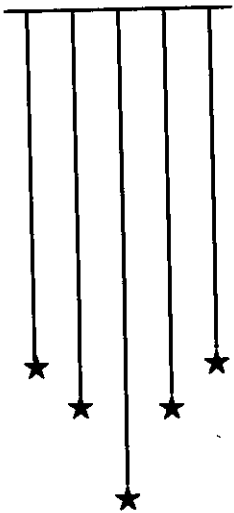


AUTOMATIC FUEL VENDING OUTLET



2002 - 2003

P-1394



PROJECT REPORT

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Certificate

This is to certify that the project entitled

'AUTOMATIC FUEL VENDING OUTLET'

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branch of **BHARATHIAR UNIVERSITY, Coimbatore**

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(External Examiner)

Dedicated

to

our parents, for their love...

our teachers, for their guidance...

our friends, for their support...

Our sincere thanks

to

BHARAT PETROLEUM CORPORATION LIMITED,

Coimbatore.

ACKNOWLEDGEMENT

Our grateful salutations to **The Almighty**, for the strength and guidance that has been the motive power behind our every step.

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SYNOPSIS

Automation is a concept that has revolutionized the modern world due to the developing trends in electronics. The upsurge in the field of automation is reaching its pinnacle, which is evident from the mushrooming of ATM centres, surveillance and security systems. Our project seeks to implement the same automation concept for the fuel vending outlet, which is the need of the hour.

Microcontroller based “automatic fuel vending outlet” hold its importance in more security, less time consumption, reduced manual labour, comfort in use and in provision of customer friendly financial aspect. The embedded system here involved the end appliance, the fuel vending outlet, which is controlled by the microcontroller PIC16f877.

Our project deals with the prototype model and the flexibility of this project provides us with ample opportunity to alter its design and expand its functionality of the system as per requirements.

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INTRODUCTION

INTRODUCTION

The art of automation has created a niche for itself in the industrial world. It has a wide and extensive scope in various industrial applications where speed, security and sophistication are indispensable. This project aims to design a prototype model for such a control application.

The aspect of security that is newly incorporated in to the existing fuel vending outlet, by this project, is achieved by customer identification through password. A vast database comprising of the account details of every customer is created in a non-volatile memory unit with the provision of automatic updating by the administrator. Based on the requested quantity, the microcontroller delivers the fuel to the customer via . the fuel vending outlet. The pulsar, the sensor unit, detects the fuel flow. Based on parameters such as the quantity input, database account, sensor output, the timer unit of PIC16F877 delivers correct quantity of fuel to the customer.

The customization of the design can further be done for liquids of various densities and viscosities .Two or more such liquids can be combined and delivered to the customer. The project is aimed at developing an efficient and easy to use fuel vending outlet.

SYSTEM ANALYSIS

SYSTEM ANALYSIS

2.1 INTRODUCTION

This project is aimed at delivery of the required quantity of fuel to the customer automatically with enhanced security. The customer is required to deposit a certain amount of money which acts as the pre-paid account of that customer. Every time the customer visits the outlet, he can make use of the money deposited before hand and the amount in his account is automatically updated. A unique password is allotted to every customer to ensure that the money he has deposited is not subject to misuse.

2.2 MODES OF OPERATION

The password entered by the user determines whether he is the administrator or a customer. Based on this, two modes of operation are specified.

2.2.1 ADMINISTRATOR MODE

This mode is accessible only to the administrator. He can access the administrator mode by entering the administrator password. The user in the administrator mode has two options. These options can be listed as:

2.2.1.1 OPTIONS

- ✓ Registering new user
- ✓ Updating current price of fuel

The administrator can register a new user by specifying a password of the users choice. This password must have a length of 4 digits. This length can be increased in future if the customer base increases rapidly. If the entered password has been previously assigned to some other user, an error message is displayed. The prompt requesting the user to enter a new password is once again displayed. This continues till a unique password is allotted to the new user.

A specific pre-paid amount is also entered in to the database along with this password. The new user can now make use of the automatic fuel vending service by accessing the user mode with the help of the assigned password.

If the amount in the pre-paid account of an already registered user has reduced below the allowable amount, he can no longer access the system. To solve this problem provision has been made so that he can renew his account by paying the specified amount and retaining the old password. Thus old customers can be retained without allotting new passwords. This increases the customer base for a given number of passwords.

The database also contains the current price per litre of fuel. This amount is prone to frequent changes as the rise and dip in fuel prices is unpredictable. To ensure proper working of the system, the administrator mode has a provision for updating the current price per litre of fuel. This ensures the proper working of the system in spite of the fluctuations in fuel prices.

These two options enable the administrator to maintain the system fault free and user friendly. It serves to reduce the manual strain on the administrator. It also helps in better co-ordination between the administrator and the user, which is a must for the successful implementation and maintaining of any customer oriented service.

2.2.2 USER MODE

This mode is the normal mode of operation. It is accessible by all the users having a pre-paid account. A user in this mode can use the automatic fuel-vending outlet by following a sequence of steps.

2.2.2.1 STEPS

- ✓ Enter 4 digit password of the user
- ✓ If entered password is found to be invalid, error message is displayed.
- ✓ If entered password is valid, the quantity of fuel required is entered.
- ✓ Account details of the user, stored in the database, is accessed to check if cost of required quantity can be paid with the amount in his account.
- ✓ If the pre-paid amount in the user's account is not sufficient to pay for the required quantity, an error message is displayed.
- ✓ If the pre-paid amount in the user's account is greater than the amount to be paid, the user is requested to press the OK button.
- ✓ The pressing of this button initiates the flow of fuel.
- ✓ The pulsar detects the presence of fuel flow.
- ✓ Detection of the absence of fuel flow closes the valve and sends out an error message.
- ✓ If fuel flow is detected by the pulsar, the valve is kept open till the required quantity of fuel is delivered.

The above steps follow each other automatically as required. These steps ensure that a user who is not technically skilled can use the system properly without any strain. The steps are simple and are not time consuming. Hence the maximum number of users can use the system in a given period of time.

The display of an error message in any of the above steps automatically resets the system. The user can start from the beginning automatically if he encounters an error. Once the current user has finished operating the system, the next user can start normal operation immediately. Hence the system is time saving and requires minimum manual interruption even when the system is being used continuously for months and years together.

The system has been designed such that it resets automatically after the delivery of fuel is over. This provision of automatic resetting of the system provides the required security, as back tracking of the previous users password and account details is impossible once he has finished operating the system. The system is thus secure against hackers. The customer is guaranteed that the money he has deposited is in safe hands.

The display and the keypad provided at the user end are simple to comprehend. The closing and opening of the valve requires minimum manual operation. Thus the above steps ensure that the system is secure, timesaving, easy to use and customer friendly.

BLOCK DIAGRAM

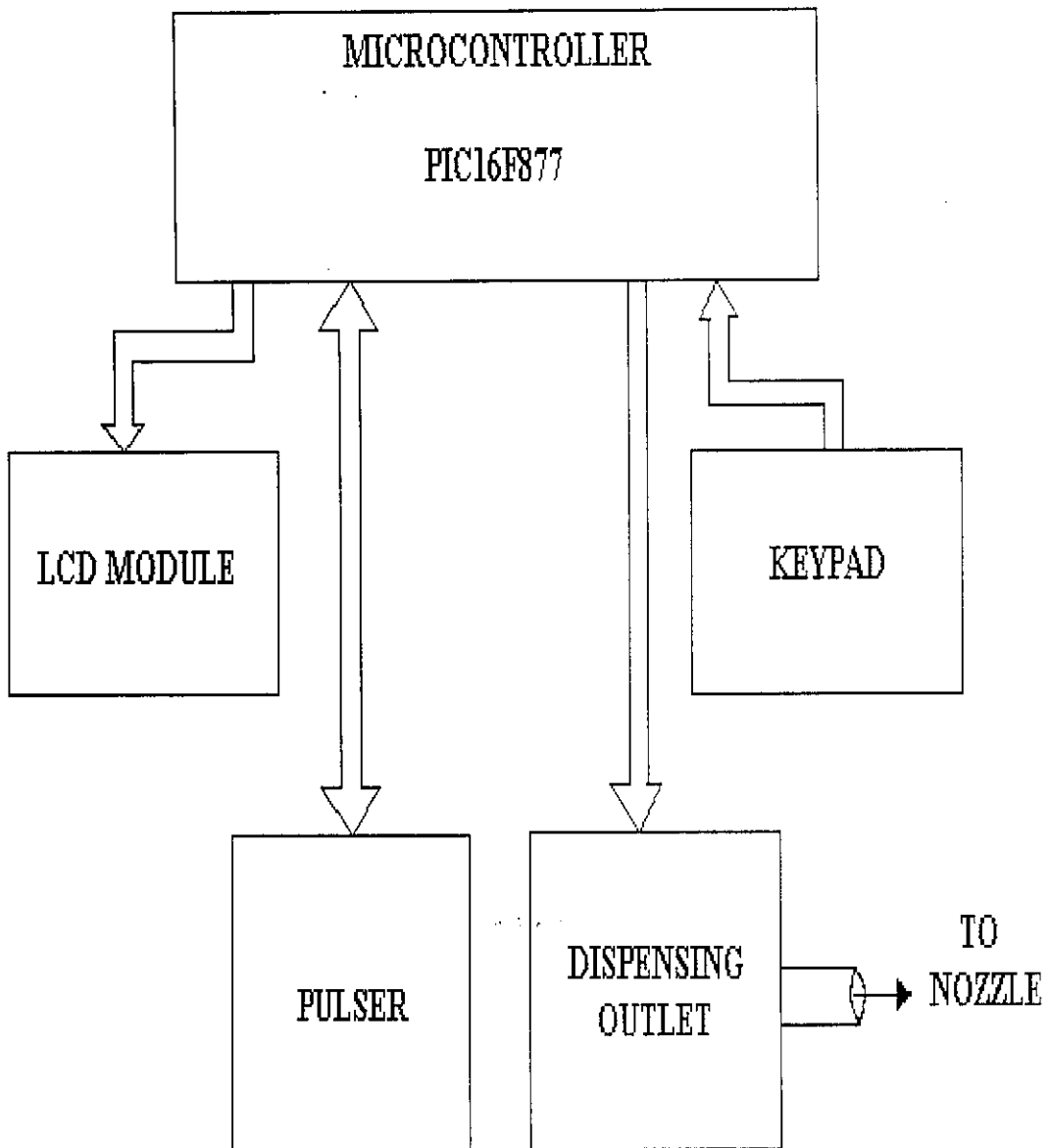


Fig: 2.1 BLOCK DIAGRAM OF THE SYSTEM

10/2/11

SYSTEM DESIGN

SYSTEM DESIGN

The details of the important blocks of the system are defined briefly in this section (ref fig . 3.1) . A detailed description of each is discussed in the forthcoming sections.

