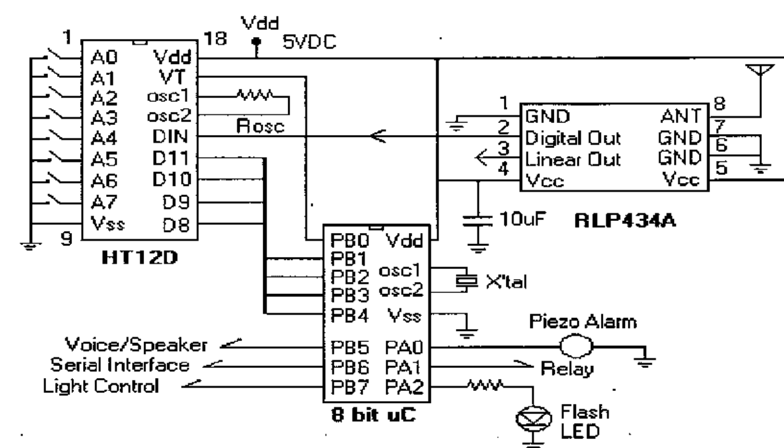
Modulation : ASK
Supply Voltage : 3.3 - 6.0 VDC
Output : Digital & Linear

Symbol	Parameter	Conditions	Min	Typ	Max	
Vcc	Operating supply voltage		3.3	5.0V	6.0	V
Itot	Operating Current		-	4.5		mA
Vdata	Data Out	Idata = +200 uA (High)	Vcc-0.5	-	Vcc	V
		Idata = -10 uA (Low)	-	-	0.3	V

Electrical Characteristics

Characteristics	SYM	Min	Typ	Max	Unit
Operation Radio Frequency	FC		315, 418 and 433.92		MHz
Sensitivity	Pref		-110		dBm
Channel Width			+-500		Khz
Noise Equivalent BW			4		Khz
Receiver Turn On Time			5		ms
Operation Temperature	Top	-20	-	80	C
Baseboard Data Rate			4.8		KHz

Application Circuit :
Typical RF Receiver using HT12D-18DIP, a Binary 12 bit Decoder with 8 bit uC HT48RXX from Holtek Semiconductor Inc.



APPENDIX I:

ENCODER AND DECODER DATASHEET

Description

The CIP-8 series 8-bit encoder/decoder IC's offer an easy to use, low-cost solution for simple remote control applications in a convenient industry standard 20-pin PDIP package.

Encoder Operation

On power-up the encoder enters low power sleep mode. When the transmit enable pin is pulled to ground, the encoder will wake up and begin the transmit process.

First, the encoder will record the state of the 8-bit address/data lines, encode for error correction and assemble the packet.

It will then sample the A0/BAUD pin to fix the data rate, and then output the address and encoded data packet on DOUT.

The encode/transmit process will continue for as long as the /TE pin is low, and return to low power sleep mode when /TE returns high.

It will update the state of the address and data lines with each packet and finish the current transmission even after the /TE pin is released from ground.

Encoded Data Packet

Each data packet consists of seven bytes of information to be transmitted.

- The preamble
- The synchronization byte
- The 1st address byte
- The 1st data byte
- The 2nd address byte
- The 2nd data byte
- The address/data checksum

A 10mS guard time is inserted between each encoded packet transmission to allow the decoder time to receive, decode, verify, and process each packet. The encoder returns to low power sleep mode for power conservation immediately once /TE returns to logic 1, and the packet transmission is complete.

Features

- Latched or momentary outputs
- No programming necessary
- Very easy to use
- Very low component count
- Low current consumption
- Up to 25mA per decoder output
- Eight bit data (D0 to D7)
- Eight bit binary address (0 to 255)
- Selectable baud rates (2400/4800)
- High noise immunity
- Standard 20-pin PDIP package

Applications

- Simple remote control
- Wire elimination
- Remote status monitoring
- Remote lighting control

Decoder Operation

The decoder enters a timed loop waiting for the synchronization byte. An internal 16-bit timer is used to force an exit from the receive loop, and reset the output pins (in momentary mode) every 65.5mS if no valid synch byte is received during this time period.