3.1 MICROCONTROLLER

The Microchip series PIC16F877 is a low power, high performance 40 pin, 8 bit CMOS FLASH microcontroller. It is provided with 8kx14 words of flash program memory, 368x8 bytes of data memory (RAM) and 256x8 bytes of EEPROM data memory. The microcontroller is programmed with the PIC16F87X instructions. The various blocks like the LCD module, keypad, pulsar module, and valve are interfaced to the microcontroller. The microcontroller, acting as the heart of the system, controls the entire system.

3.2 KEYPAD

The prototype automatic fuel-vending outlet uses a 4x4 matrix keypad. The keypad is provided with number keys from 0 to 9 for password and quantity entry and certain special function keys for specific functions. The keypad logic involves the identification of the row and column to which the key pressed is connected. This enables the identification of the key pressed.

3.3 LCD MODULE

The LCD module interfaced with the microcontroller acts as the display unit. The prompts which request the user to type in the password, the quantity of fuel required and the messages which tell whether the password entered is correct or not are conveyed to the user through the LCD unit. The alphanumeric Dot matrix LCD is a 1

line 16-character display with LED backlighting facility. The LCD has an 8 bit data line interface. A character code map provides the hexadecimal code for commonly used display commands.

3.4 PULSER UNIT

During dispensing of the product, the pulser unit is rotated by a shaft and sends signals to the microcontroller indicating the flow of fuel. It consists of three pairs of photoelectric sensors and a disc with 25 slots.

3.5 NON-VOLATILE MEMORY UNIT

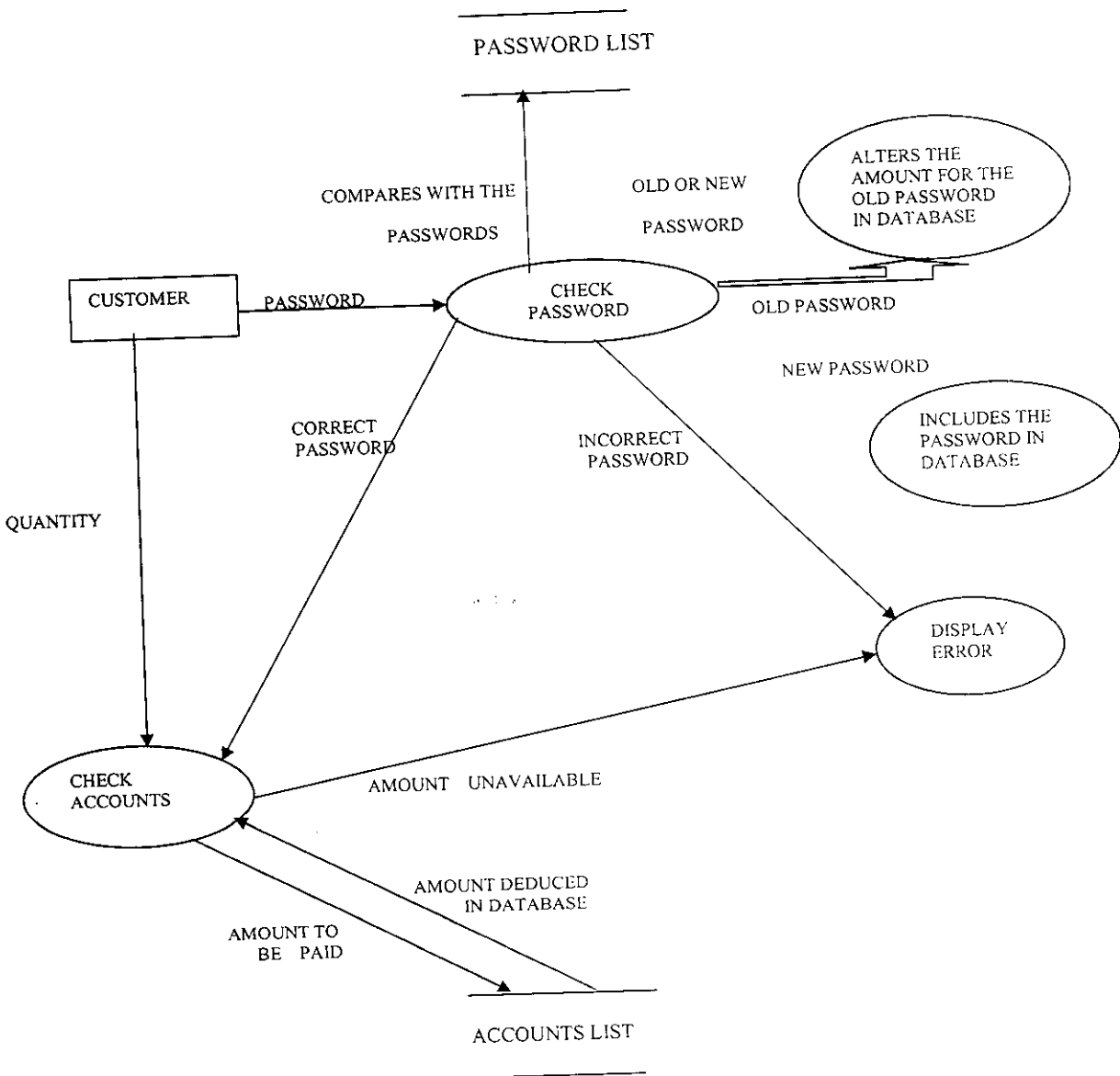
The Dallas semiconductor series MAXIM DS1230Y is a 256k non-volatile, fully static SRAM organized as 32,768 words by 8 bits. It houses the database of customer account details. It is a low power CMOS 28-pin encapsulated package. There is no limit on the number of read and write cycles and no additional circuitry is required for interfacing to the microcontroller. Multiplexing of address and data lines is done with the help of a latch, 74HC573.

3.6 FUEL-VENDING OUTLET UNIT

The fuel-vending outlet used here is a 12V, 1A solenoid valve. The opening and closing of this valve is controlled by the microcontroller through a control circuit. The control circuit has been specifically designed for controlling the 12V solenoid valve through the output (~ 5V) from a port pin of the microcontroller. This valve is such that the nozzle assembly and hose pump used in some of the existing petrol dispensing pumps can be interfaced to it.

DATA FLOW DIAGRAM

fig. 3 . a



MICROCONTROLLER

THE MICROCONTROLLER

4.1 INTRODUCTION

The revolution in embedded intelligence is driven by microcontrollers. Microcontrollers can be described as microprocessors with RAM, ROM, various I/O facilities, timers, counters and many other optional facilities on a single chip. The microcontrollers are also known as System On Chip (SOC) as all resources are included on a single chip.

4.2 MICROCONTROLLER PIC16F877 OVERVIEW

4.2.1 DESCRIPTION

The prefix PIC stands for Peripheral Interface Controller which denotes the single chip microcontrollers developed by Microchip Technology. The low power, high speed CMOS FLASH technology allows the program memory to be reprogrammed in-system. This powerful (200 nanosecond instruction execution) yet easy-to-program (only 35 single word instructions) CMOS FLASH-based 8-bit microcontroller packs Microchip's powerful PIC architecture into a 40-pin package. The PIC16F877 features 256 bytes of EEPROM data memory, self programming, an ICD, 8 channels of 10-bit Analog-to-Digital (A/D) converter, 2 additional timers, 2 capture/compare/ PWM functions, the synchronous serial port can be configured as either 3-wire Serial Peripheral Interface (SPI™) or the 2-wire Inter-Integrated Circuit (I²C™) bus and a Universal Asynchronous Receiver Transmitter (USART). Thus the PIC16F877 provides the performance and versatility to meet the more demanding requirements of today's cost-sensitive marketplace for mid-range applications.

4.2.2 FEATURES

- ✓ High performance RISC CPU
- ✓ 8k X 14 words of on-chip flash memory
- ✓ 368 X 8 bytes of data memory
- ✓ 256 X 8 bytes of EEPROM data memory
- ✓ Interrupt capability-up to 14 sources
- ✓ Eight level deep hardware stack
- ✓ Instruction set-35 single word instructions
- ✓ All single cycle instructions except for program branches (two cycle)
- ✓ Low power consumption: <0.6mA at 3V, 4MHz
- ✓ Power on reset (POR)
- ✓ Power up-timer (PWRT) and oscillator start up timer (OST)
- ✓ Watchdog timer (WDT) with its own on-chip RC oscillator.
- ✓ Programmable code protection
- ✓ Power saving sleep mode
- ✓ Selectable oscillator options
- ✓ Low power, high speed Flash/EEPROM technology
- ✓ Fully static design
- ✓ Wide operating voltage range 2.0V to 5.5V
- ✓ High sink/source current: 25mA
- ✓ 3 timers-2, 8-bit and 1,16-bit timer
- ✓ Brown-out detection circuitry for brown-out reset (BOR)
- ✓ Universal synchronous/asynchronous receiver transmitter(USART/SC)
- ✓ 10 bit multi-channel Analog to Digital converter
- ✓ Commercial, extended and industrial temperature ranges
- ✓ Number of ports available: 4

Ports B, C, D are 8-bit, bi-directional port

Port A is a 6-bit, bi-directional port

Port E is a 3-bit, bi-directional port

4.2.3 I/O PORTS

Some pins for the I/O ports are multiplexed with an alternate function for the peripheral features on the device. In general, when a peripheral is enabled, that pin may not be used as a general purpose I/O pin.

4.2.3.1 PORT A

PORTA is a 6-bit wide, bi-directional port. The corresponding data direction register is TRISA. Setting a TRISA bit (= 1) will make the corresponding PORTA pin an input (i.e., put the corresponding output driver in a Hi-Impedance mode). Clearing a TRISA bit (= 0) will make the corresponding PORTA pin an output (i.e., put the contents of the output latch on the selected pin).

Reading the PORTA register reads the status of the pins, whereas writing to it will write to the port latch. All write operations are read-modify-write operations. Therefore, a write to a port implies that the port pins are read, the value is modified and then written to the port data latch.

Pin RA4 is multiplexed with the Timer0 module clock input to become the RA4/T0CKI pin. The RA4/T0CKI pin is a Schmitt Trigger input and an open drain output. All other PORTA pins have TTL input levels and full CMOS output drivers. Other PORTA pins are multiplexed with analog inputs and analog VREF input. The operation of each pin is selected by clearing/setting the control bits in the ADCON1 register (A/D Control Register1).

4.2.3.2 PORT B

PORTB is an 8-bit wide, bi-directional port. The corresponding data direction register is TRISB. Setting a TRISB bit (= 1) will make the corresponding PORTB pin an input (i.e., put the corresponding output driver in a Hi-Impedance mode). Clearing a TRISB bit (= 0) will make the corresponding PORTB pin an output (i.e., put the contents of the output latch on the selected pin). Three pins of PORTB are multiplexed with the Low Voltage Programming function: RB3/PGM, RB6/PGC and RB7/PGD. Each of the PORTB pins has a weak internal pull-up. A single control bit can turn on all the pull-ups. This is performed by clearing bit RBPU (OPTION_REG<7>). The weak pull-up is automatically turned off when the port pin is configured as an output. The pull-ups are disabled on a Power-on Reset.

4.2.3.3 PORT C

PORTC is an 8-bit wide, bi-directional port. The corresponding data direction register is TRISC. Setting a TRISC bit (= 1) will make the corresponding PORTC pin an input (i.e., put the corresponding output driver in a Hi-Impedance mode). Clearing a TRISC bit (= 0) will make the corresponding PORTC pin an output (i.e., put the contents of the output latch on the selected pin).

PORTC is multiplexed with several peripheral functions (Table 3-5). PORTC pins have Schmitt Trigger input buffers. When the I²C module is enabled, the PORTC<4:3> pins can be configured with normal I²C levels.

4.2.3.4 PORT D

PORTD is an 8-bit port with Schmitt Trigger input buffers. Each pin is individually configurable as an input or output. PORTD can be configured as an 8-bit wide microprocessor port (parallel slave port) by setting control bit PSPMODE (TRISE<4>). In this mode, the input buffers are TTL.

4.2.3.5 PORT E

PORTE has three pins (RE0/RD/AN5, RE1/WR/AN6, and RE2/CS/AN7), which are individually configurable as inputs or outputs. These pins have Schmitt Trigger input buffers. PORTE pins are multiplexed with analog inputs. When selected for analog input, these pins will read as '0's. TRISE controls the direction of the RE pins, even when they are being used as analog inputs.

4.2.4 FLASH PROGRAM MEMORY

The Data EEPROM and FLASH Program Memory are readable and write-able during normal operation over the entire VDD range. These operations take place on a single byte for Data EEPROM memory and a single word for Program memory. A write operation causes an erase-then-write operation to take place on the specified byte or word. A bulk erase operation may not be issued from user code (which includes removing code protection). Access to program memory allows for checksum calculation. The values written to program memory do not need to be valid instructions. Therefore, up to 14-bit numbers can be stored in memory for use as

calibration parameters, serial numbers, packed 7-bit ASCII, etc. Executing a program memory location containing data that form an invalid instruction, results in the execution of a NOP instruction.

The EEPROM Data memory is rated for high erase/ write cycles. EEPROM data memory can be used to store frequently updated values. A byte or word write automatically erases the location and writes the new value (erase before write). Writing to EEPROM data memory does not impact the operation of the device. Writing to program memory will cease the execution of instructions until the write is complete. The program memory cannot be accessed during the write. During the write operation, the oscillator continues to run, the peripherals continue to function. Read and write access to both memories take place indirectly through a set of Special Function Registers (SFR). The six SFRs used are: EEDATA, EEDAT, EEADR, EEADRH, EECON1, EECON2.

4.2.5 INSTRUCTION SET

Each PIC16F87X instruction is a 14-bit word, divided into an opcode which specifies the instruction type and one or more operands which further specify the operation of the instruction. The PIC16F87X instruction set consists of byte-oriented, bit-oriented, and literal and control instructions.

All instructions are executed within one single instruction cycle, unless a conditional test is true or the program counter is changed as a result of an instruction. In this case, the execution takes two instruction cycles with the second cycle executed as a NOP. One instruction cycle consists of four oscillator periods. Thus, for an oscillator frequency of 4 MHz, the normal instruction execution time is 1 micro second. If a conditional test is true, or the program counter is changed as a result of an instruction, the instruction execution time is 2 micro seconds.

4.3 SPECIAL FEATURES OF THE CPU

All PIC16F877 devices have a host of features intended to maximize system reliability, minimize cost through elimination of external components, provide power saving operating modes and offer code protection.

These are:

- ✓ Oscillator Selection
- ✓ RESET
- ✓ Power-on Reset (POR)
- ✓ Power-up Timer (PWRT)
- ✓ Oscillator Start-up Timer (OST)
- ✓ Brown-out Reset (BOR)
- ✓ Interrupts
- ✓ Watchdog Timer (WDT)
- ✓ SLEEP
- ✓ Code Protection
- ✓ ID Locations
- ✓ In-Circuit Serial Programming
- ✓ Low Voltage In-Circuit Serial Programming
- ✓ In-Circuit Debugger

PIC16F877 devices have a Watchdog Timer, which can be shut-off only through configuration bits. It runs off its own RC oscillator for added reliability. There are two timers that offer necessary delays on power-up. One is the Oscillator Start-up Timer (OST), intended to keep the chip in RESET until the crystal oscillator is stable. The other is the Power-up Timer (PWRT), which provides a fixed delay of 72 ms (nominal) on power-up only. It is designed to keep the part in RESET while the power supply stabilizes.

With these two timers on-chip, most applications need no external RESET circuitry.

SLEEP mode is designed to offer a very low current Power-down mode. The user can wake-up from SLEEP through external RESET, Watchdog Timer Wake-up, or through an interrupt.

Several oscillator options are also made available to allow the part to fit the application. The RC oscillator option saves system cost while the LP crystal option saves power. A set of configuration bits is used to select various options.

PIN DIAGRAM OF PIC16F877

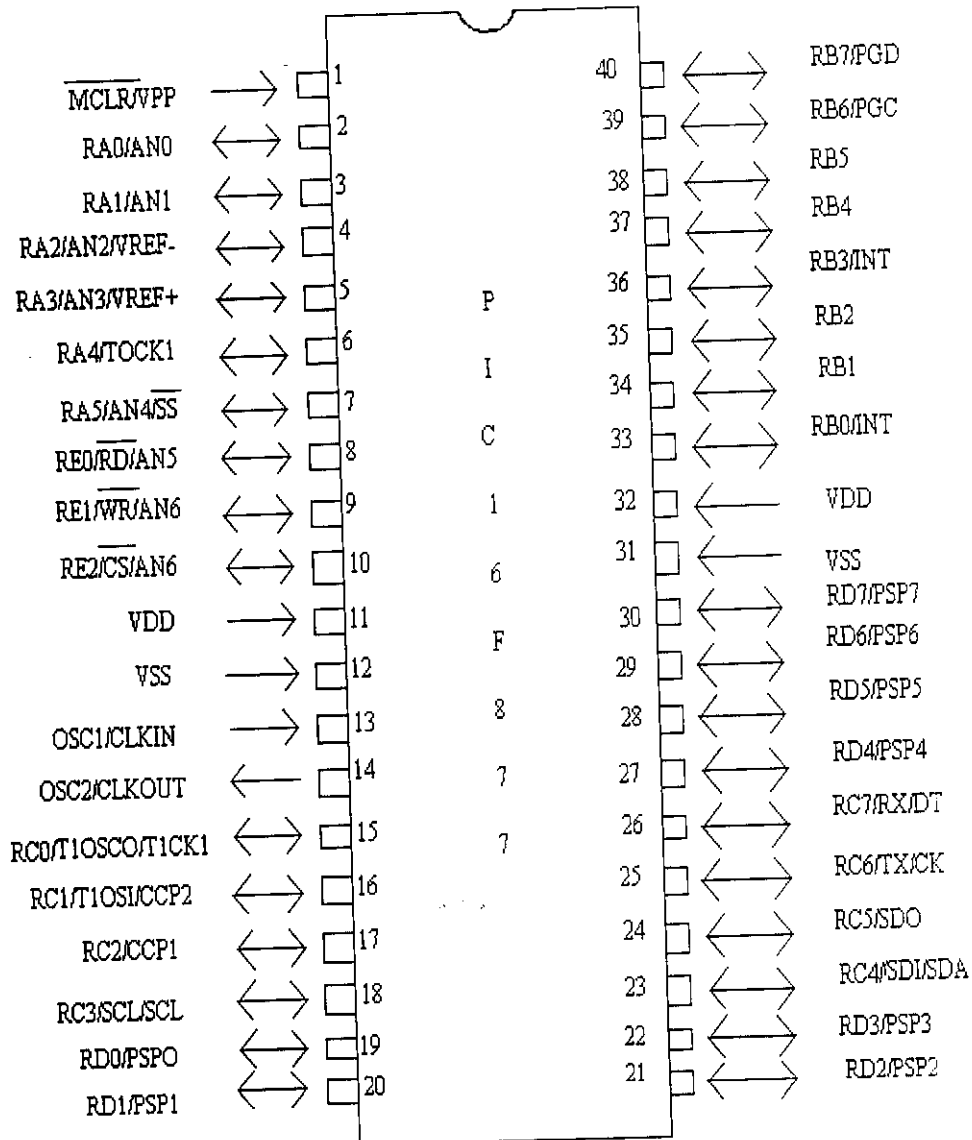


Fig.4.1 Pin diagram of PIC16F877

KEYPAD INTERFACE

KEYPAD INTERFACE

5.1 INTRODUCTION

The front end of the system is the numeric keypad. Users enter their individual four digit passwords by using this. Each press of a numeric key can be sensed by the controller so that the user can see the successive digit entries simultaneously.

The keypad is interfaced to the Single-line LCD display through the PIC controller. The LCD display serves to display instructions to the user to get required data from them. Both display and keypad are controlled by control signals from microcontroller. Separate ports of the microcontroller are used for this purpose. Interactions with key switches raise issues like the debouncing of mechanical keys. Key switches also raise issues when used with a display like identifying which of several displayed data is to be modified. All issues are to be considered while programming the keypad.

5.2 KEYPAD CIRCUIT DESCRIPTION

5.2.1 SPECIFICATIONS

- ✓ 4x4 array switches.
- ✓ +5volts supply line
- ✓ Control signal from PORT lines.
- ✓ 9 Pin connector.
- ✓ Active low switch connection.

5.2.2 CIRCUIT DESCRIPTION

Port A of the Microcontroller is used to interface the key pad. Initially all port lines are in high level. Here the debounce delay (or) time of 10 ms is selected because the maximum key bounce time of most mechanical key switches is less than 10 ms. Because key switches are not changed very fast, they can be checked once each time around the mainline loop in a “ Key Switch “ subroutine.