Once a valid synch byte is received, the timer is disabled, and the remainder of the data packet is received and stored for the verification process.

Immediately after receiving a valid data packet it begins the process of verifying the data, and checking it for errors.

Once data has been verified, the decoded data will be placed on the output pins, and the decoder re-enters the timed loop waiting for the next valid packet.

If the decoder is operating in latch mode, the last valid 8-bit binary data value received will remain on the decoder outputs until a different valid binary data packet is received.

Pin Descriptions
Pins A0 to A7 on the CIP-8 encoder and decoder IC's are used to set a unique address relationship between the encoder and decoder.

This helps prevent accidental activation of decoder outputs, and allows a single encoder the ability to control multiple decoders by simply changing the encoder address to match the decoder to control.

Ensure the address set on the encoder matches the decoder you wish to control. A single bit difference, and the decoder will not respond.

A0/BAUD Pin
The A0/BAUD input serves two functions. One is being the least significant bit of the 8-bit encoder/decoder address. Two is being the data rate selection pin. With A0/BAUD connected to ground, the least significant bit of the 8-bit binary address is 0, and the serial data rate is 2400bps.

With this pin at Vcc, the least significant address bit is 1, and the serial data rate is 4800bps. This option allows support for low-end RF modules that require the lower data rates, while providing the faster data rate option for higher end RF modules such as the excellent Linx Technologies® LR series, and others.

Encoder & Decoder Data Pins D0-D7
On the encoder, pins D0-D7 are the data input pins. The logic value present on these inputs will be transferred to the corresponding D0-D7 data output pins on the decoder when /TE (transmit enable) pin on the encoder is pulled to ground.

Encoder /TE Pin
/TE is the transmit enable pin. This pin will cause the encoder to sample the address and data pins, and transmit continuously while held at ground. Returning /TE to Vcc through the pull-up resistor as shown in the CIP-8 example schematics will end the transmission, and place the encoder in low power sleep mode.

Decoder Latch/Momentary Modes
The decoder L/M pin provides a mode select to switch between momentary or latched decoder operating modes.

Logic 1 = Latch Mode
Logic 0 = Momentary Mode

In momentary mode, the decoder outputs that will maintain the 8-bit data value being received for the duration of valid address and data reception.

If any part of the verification process fails, or reception is interrupted for longer than 65.5mS, decoder will timeout, immediately discard the packet, reset the timer, force all decoder data outputs back to ground, and re-enter the timed loop waiting for the next packet.

When receiving a continuous stream of valid data, the timer is disabled, and the decoder will respond rapidly to changing data values, and hold the received binary pattern on the outputs.

Connect All Pins
All address, data, and function select pins such as /TE, and L/M pins must be connected to either Vcc or ground as required. Leaving any pins floating (not connected) will cause erratic operation of the encoder, decoder, or both.

Ensure that encoder data inputs D0-D7 are at the required logic levels before the /TE pin is pulled to ground.

When prototyping circuits on a breadboard, it may be desirable to test logic levels on all encoder/decoder pins with a logic probe or meter before operation.

VCC And Ground
VCC is the positive power supply. GND is ground.

Ordering Information	
Part #	Description
CIP-8D	8-Bit Decoder IC
CIP-8E	8-Bit Encoder IC

Electrical Characteristics

Parameter	Designation	Min.	Typ.	Max.	Units	Notes
Supply Voltage	Vcc	3.0	--	5.5	VDC	
Supply Current	IDD					
@ 3.0V VCC		---	500	TBD	µA	1
@ 5.0V VCC		---	800	TBD	µA	1
Sleep Current						
@ 3.0V VCC		---	0.1	0.85	µA	
@ 5.0V VCC		---	0.2	0.95	µA	
Input Low Voltage	VIL	GND	---	0.2 VCC	V	2
Input High Voltage	VIH	0.8 VCC	---	VCC	V	3
Output Low Voltage	VOL	---	---	0.6	V	
Output High Voltage	VOH	VCC – 0.7	---	---	V	

Notes

1. Current consumption with no active loads
2. For 3V supply, (0.2 x 3.0) = 0.6V max.
3. For 3V supply, (0.8 x 3.0) = 2.4V min.