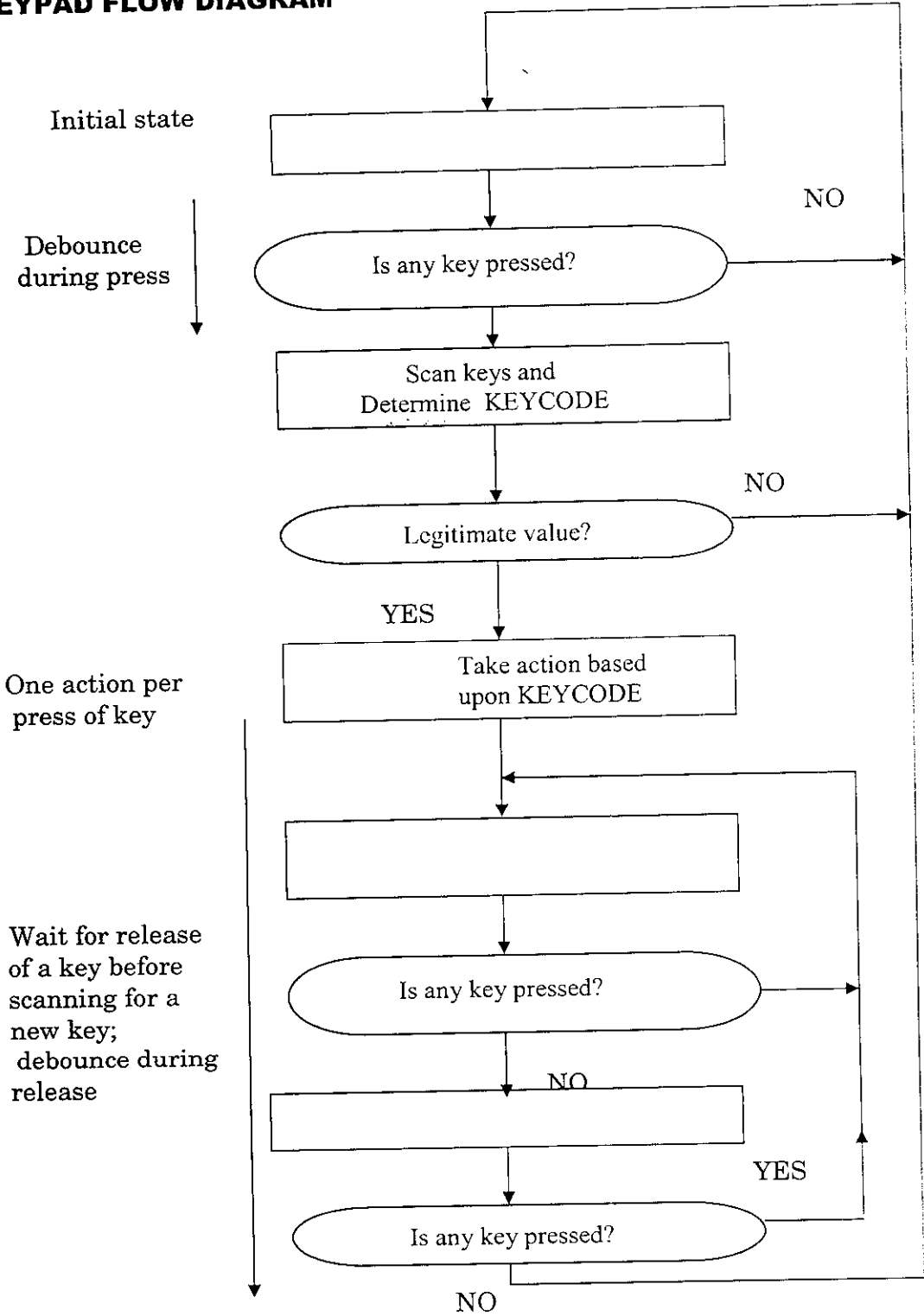
Consequently, if keyswitch detects that a key is newly pressed, it can be assured that the next time it is called, 10 ms later, any erratic bouncing of the key contact will have selected out, with the contacts firmly closed.

The press and release of a key switch occurs over an interval of many tens of milliseconds. For example, if a key switch is pressed and released at the relatively fast rate of four times a second, the switch may be closed for 12 loop times, open for 12 loop times, closed for 12 loop times, etc. The Key switch subroutine will use a State Variable called KEY STATE to keep track, from one call to the next, of the sequencing of the following tasks :

- ✓ Debounce the key switch
- ✓ Determine which key is pressed
- ✓ Take appropriate action once for that press of the key
- ✓ Wait for the release of that key

A flow chart of the Key Switch subroutine algorithm is shown in Figure. The job of the Key Switch subroutine in this case is to determine whether any key is newly pressed.

5.3 KEYPAD FLOW DIAGRAM



A subroutine which determines if a key has been pressed returns with
Z = 0 in STATUS if any key is pressed
Z = 1 in STATUS if no key is pressed

5.4 SUBROUTINE FOR DETECTION OF KEY PRESS

Any key

```
clrf      PORTB      : Drive 3 columns low
bcf       PORTD,7    : Drive 4th column low
movlw    B'11110000' : Load W with expected value if none pressed
xorwf    PORTB, W    : Get B '0000000x' if none pressed
andlw    B'11111110' : Force bit 0 to zero
return                               : Return with Z = 1 if none pressed
```

This subroutine surveys all key at once. If none is pressed, it will read back ones in the upper 4 bits. This subroutine looks for this condition, converting it to a condition of all zeros in w (if no key is pressed) that will set the z bit in status.

The key algorithm tests the status register's z bit upon returning from the any key subroutine. If z = 1, a return from the key subroutine occurs. On the other hand if z = 0 a key is newly pressed, so key state is incremented to H'01 before returning from the subroutine.

Ten milliseconds later the key subroutine is reentered, this time with keystate = H'01' if a key press was detected last time. By now any keybounce has settled out. A scankey subroutine is called. It returns with z = 1 and a keycode RAM variable loaded with a value that identifies the pressed key. If for any reason it could not identify the pressed key, it returns with z =0 in the status register.

5.5 ACTIVE LOW SWITCH OPERATION

Normally a switch consists of four pins. Two switches are interconnected. Pins 1-3 & 2-4 are interconnected.

Control signal from port is given to pin no.1 and +5Vcc supply is given to pin no.3 which is interconnected with pin no.1. Either pins of 2 or 4 are connected to ground line.

While key is pressed, ground and supply gets interconnected, therefore port pin is pulled to ground. This zero volts at the PORT pin is taken as the active low signal by the microcontroller.

Thus keys are being sensed, according to the further decisions are taken by the controller.

LIQUID CRYSTAL DISPLAY

LIQUID CRYSTAL DISPLAY

6.1 INTRODUCTION

Liquid Crystal display is one of the classic technologies used to give directions or data values to users. The technique used here provides digit-oriented displays. They do not emit their own light but simply change reflection of the available light. The Microcontroller reads the instructions, processes them as per the instructions whose results are displayed on an output device such as LCD. They possess several advantages over other display devices.

- ✓ LCD displays use very low power
- ✓ LCD displays are portable
- ✓ They can be used in battery powered instruments

6.2 LCD MODULE OVERVIEW

The display used here is 16 x 2 alphanumeric dot matrix lmi16101 single line 16 – bit lcd from lampex with inherent driver and controller chip. Each bit is addressed with a specific address starting from 0x80 to 0x87 AND 0xc0 to 0xc7. The module automatically performs initialization when powered on using internal reset circuit. The LCD used here is built with a quad pin integrated circuit. Backlighting feature is another option provided by Lampex, which provides a fluorescent yellow background giving a lively display. The feature includes no noise interference and a long life typically 1000000 hours. Viewing angle is in the range of 10 to 40 degrees.

6.2.1 LCD ARCHITECTURE

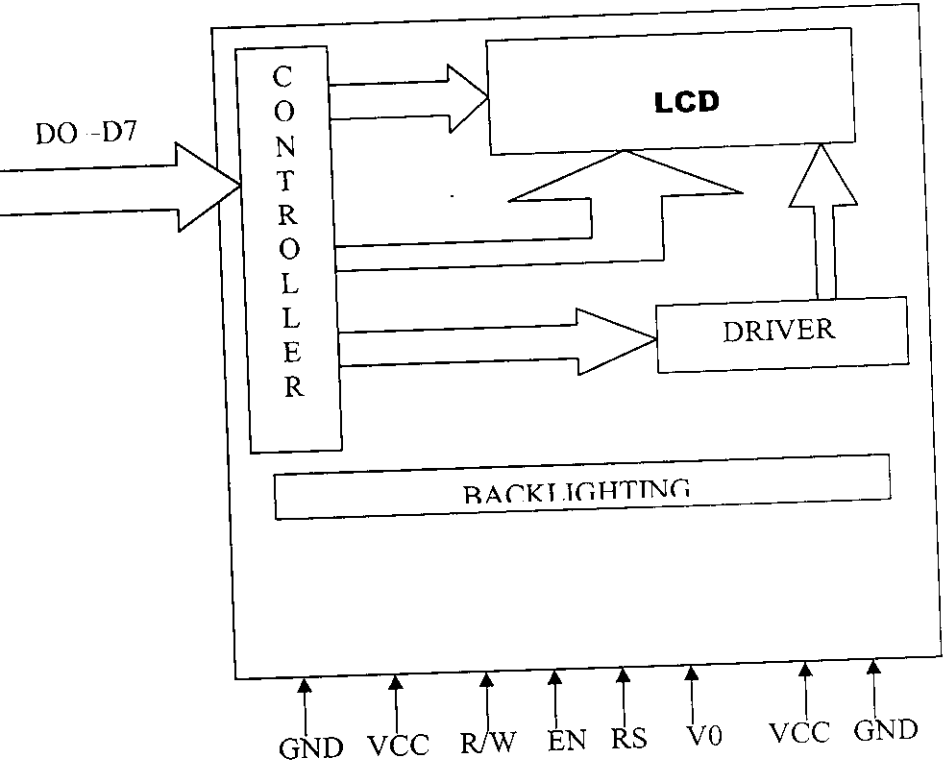
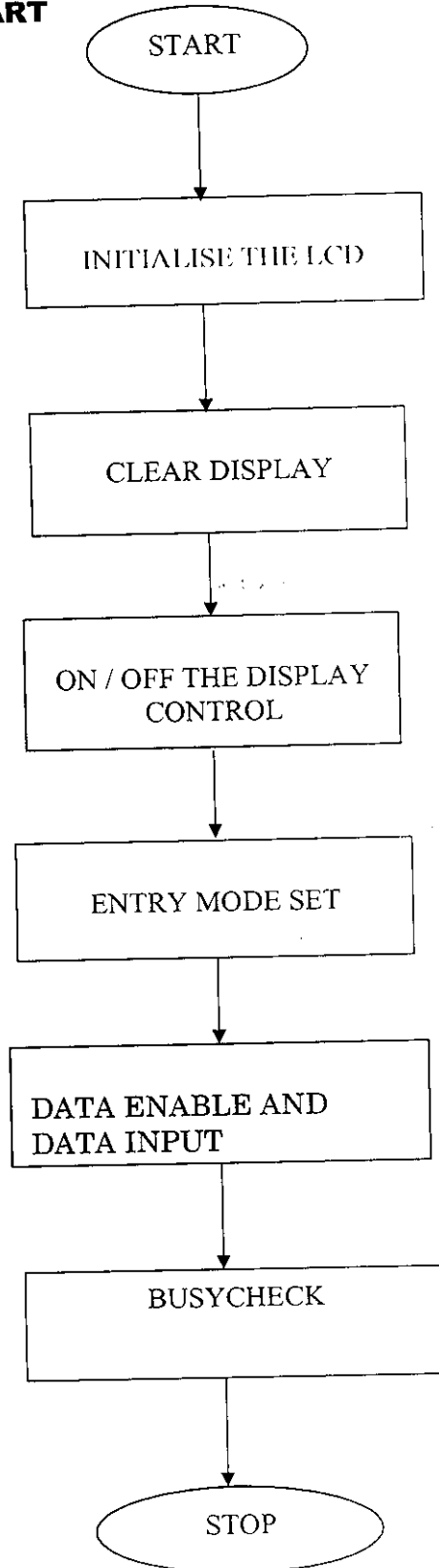


Fig.6.1 LCD architecture

6.3 LCD FLOW CHART



6.4 POWER SUPPLY REQUIREMENTS:

- ✓ Wide temperature range version
- ✓ Standard
- ✓ Super – Twist Display version

The architecture shows the typical power supply connection for all dot matrix modules. The display voltage (V_{lcd}) is slightly different version. It is always recommended to use a variable resistor for optimum V_{lcd} (V_{DD} to V_0) adjustment to obtain best display contrast and viewing angle.

LED current intensity is controlled through a series limiting resistor (3.3 ohm to 47 ohm).

6.5 LCD INTERFACE:

Supply and the ground pin connections are given. Back lit for the display is also enabled to give a lively yellow background. Register select, Read, Write, Enable pins are connected to the respective port pins of the Microcontroller. Register select is set low for command mode and high for data mode. Read Write is set low for reading data and high for writing the data. Microcontroller enables the LCD through the Enable pin.

Eight data lines of the LCD are connected to a port of PIC16F877. Brightness control is connected to a potentiometer to vary the brightness with varying resistance. Command mode is enabled to send commands to the LCD from the Microcontroller. Data mode is sent to send data to the LCD from the Microcontroller.

6.6 ROLE OF LCD IN THIS PROJECT:

LCD plays the key role in bringing out this project lively and interactive. LCD is interfaced to the Microcontroller PIC16F877. The customer is provided with commands, requests, interrogations and messages through the LCD. Initially, the customer is requested to enter in the password. After appropriate manipulations in connection with the database, the system asks for the quantity of fuel required. The calculations for the required quantity is done and the amount to be deduced from his account is displayed in the LCD. With the command from the customer through an enter key, the customer can deliver the appropriate amount of fuel.

At each stage, the customer is provided with a correct or an error message to make it more users friendly. If an error message occurs at any stage, further processing for the customer is halted. Moreover, the password entered, the quantity of fuel required, the amount to be deposited are also displayed on the LCD to give a better interaction for the customer with the system. Functionality of every key press is made visible to the user through the display.

DATABASE UNIT

DATABASE UNIT

7.1 INTRODUCTION

The database unit plays an important role in the project. The individual passwords and account details of all the customers is stored in this database. The huge database is designed such that new data can be entered at any time through software. At the same time retention of already entered data without any changes is also maintained. This versatility of the database is achieved by the use of a NON-VOLATILE SRAM. The NVRAM used here is the DS1230Y 256k non-volatile SRAM.

7.2 DS1230Y NON-VOLATILE SRAM OVERVIEW

7.2.1 DESCRIPTION

The DS1230 256k Nonvolatile SRAMs are 262,144-bit, fully static, nonvolatile SRAMs organized as 32,768 words by 8 bits. Each NV SRAM has a self-contained lithium energy source and control circuitry, which constantly monitors VCC for an out-of-tolerance condition. When such a condition occurs, the lithium energy source is automatically switched on and write protection is unconditionally enabled to prevent data corruption. DIP-package DS1230 devices can be used in place of existing 32k x 8 static RAMs directly conforming to the popular byte wide 28-pin DIP standard. The DIP devices also match the pin out of 28256 EEPROMs, allowing direct

substitution while enhancing performance. DS1230 devices in the Low Profile Module package are specifically designed for surface-mount applications. There is no limit on the number of write cycles that can be executed and no additional support circuitry is required for microcontroller interfacing.

7.2.2 FEATURES

- ✓ 10 years minimum data retention in the absence of external power
- ✓ Data is automatically protected during power loss
- ✓ Replaces 32k x 8 volatile static RAM, EEPROM or Flash memory
- ✓ Unlimited write cycles
- ✓ Low-power CMOS
- ✓ Read and write access times as fast as 70 ns
- ✓ Lithium energy source is electrically disconnected to retain freshness until power is applied for the first time
- ✓ Full 10% VCC operating range (DS1230Y)
- ✓ Optional 5% VCC operating range
- ✓ Optional industrial temperature range of 40 C to +85C
- ✓ JEDEC standard 28-pin DIP package
- ✓ Standardized pin out for all nonvolatile SRAM products

7.2.3 ABSOLUTE MAXIMUM RATINGS

Voltage on Any Pin Relative to Ground	-0.3V to +7.0V
Operating Temperature	0°C to 70°C, -40°C to +85°C
Storage Temperature	-40°C to +70°C, -40°C to +85°C
Soldering Temperature	260°C for 10 seconds

PIN DIAGRAM OF DS 1230Y

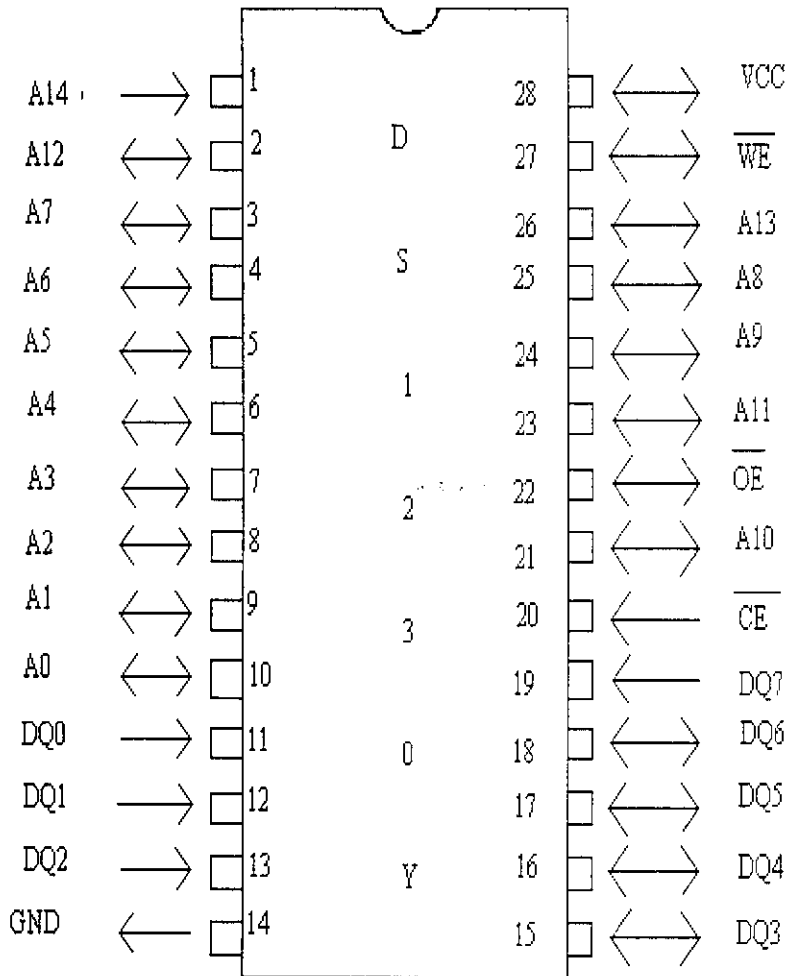


Fig.7.1. PIN DIAGRAM OF DS1230YNV SRAM

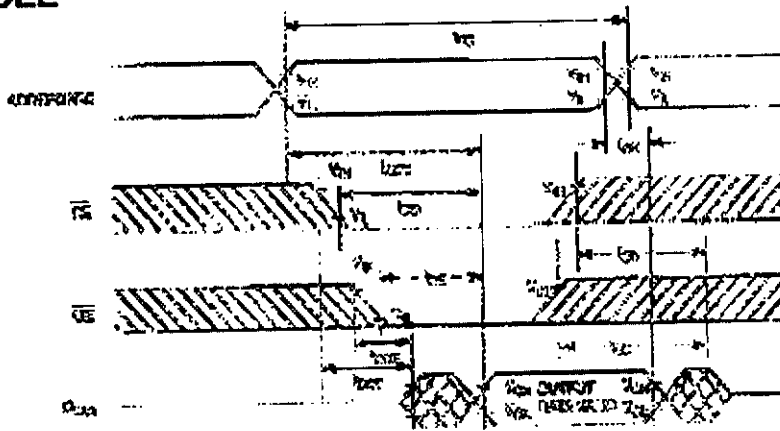
7.2.4 READ MODE

The DS1230 devices execute a read cycle whenever WE (Write Enable) is inactive (high) and CE (Chip Enable) and OE (Output Enable) are active (low). The unique address specified by the 15 address inputs (A0 - A14) defines which of the 32,768 bytes of data is to be accessed. Valid data will be available to the eight data output drivers within t_{ACC} (Access Time) after the last address input signal is stable, providing that CE and OE (Output Enable) access times are also satisfied. If OE and CE access times are not satisfied, then data access must be measured from the later-occurring signal (CE or OE) and the limiting parameter is either t_{CO} for CE or t_{OE} for OE rather than address access.

7.2.5 WRITE MODE

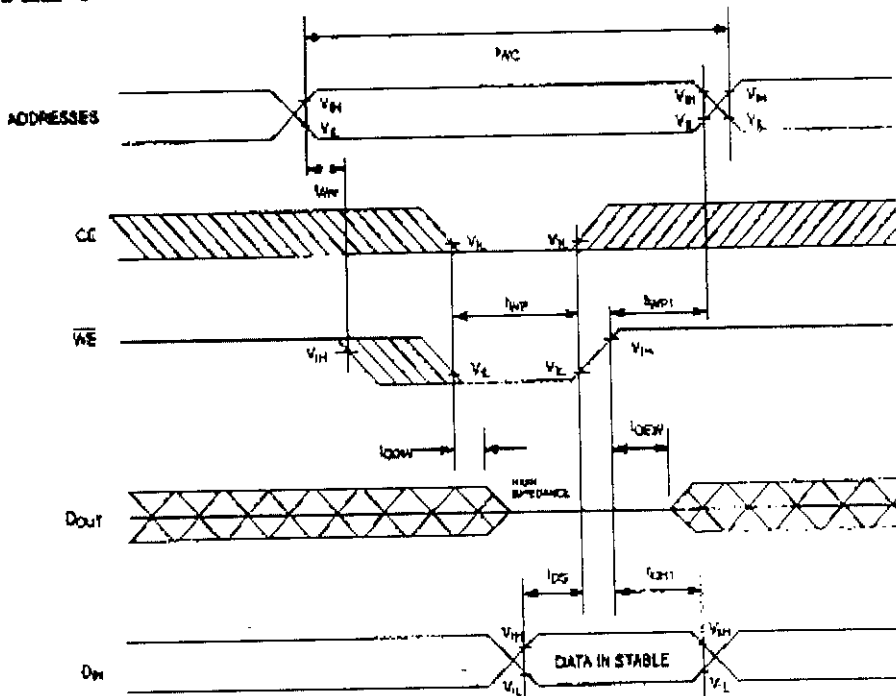
The DS1230 devices execute a write cycle whenever the WE and CE signals are active (low) after address inputs are stable. The later-occurring falling edge of CE or WE will determine the start of the write cycle. The write cycle is terminated by the earlier rising edge of CE or WE. All address inputs must be kept valid throughout the write cycle. WE must return to the high state for a minimum recovery time (t_{WR}) before another cycle can be initiated. The OE control signal should be kept inactive (high) during write cycles to avoid bus contention. However, if the output drivers are enabled (CE and OE active) then WE will disable the outputs in t_{ODW} from its falling edge.