Absolute Maximum Ratings

Ambient temperature under bias..-40° to +125°C
Storage temperature ....-65°C to +150°C
Voltage on V_{DD} with respect to Vss ....-0.3V to +6.5V
Voltage on MCLR with respect to Vss ....-0.3V to +13.5V
Voltage on all other pins with respect to Vss ....-0.3V to (V_{DD} + 0.3V)
Total power dissipation ....800 mW
Maximum current out of Vss pin ....300 mA
Maximum current into V_{DD} pin ....250 mA
Input clamp current, I_{IK} (V_I < 0 or V_I > DD)..± 20 mA
Output clamp current, I_{OK} (Vo < 0 or Vo V_{DD})..± 20 mA
Maximum output current sunk by any I/O pin..25 mA
Maximum output current sourced by any I/O pin ....25 mA
Maximum current sunk or sourced by all pins combined ....200 mA

Disclaimer

These devices are not intended for use in applications of a critical nature where safety, life, or property is at risk. The user of this product assumes full liability for the use of this product in all applications. Under no conditions will Reynolds Electronics be responsible for losses arising from the use or failure of the device in any application, other than the repair, replacement, or refund limited to the original product purchase price.

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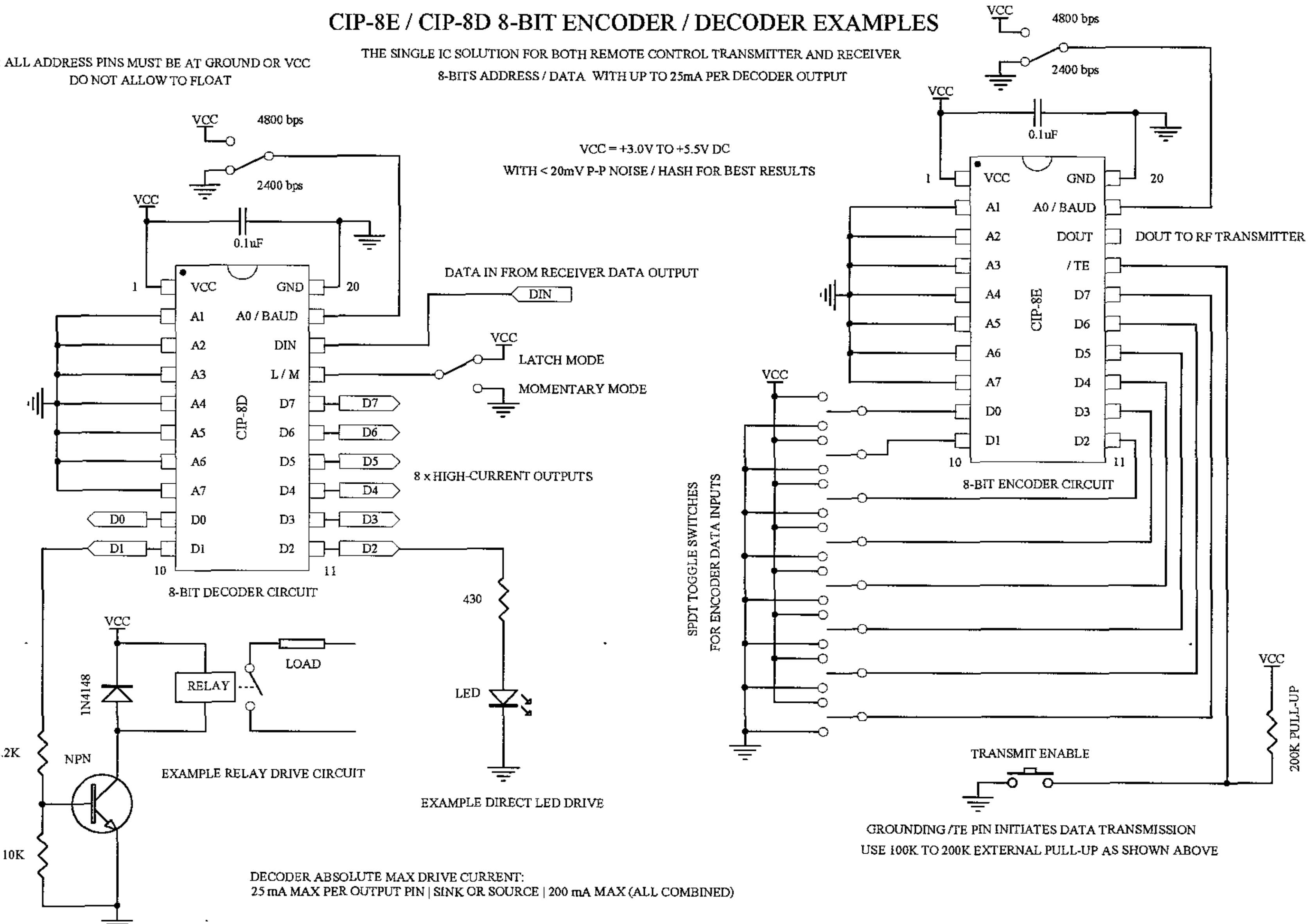
The CIP-8 encoder/decoder IC's are available for purchase online at: http://www.rentron.com