READ CYCLE



SEE NOTE 1

WRITE CYCLE 1



SEE NOTES 2, 3, 4, 5, 7, 8, and 12

WRITE CYCLE 2

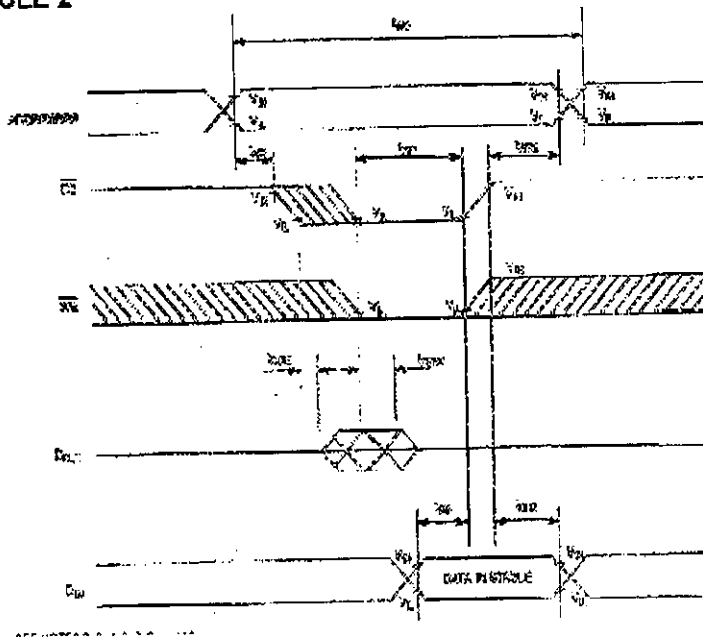


Fig. 7.2. Read and write cycles

NOTES:

1. \overline{WE} is high for a Read Cycle.
2. $\overline{OE} = V_{IH}$ or V_{IL} . If $\overline{OE} = V_{IH}$ during write cycle, the output buffers remain in a high-impedance state.
3. t_{WP} is specified as the logical AND of \overline{CE} and \overline{WE} . t_{WP} is measured from the latter of \overline{CE} or \overline{WE} going low to the earlier of \overline{CE} or \overline{WE} going high.
4. t_{DH} , t_{DS} are measured from the earlier of \overline{CE} or \overline{WE} going high.
5. These parameters are sampled with a 5 pF load and are not 100% tested.

6. If the CE low transition occurs simultaneously with or later than the WE low transition, the output buffers remain in a high-impedance state during this period.
7. If the CE high transition occurs prior to or simultaneously with the WE high transition, the output buffers remain in high-impedance state during this period.
8. If WE is low or the WE low transition occurs prior to or simultaneously with the CE low transition, the output buffers remain in a high-impedance state during this period.
9. Each DS1230 has a built-in switch that disconnects the lithium source until VCC is first applied by the user. The expected t_{DR} is defined as accumulative time in the absence of VCC starting from the time power is first applied by the user.
10. All AC and DC electrical characteristics are valid over the full operating temperature range. For commercial products, this range is 0_C to 70_C. For industrial products (IND), this range is -40_C to +85_C.
11. In a power-down condition the voltage on any pin may not exceed the voltage on VCC.
12. t_{WR1} and t_{DH1} are measured from WE going high.
13. t_{WR2} and t_{DH2} are measured from CE going high.
14. DS1230 modules are recognized by Underwriters Laboratory (U.L.) under file E99151.

7.2.5. DATA RETENTION MODE

The DS1230AB provides full functional capability for VCC greater than 4.75 volts and write protects by 4.5 volts. The DS1230Y provides full functional capability for VCC greater than 4.5 volts and write protects by 4.25 volts. Data is maintained in the absence of VCC without any additional support circuitry. The nonvolatile static RAMs constantly monitor VCC.

Should the supply voltage decay, the NV SRAMs automatically write protect themselves, all inputs become “don’t care,” and all outputs become high impedance. As VCC falls below approximately 3.0 volts, a power switching circuit connects the lithium energy source to RAM to retain data. During power-up, when VCC rises above approximately 3.0 volts the power switching circuit connects external VCC to RAM and disconnects the lithium energy source. Normal RAM operation can resume after VCC exceeds 4.75 volts for the DS1230AB and 4.5 volts for the DS1230Y.

7.2.5 FRESHNESS SEAL

Each DS1230 device is shipped from Dallas Semiconductor with its lithium energy source disconnected, guaranteeing full energy capacity. When vcc is first applied at a level greater than 4.25 volts, the lithium energy source is enabled for battery back-up operation.

7.2.6 RECOMMENDED DC OPERATING

PARAMETER	SYMBOL	MIN	TYP	MAX	UNITS
DS1230AB Power Supply Voltage	V _{CC}	4.5	5.0	5.5	V
Logic 0	V _{IH}	2.2		V _{CC}	V
Logic 1	V _{IL}	0.0		0.8	V

7.3 LATCH

The address lines from the microcontroller to the NVRAM and the data lines to and from the microcontroller are multiplexed with the help of a latch.

This reduces the number of port lines needed to interface the NVRAM with the microcontroller. The latch used here is the HD 74573.

It has two control signals- latch enable (le) and output enable (oe). The output lines from the latch contain the address bits when the latch enable is high. Otherwise the data is output. The output enable is to be held low in order to activate the output lines of the latch. The latch enable is an active high signal whereas the output enable is an active low signal.

PIN DIAGRAM OF HD 74573

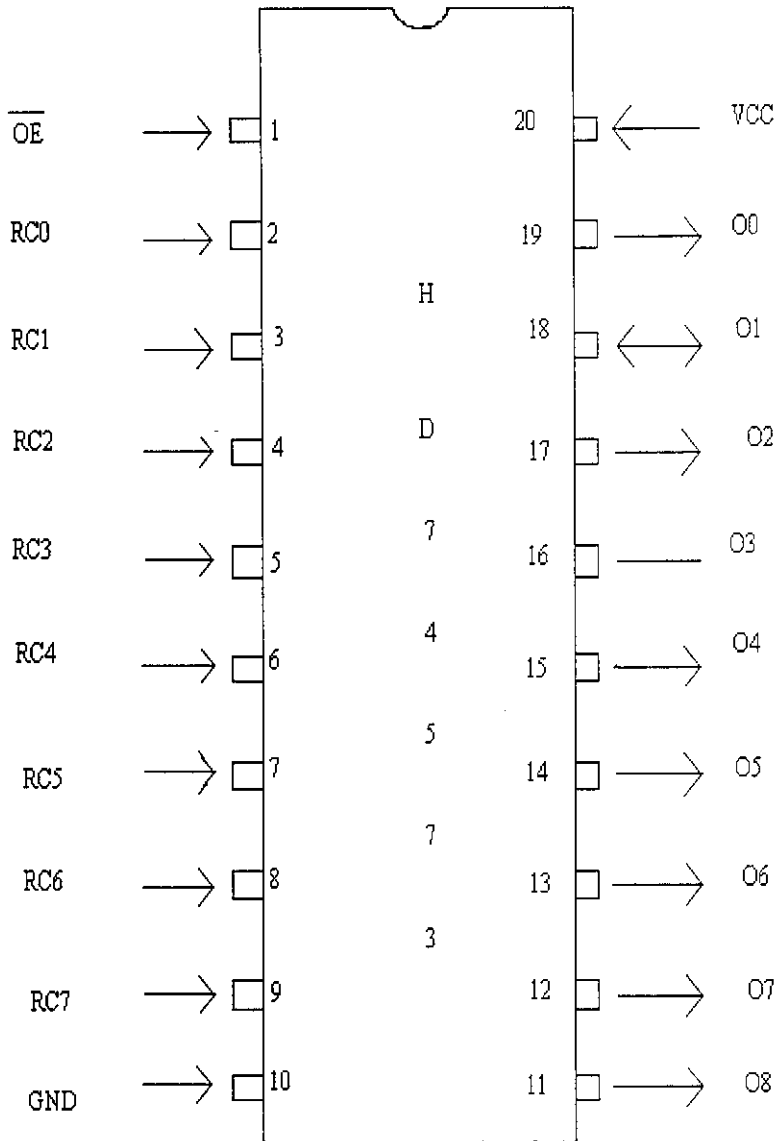


Fig. 7.3. Pin diagram of latch

PULSER AND FUEL DISPENSING OUTLET

PULSER AND FUEL DISPENSING UNIT

8.1 INTRODUCTION

The pulser and the fuel vending valve act fuel dispensing unit. The pulser acts as a sensor which detects any interruption in the flow of the liquid fuel. Interruptions in fuel flow may occur due to absence of fuel in the fuel storage tank or leakage in the tube leading from the tank to the valve. The absence of fuel flow is detected by the pulser which sends an control signal to the microcontroller which promptly sends signals to close the valve and to display an error message.

The fuel dispensing valve is a 12V, 1A DC liquid flow solenoid valve. This valve can be interfaced to the fuel dispensing nozzles which are currently being used in many petrol bunks across the country.

8.2 OVERVIEW OF PULSER UNIT

The main function of the pulser unit used in this system is to detect untimely interruptions in the fuel flow. The pulser unit is rotated by a shaft. When the microcontroller sends signals to open the valve, the pulser also receives signals. These signals initiate the pulser unit to start monitoring the fuel flow. When the pulser detects the absence of fuel flow, it sends interrupt signals to the microcontroller. If the fuel flow is continuous without any disruptions, the required amount of fuel is allowed to pass through. The microcontroller then sends signals to close the valve and to terminate the working of the pulser.

8.2.1 DESCRIPTION

The pulser unit consists of three pairs of photoelectric sensors and a disc with 25 slots. The flow of fuel rotates the shaft of the pulser unit. As a result the disc of the pulser unit connected to the shaft also rotates. The sensors sense the rotation of the disc.

The three pairs of sensors are the infrared emitters and a photo detector. As the name indicates, the infrared emitters emit light. The infrared light emitted by the emitters pass through the slots in the disc. The photo detector is placed on the other side of the disc. It detects the light emitted by the emitters, which pass through the slots in the disc and reach the detector. The detector converts the light signals received in to electrical pulses and sends these pulses to microcontroller. The microcontroller polls the corresponding pin line for these pulses.

. The presence of these pulses indicates the fuel flow. These pulses are sent to the microcontoller which scans the corresponding pin for a high voltage till the required quantity has flown through. An abrupt low on the pin initiates a subroutine, which closes the valve and displays an error message.

As the unit has three pairs of sensors, it continues to operate in spite of a single sensor failure. A six way cable, colours being one red, one black, three yellow and one blue. Through the red and black cable, the pulser receives 5V dc supply voltage.

8.3 FUEL DISPENSING UNIT

The fuel dispensing outlet is a 12V, 1A DC liquid flow solenoid valve. It is controlled by a control circuit which consists of a relay operated through a transistor. This circuit opens and closes the solenoid valve according to the control signal from the microcontroller port. This solenoid valve is similar to the one used in the existing petrol vending outlets across the country. It can be interfaced to the fuel dispensing nozzle without any complicated interface circuitry. Hence it fulfills our requirements.

CONCLUSION

CONCLUSION

The automatic fuel vending outlet is an useful system that reduces the time and enhances the security of the existing petrol vending outlets. It's features make it highly effective and compact system. This is system can be configured for the automating dispensing of almost all kinds of fuel dispensing purposes.

It also eliminates the manual work needed to operate the fuel vending outlets. It provides round the clock service to the customer and reduces the risks involved in handling money. The customer is ensured of quality service even at odd hours. There is no necessity for the customer to carry money around. The money deposited by the customer is secure and safe as the customer's password is unknown to anyone else except the customer.

This system guarantees full satisfaction to the customer. It is time saving and guarantees the availability if the correct amount of fuel to the customer. The administrator is also immensely benefited as it reduces the costs involved in employing manual labor. It also eliminates the chances of administrator being chated by customers ,who do not pay the money for the vended fuel as the prepaid account is automatically updated.

The keypad and display units used are easy to use and can be interfaced to other controllers and devices easily. Since the entire operation is Microcontroller based any modification can be achieved through software ,the hardware is untouched. The valve used here can also be connected to the nozzle and tube extensions available in many petrol vending bunks

10/2/20

FUTURE OUTLOOK

SCOPE FOR FURTHER DEVELOPMENT

The microcontroller used has the USART and I2C bus provisions inbuilt, the system can also be interfaced to other PCs and devices. This paves the way for automatic billings. Thus the customer can have printed records of his dealings. He can efficiently keep track of his pre-paid accounts.

Many such systems can be connected together forming a LAN. Thus a customer having an account at any petrol bunk within a city can make use of his account from any petrol bunk in the city.

This leads to a completed project on prototype automation and networking of the fuel vending outlets within the required radius.

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- ▶ **'Electronics Handbook' by Jelly c**

WEB SITES

- ▶ **www.microchip.com**
- ▶ **www.piclist.com**
- ▶ **www.dontronics.com**
- ▶ **<http://www.embedded.com/mag.shtml>**

APPENDICES



PIC16F87X

EEPROM Memory Programming Specification

This document includes the programming specifications for the following devices:

- PIC16F870
- PIC16F874
- PIC16F871
- PIC16F876
- PIC16F872
- PIC16F877
- PIC16F873

1.0 PROGRAMMING THE PIC16F87X

The PIC16F87X is programmed using a serial method. The Serial mode will allow the PIC16F87X to be programmed while in the user's system. This allows for increased design flexibility. This programming specification applies to PIC16F87X devices in all packages.

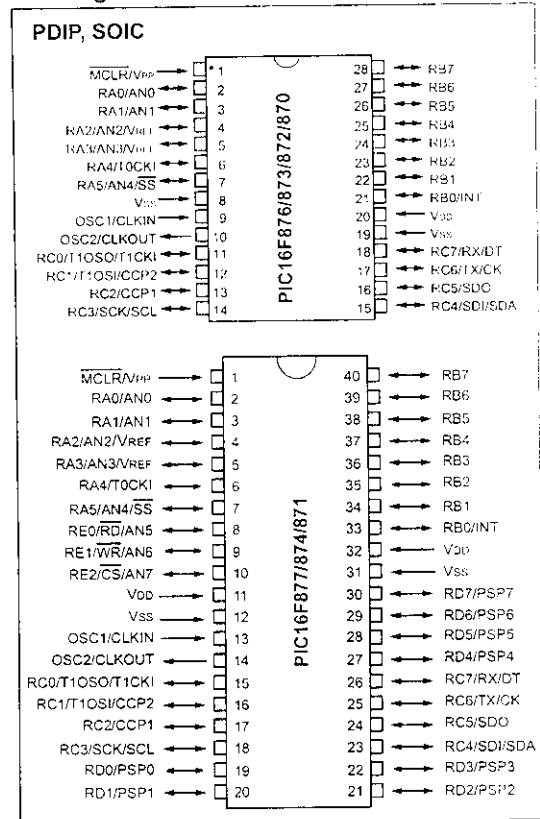
1.1 Programming Algorithm Requirements

The programming algorithm used depends on the operating voltage (V_{DD}) of the PIC16F87X device. Algorithm 1 is designed for a V_{DD} range of $2.2V \leq V_{DD} < 5.5V$. Algorithm 2 is for a range of $4.5V \leq V_{DD} \leq 5.5V$. Either algorithm can be used with the two available programming entry methods. The first method follows the normal Microchip Programming mode entry of applying a V_{PP} voltage of $13V \pm .5V$. The second method, called Low Voltage ICSP™ or LVP for short, applies V_{DD} to \overline{MCLR} and uses the I/O pin RB3 to enter Programming mode. When RB3 is driven to V_{DD} from ground, the PIC16F87X device enters Programming mode.

1.2 Programming Mode

The Programming mode for the PIC16F87X allows programming of user program memory, data memory, special locations used for ID, and the configuration word.

Pin Diagram



PIC16F87X

PIN DESCRIPTIONS (DURING PROGRAMMING): PIC16F87X

Pin Name	During Programming		
	Function	Pin Type	Pin Description
RB3	PGM	I	Low voltage ICSP programming input if LVP configuration bit equals 1
RB6	CLOCK	I	Clock input
RB7	DATA	I/O	Data input/output
MCLR	VTEST MODE	P*	Program Mode Select
VDD	VDD	P	Power Supply
VSS	VSS	P	Ground

Legend: I = Input, O = Output, P = Power

* In the PIC16F87X, the programming high voltage is internally generated. To activate the Programming mode, high voltage needs to be applied to the MCLR input. Since the MCLR is used for a level source, this means that MCLR does not draw any significant current.

2.0 PROGRAM MODE ENTRY

2.1 User Program Memory Map

The user memory space extends from 0x0000 to 0x1FFF (8K). In Programming mode, the program memory space extends from 0x0000 to 0x3FFF, with the first half (0x0000-0x1FFF) being user program memory and the second half (0x2000-0x3FFF) being configuration memory. The PC will increment from 0x0000 to 0x1FFF and wrap to 0x0000, 0x2000 to 0x3FFF and wrap around to 0x2000 (not to 0x0000). Once in configuration memory, the highest bit of the PC stays a '1', thus always pointing to the configuration memory. The only way to point to user program memory is to reset the part and re-enter Program/Verify mode, as described in Section 2.4.

In the configuration memory space, 0x2000-0x200F are physically implemented. However, only locations 0x2000 through 0x2007 are available. Other locations are reserved. Locations beyond 0x200F will physically access user memory (see Figure 2-1).

2.2 Data EEPROM Memory

The EEPROM data memory space is a separate block of high endurance memory that the user accesses using a special sequence of instructions. The amount of data EEPROM memory depends on the device and is shown below in number of bytes.

Device	# of Bytes
PIC16F870	64
PIC16F871	64
PIC16F872	64
PIC16F873	128
PIC16F874	128
PIC16F876	256
PIC16F877	256

The contents of data EEPROM memory have the capability to be embedded into the HEX file.

The programmer should be able to read data EEPROM information from a HEX file and conversely (as an option), write data EEPROM contents to a HEX file, along with program memory information and configuration bit information.

The 256 data memory locations are logically mapped starting at address 0x2100. The format for data memory storage is one data byte per address location, LSB aligned.

2.3 ID Locations

A user may store identification information (ID) in four ID locations. The ID locations are mapped in [0x2000 : 0x2003]. It is recommended that the user use only the four Least Significant bits of each ID location. In some devices, the ID locations read out in an unscrambled fashion after code protection is enabled. For these devices, it is recommended that ID location is written as "11 1111 1000 bbbb" where 'bbbb' is ID information.

In other devices, the ID locations read out normally, even after code protection. To understand how the devices behave, refer to Table 5-1.

To understand the scrambling mechanism after code protection, refer to Section 4.0.

2.4 Program/Verify Mode

The Program/Verify mode is entered by holding pins RB6 and RB7 low, while raising MCLR pin from V_{IL} to V_{IHH} (high voltage). In this mode, the state of the RB3 pin does not effect programming. Low voltage ICSP Programming mode is entered by raising RB3 from V_{IL} to V_{DD} and then applying V_{DD} to MCLR. Once in this mode, the user program memory and the configuration memory can be accessed and programmed in serial fashion. The mode of operation is serial, and the memory that is accessed is the user program memory. RB6 and RB7 are Schmitt Trigger Inputs in this mode.

Note: The OSC must not have 72 osc clocks while the device MCLR is between V_{IL} and V_{IHH}.

The sequence that enters the device into the Programming/Verify mode places all other logic into the RESET state (the MCLR pin was initially at V_{IL}). This means that all I/O are in the RESET state (high impedance inputs).

The normal sequence for programming is to use the load data command to set a value to be written at the selected address. Issue the begin programming command followed by read data command to verify, and then increment the address.

A device RESET will clear the PC and set the address to 0. The "increment address" command will increment the PC. The "load configuration" command will set the PC to 0x2000. The available commands are shown in Table 2-2.

2.4.1 LOW VOLTAGE ICSP PROGRAMMING MODE

Low voltage ICSP Programming mode allows a PIC16F87X device to be programmed using V_{DD} only. However, when this mode is enabled by a configuration bit (LVP), the PIC16F87X device dedicates RB3 to control entry/exit into Programming mode.

When LVP bit is set to '1', the low voltage ICSP programming entry is enabled. Since the LVP configuration bit allows low voltage ICSP programming entry in its erased state, an erased device will have the LVP bit enabled at the factory. While LVP is '1', RB3 is dedicated to low voltage ICSP programming. Bring RB3 to V_{DD} and then MCLR to V_{DD} to enter programming mode. All other specifications for high voltage ICSP™ apply.

To disable low voltage ICSP mode, the LVP bit must be programmed to '0'. This must be done while entered with High Voltage Entry mode (LVP bit = 1). RB3 is now a general purpose I/O pin.