CIP-8E / CIP-8D 8-BIT ENCODER / DECODER EXAMPLES

THE SINGLE IC SOLUTION FOR BOTH REMOTE CONTROL TRANSMITTER AND RECEIVER
8-BITS ADDRESS / DATA WITH UP TO 25mA PER DECODER OUTPUT

NOTE: ALL ADDRESS PINS MUST BE AT GROUND OR VCC
DO NOT ALLOW TO FLOAT

VCC = +3.0V TO +5.5V DC
WITH < 20mV P-P NOISE / HASH FOR BEST RESULTS



GROUNDING /TE PIN INITIATES DATA TRANSMISSION
USE 100K TO 200K EXTERNAL PULL-UP AS SHOWN ABOVE

DECODER ABSOLUTE MAX DRIVE CURRENT:
25 mA MAX PER OUTPUT PIN | SINK OR SOURCE | 200 mA MAX (ALL COMBINED)

ADDRESS PINS MAY BE CONNECTED TO GROUND, VCC, OR ANY COMBINATION
OF GROUND & VCC, AND SHOULD NOT BE ALLOWED TO FLOAT

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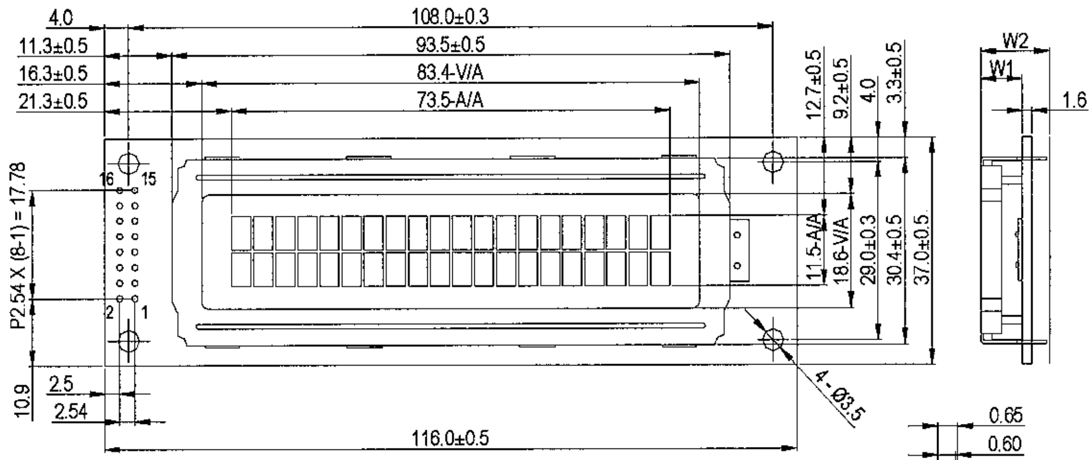
Title	SAMPLE ENCODER / DECODER CIRCUIT SCHEMATICS FOR 8-BIT "CIP-8E" ENCODER & "CIP-8D" DECODER IC's		
Size: Orcad A	Number: CIP-8E / CIP-8D	Revision: A.1	
Date:	7-Nov-2006	Sheet of	1 of 1
File:	C:\CAD\SCHEMATICS.Ddb	Drawn By:	B. REYNOLDS

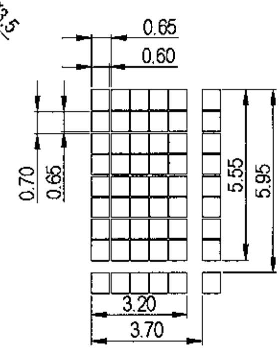
APPENDIX J:

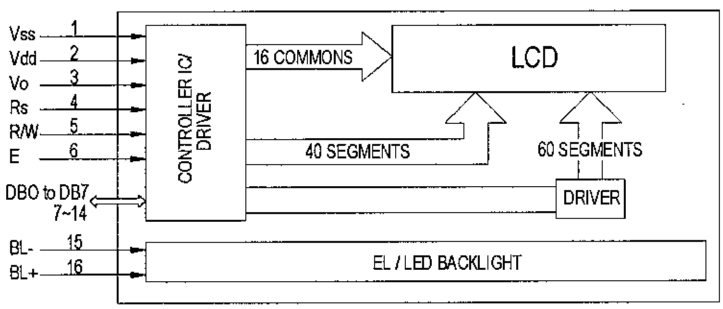
LCD DISPLAY DATASHEET

STANDARD CHARACTER MODULES

C220x01 .... OUTLINE DIMENSION AND BLOCK DIAGRAM







VERSION	W1	W2
NO/EL BACKLIGHT	5.00±0.5	10.00 MAX
LED BACKLIGHT	6.90±0.5	11.5 MAX

The tolerance unless classified ±0.3 mm

PIN ASSIGNMENT

Pin No.	Symbol	Function
1	Vss	Ground Terminal
2	Vdd	Supply Terminal
3	Vo	Power Supply for LCD driver
4	RS	Register Select Signal
5	R/W	Read/Write Selection
6	E	Enable Signal
7	DB0	Data Bus Line
8	DB1	Data Bus Line
9	DB2	Data Bus Line
10	DB3	Data Bus Line
11	DB4	Data Bus Line
12	DB5	Data Bus Line
13	DB6	Data Bus Line
14	DB7	Data Bus Line
15	BL-	Led Backlight Ground
16	BL+	Led Backlight Power Supply

OPTION - REVERSE BACKLIGHT CONNECTION

15	BL+	Led Backlight Power Supply
16	BL-	Led Backlight Ground

NOTE :
1. BACKLIGHT - YELLOW GREEN : BOTTOM LED BACKLIGHT
2. BACKLIGHT - OTHER COLOR : SIDE LED BACKLIGHT

ABSOLUTE MAXIMUM RATING

Item		Symbol	Conditions	Min.	Max.	Unit
Power Supply Voltage		Vdd-Vss	-	-0.3	7.0	V
Input Voltage		Vin	-	Vss	Vdd	V
NORMAL	OPERATING TEMPERATURE	Topr	Normal	0	+50	°C
	STORAGE TEMPERATURE	Tstg	Normal	-20	+70	°C
WIDE	OPERATING TEMPERATURE	Topr	Normal	-20	+70	°C
	STORAGE TEMPERATURE	Tstg	Normal	-30	+80	°C

ELECTRICAL CHARACTERISTIC (Vdd = + 5v, Ta = 25°C)