2.4.2 SERIAL PROGRAM/VERIFY OPERATION

The RB6 pin is used as a clock input pin, and the RB7 pin is used for entering command bits and data input/output during serial operation. To input a command, the clock pin (RB6) is cycled six times. Each command bit is latched on the falling edge of the clock, with the Least Significant bit (LSb) of the command being input first. The data on pin RB7 is required to have a minimum setup and hold time (see AC/DC specifications), with respect to the falling edge of the clock. Commands that have data associated with them (read and load) are specified to have a minimum delay of 1 μs between the command and the data. After this delay, the clock pin is cycled 16 times with the first cycle being a START bit and the last cycle being a STOP bit. Data is also input and output LSb first.

Therefore, during a read operation, the LSb will be transmitted onto pin RB7 on the rising edge of the second cycle, and during a load operation, the LSb will be latched on the falling edge of the second cycle. A minimum 1 μs delay is also specified between consecutive commands.

All commands are transmitted LSb first. Data words are also transmitted LSb first. The data is transmitted on the rising edge and latched on the falling edge of the clock. To allow for decoding of commands and reversal of data pin configuration, a time separation of at least 1 μs is required between a command and a data word (or another command).

The commands that are available are:

2.4.2.1 Load Configuration

After receiving this command, the program counter (PC) will be set to 0x2000. By then applying 16 cycles to the clock pin, the chip will load 14-bits in a "data word," as described above, to be programmed into the configuration memory. A description of the memory mapping schemes of the program memory for normal operation and Configuration mode operation is shown in Figure 2-1. After the configuration memory is entered, the only way to get back to the user program memory is to exit the Program/Verify Test mode by taking MCLR low (V_{IL}).

2.4.2.2 Load Data for Program Memory

After receiving this command, the chip will load in a 14-bit "data word" when 16 cycles are applied, as described previously. A timing diagram for the load data command is shown in Figure 6-1.

PIC16F87X

2.4.2.3 Load Data for Data Memory

After receiving this command, the chip will load in a 14-bit "data word" when 16 cycles are applied. However, the data memory is only 8-bits wide, and thus, only the first 8-bits of data after the START bit will be programmed into the data memory. It is still necessary to cycle the clock the full 16 cycles in order to allow the internal circuitry to reset properly. The data memory contains up to 256 bytes. If the device is code protected, the data is read as all zeros.

2.4.2.4 Read Data from Program Memory

After receiving this command, the chip will transmit data bits out of the program memory (user or configuration) currently accessed, starting with the second rising edge of the clock input. The RB7 pin will go into Output mode on the second rising clock edge, and it will revert back to Input mode (hi-impedance) after the 16th rising edge. A timing diagram of this command is shown in Figure 6-2.

2.4.2.5 Read Data from Data Memory

After receiving this command, the chip will transmit data bits out of the data memory starting with the second rising edge of the clock input. The RB7 pin will go into Output mode on the second rising edge, and it will revert back to Input mode (hi-impedance) after the 16th rising edge. As previously stated, the data memory is 8-bits wide, and therefore, only the first 8-bits that are output are actual data.

2.4.2.6 Increment Address

The PC is incremented when this command is received. A timing diagram of this command is shown in Figure 6-3.

2.4.2.7 Begin Erase/Program Cycle

A load command must be given before every begin programming command. Programming of the appropriate memory (test program memory, user program memory or data memory) will begin after this command is received and decoded. An internal timing mechanism executes an erase before write. The user must allow for both erase and programming cycle times for programming to complete. No "end programming" command is required.

2.4.2.8 Begin Programming

Note: The Begin Program operation must take place at 4.5 to 5.5 VDD range.

A load command must be given before every begin programming command. Programming of the appropriate memory (test program memory, user program memory or data memory) will begin after this command is received and decoded. An internal timing mechanism executes a write. The user must allow for program cycle time for programming to complete. No "end programming" command is required.

This command is similar to the ERASE/PROGRAM CYCLE command, except that a word erase is not done. It is recommended that a bulk erase be performed before starting a series of programming only cycles.

TABLE 2-2: COMMAND MAPPING FOR PIC16F87X

Command	Mapping (MSB ... LSB)						Data	Voltage Range
Load Configuration	X	X	0	0	0	0	0, data (14), 0	2.2V - 5.5V
Load Data for Program Memory	X	X	0	0	1	0	0, data (14), 0	2.2V - 5.5V
Read Data from Program Memory	X	X	0	1	0	0	0, data (14), 0	2.2V - 5.5V
Increment Address	X	X	0	1	1	0		2.2V - 5.5V
Begin Erase Programming Cycle	0	0	1	0	0	0		2.2V - 5.5V
Begin Programming Only Cycle	0	1	1	0	0	0		4.5V - 5.5V
Load Data for Data Memory	X	X	0	0	1	1	0, data (14), 0	2.2V - 5.5V
Read Data from Data Memory	X	X	0	1	0	1	0, data (14), 0	2.2V - 5.5V
Bulk Erase Setup1	0	0	0	0	0	1		4.5V - 5.5V
Bulk Erase Setup2	0	0	0	1	1	1		4.5V - 5.5V

2.5 Erasing Program and Data Memory

Depending on the state of the code protection bits, program and data memory will be erased using different procedures. The first set of procedures is used when both program and data memories are not code protected. The second set of procedures must be used when either memory is code protected. A device programmer should determine the state of the code protection bits and then apply the proper procedure to erase the desired memory.

2.5.1 ERASING NON-CODE PROTECTED PROGRAM AND DATA MEMORY

When both program and data memories are not code protected, they must be individually erased using the following procedures. The only way that both memories are erased using a single procedure is if code protection is enabled for one of the memories. These procedures do not erase the configuration word or ID locations.

Procedure to bulk erase program memory:

1. Execute a Load Data for Program Memory command (000010) with a '1' in all locations (0x3FFF)
2. Execute a Bulk Erase Setup1 command (000001)
3. Execute a Bulk Erase Setup2 command (000111)
4. Execute a Begin Erase/Programming command (001000)
5. Wait 8 ms
6. Execute a Bulk Erase Setup1 command (000001)
7. Execute a Bulk Erase Setup2 command (000111)

Procedure to bulk erase data memory:

1. Execute a Load Data for Data Memory command (000011) with a '1' in all locations (0x3FFF)
2. Execute a Bulk Erase Setup1 command (000001)
3. Execute a Bulk Erase Setup2 command (000111)
4. Execute a Begin Erase/Programming command (001000)
5. Wait 8 ms
6. Execute a Bulk Erase Setup1 command (000001)
7. Execute a Bulk Erase Setup2 command (000111)

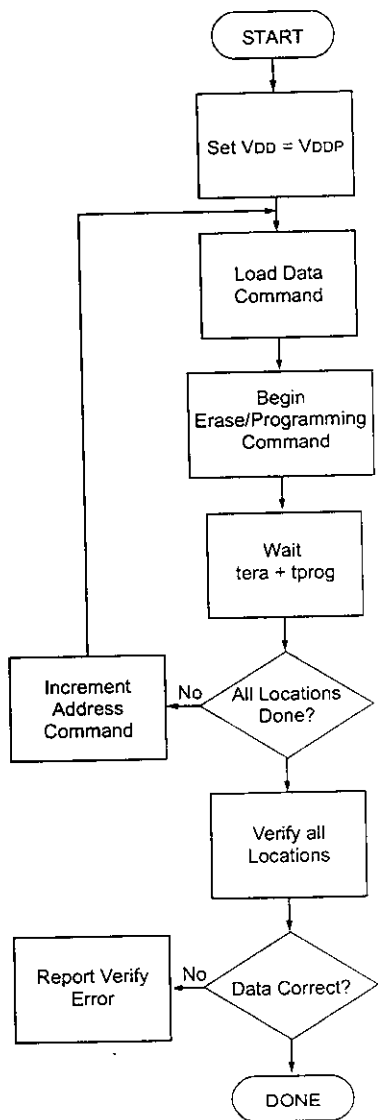
2.5.2 ERASING CODE PROTECTED MEMORY

For the PIC16F87X devices, once code protection is enabled, all protected program and data memory locations read all '0's and further programming is disabled. The ID locations and configuration word read out unscrambled and can be reprogrammed normally. The only procedure to erase a PIC16F87X device that is code protected is shown in the following procedure. This method erases program memory, data memory, configuration bits and ID locations. **Since all data within the program and data memory will be erased when this procedure is executed, the security of the data or code is not compromised.**

1. Execute a Load Configuration command (000000) with a '1' in all locations (0x3FFF)
2. Execute Increment Address command (000110) to set address to configuration word location (0x2007)
3. Execute a Bulk Erase Setup1 command (000001)
4. Execute a Bulk Erase Setup2 command (000111)
5. Execute a Begin Erase/Programming command (001000)
6. Wait 8 ms
7. Execute a Bulk Erase Setup1 command (000001)
8. Execute a Bulk Erase Setup2 command (000111)

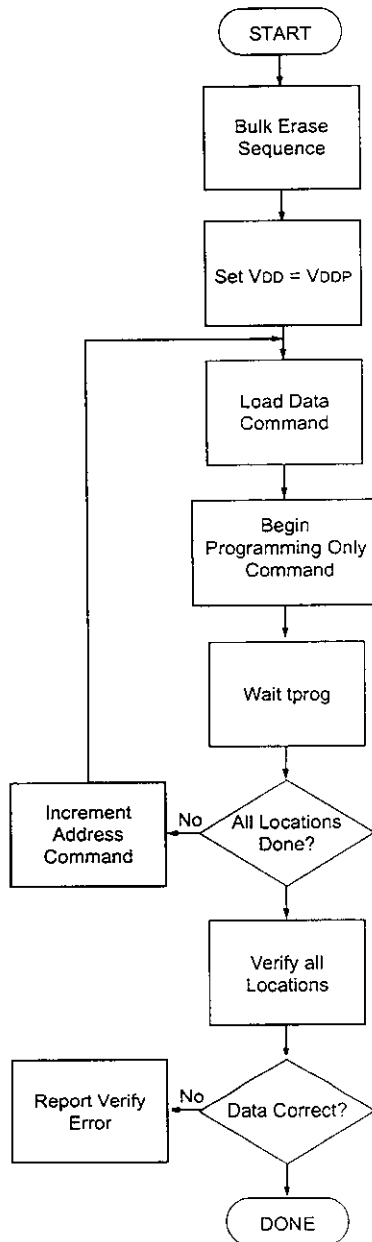
PIC16F87X

FIGURE 2-1: FLOW CHART - PIC16F87X PROGRAM MEMORY ($2.2V \leq V_{DD} < 5.5V$)



PIC16F87X

FIGURE 2-2: FLOW CHART – PIC16F87X PROGRAM MEMORY ($4.5V \leq V_{DD} \leq 5.5V$)



PIC16F87X

FIGURE 2-3: FLOW CHART – PIC16F87X CONFIGURATION MEMORY ($2.2V \leq V_{DD} < 5.5V$)