Item	Symbol	Conditions	Min.	Typ.	Max.	Unit
Logic Supply Voltage	Vdd	-	4.5	5.0	5.5	V
"H" Input Voltage	V_{IH}	-	0.7Vdd	-	Vdd	V
"L" Input Voltage	V_{IL}	-	-0.3	-	0.6	V
"H" Output Voltage	V_{OH}	-	0.75Vdd	-	-	V
"L" Output Voltage	V_{OL}	-	-	-	0.2Vdd	V
Module Supply Current	Idd	-	-	1.0	2.0	mA
LCD Driving Voltage	V_{LCD}	Vdd-Vo	4.3	4.5	4.7	V

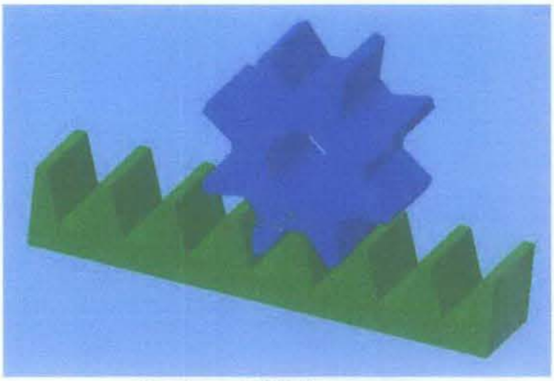
BACKLIGHT OPTION

LED COLOR	OPTION	CONDITION	FORWARD CURRENT (mA)			
			MIN	TYP	MAX	
YELLOW GREEN	YES	V_{bl} = 5.0V R_{bl} = 10ohm	-	90	-	
WHITE	YES	V_{bl} = 5.0V R_{bl} = 47 ohm	-	20	-	
BLUE	YES	V_{bl} = 5.0V R_{bl} = 47 ohm	-	20	-	
AMBER	YES	V_{bl} = 5.0V R_{bl} = 120 ohm	-	20	-	
RED	NO	-	-	-	-	
CCFL	NO	-	-	-	-	
EL	NO	-	-	-	-	

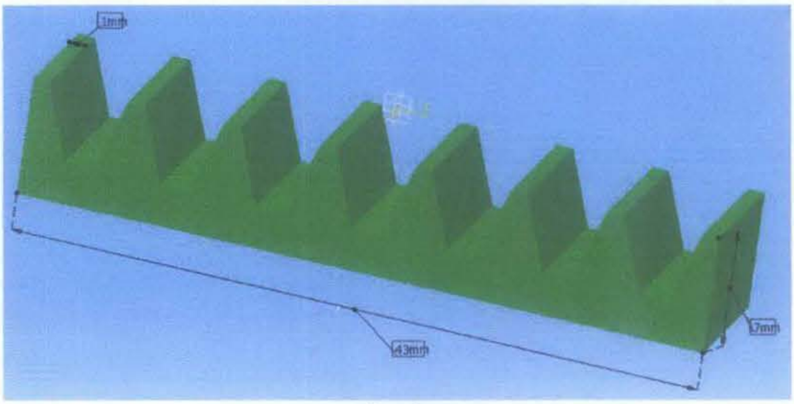
APPENDIX K:

RACK AND PINION GEARS DIMENSION

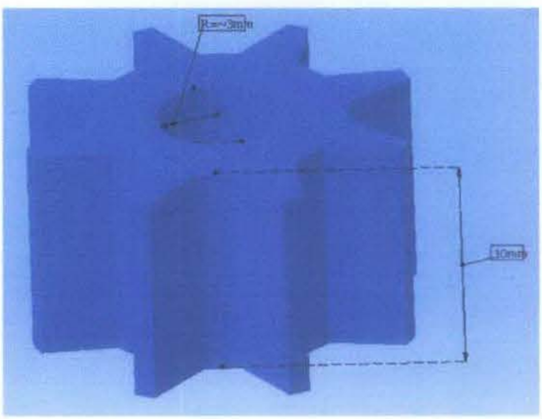
Rack and Pinion gears dimension



Rack and Pinion gears



Rack



Pinion gears