# ATMEL BASED AUTOMATIC GATE VALVE CONTROL FOR PRESSURE TESTING OF JET PUMPS



PROJECT REPORT

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Department Of Electrical And Electronics Engineering

KUMARAGURU COLLEGE OF TECHNOLOGY

Coimbatore - 641 006

**DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING**

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**COIMBATORE – 641 006**

# CERTIFICATE

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## ATMEL BASED AUTOMATIC GATE VALVE CONTROL FOR PRESSURE TESTING OF JET PUMPS

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REGISTERED OFFICE :

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*Date* : 10.03.2001

# CERTIFICATE

This is to certify that **(* * * *)** Final year **BE** (Electrical and Electronics Engineering) students of.
**KUMARAGURU COLLEGE OF TECHNOLOGY**, Coimbatore. did a project work in "***ATMEL BASED AUTOMATIC GATE VALVE CONTROL FOR PRESSURE TESTING OF JET PUMPS.***"

Period of project work : Dec 2000 to Feb 2001.

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**QUALITY-ASSURANCE CHIEF.**

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**3. S. KARTHIKEYAN**
**4. K.RATHAMANI**

*Dedicated To Our Beloved Parents*

*&*

*Dear Friends!*

# Acknowledgement

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# SYNOPSIS

In the present industrial scenario, it is essential to automate all sections of the firm in order to create a convenient, integrated and easily accessible work environment. Most of the manual work can be integrated into a single device thereby reducing the stressful, monotonous and less precise manual controls.

In this project, a stepper motor interface circuit is designed and fabricated to automate the gate valve control for pressure testing of jet pumps.

The stepper motor is fed in with the digital pulses to excite its stator windings. The Microcontroller is programmed so as to control the bi-directional rotation of the stepper motor with the required revolutions per minute.

Another scheme of PC – based control is also presented. This includes just a Darlington pair of transistors as an interface between the PC parallel port and the stepper motor excitation windings. This scheme facilitates computerization.

The stepper motor shaft is coupled to the shaft of the Gate valve through a mechanical stainless steel coupling.

The circuits are tested and the results are presented in this report.

# CONTENTS

# CHAPTER 1
# INTRODUCTION

In this age of modernization, automation has become an ubiquitous trend in every firm's work environment. Automation and Computerization is an issue every industrialist would dream to bring to reality. The reason being, reduction in inaccuracy and manual labour. The use of modern controls to automate manual operations certainly prove to be a boon to industrialists. A perfectly designed automated system is always less maintenance prone. Although initial investment may be high, it is worth making an expense as its advantages suppress the demerit.

This report on "**Automatic Gate Valve Control for Pressure testing of Jet Pumps** " has eight sections plus a glossary. Each section stands on its own merits. The eight sections are divided as follows:

- Chapter 1 : Problem Specification and Proposed Solution

  This gives the details on the requirement of the company and the proposed solution for their problem.

- Chapter 2 : Power supplies

  Here the power supplies used for the project is discussed.

- Chapter 3 : Description ATMEL 89C51 Micro Controller

  The detailed description of the micro controller in use is presented here.

- Chapter 4 : Stepper Motor

  The role played by the stepper motor and its various ratings are keenly concentrated here.

- Chapter 5 : Stepper Motor Interfacing and Software description.

  The circuit details and the software for running the system for the required specifications are dealt in detail here.

- Chapter 6 : Mechanical Coupling.

  The Coupling constructional details are briefly discussed in this section.

- Chapter 7 : Jet Pumps Testing

  The entire testing process is briefly presented.

- Chapter 8 : Computerized control of Gate valve

  The automated process can be further computerized. A detail description is presented here.

- Chapter 9 : Conclusion

This report presents the overview of the entire project and detailed description of the components and software used.

## 1.1 *Present Position of the testing section.*

The firm, Best Engineers basically manufactures Jet Pumps. It has a separate testing section for the complete analysis of a pump's characteristics. The pumps are pressure tested (both suction and delivery) and the characteristics are then evaluated.

The testing section has :

- An Operator Desk.
- A Work Platform.

The Operator desk has all meters integrated onto the desk. Autotransformer controls are also given to the operator. The pressure testing is at present done by manually controlling a gate valve. The worker places the Jet pump under test on the platform. The operator has to move to the gate valve portion and adjust it minutely in order that the pressure readings are accurately positioned. The gate valve for water entry into pump is adjusted appropriately to certain angles whereby the required specifications of the pumps are verified. Then distance between the operator and the work platform is way around 2-3 metres.

## 1.2 *Problem Specification*

Drawback faced in testing :

~ Manual control of Gate valves.
~ Distance between operator and test platform.
~ Lack of precision
~ Time delay

As can be seen the drawbacks faced will be multiple, a separate worker is to be engaged for the purpose of pressure testing. More over compared to automation it has less accuracy. The operator has to maintain the accuracy in taking the pressure readings while he operates the gate valve to bring about the variations in suction and delivery pressures. The most important of all it contributes delay in the production. These demerits add on cumulatively to the decrease in the production rate from an ideal value.

The problem specification has been clearly depicted in the **Fig.1.1**

## 1.3 *Proposed Solution*

### 1.3.1 *Technologies Utilized*

The aforesaid difficulties can be rectified using the application of **Micro controller Technology** or by **Computerization** of the entire operation. This project inculcates both these technologies. While the former can be put to immediate use, the use of the latter would prove to be feasible only if the entire system is computerized so that a single PC could be dedicated for the purpose.

### 1.3.2 *Micro controller Technology*

The Micro controller technology is as indicated in the **Fig.1.2**. The block diagram shows the keypad interface that holds the keys for controlling the rotation of the motor. The Micro controller is given a supply of 5V and the pulses are fed to the Steeper card

The Stepper card holds the DPT ( Darlington pair of transistors), the FWD ( Free wheeling Diodes ) and the Buffer Inverter (IC 7407 ). The pulses are then given to excite the control windings of the stepper motor. The fed in assembly level code controls the motor's bi-directional rotation and also its angular step.

### 1.3.3 *Computerization*

As can be seen in **Fig.1.3** the motor can also be controlled directly from the input of a PC. The Parallel port of the PC sends out pulses that are amplified by means of the Darlington pair that is present as interface. The control is facilitated by means of a software program that has been written in Turbo C.

### 1.3.4 *Mechanical Coupling*

Thus the motor rotation is controlled by these two technologies. The shaft of the motor is coupled to the gate valve shaft by means of a Stainless Steel bi-terminal coupling. This coupling transmits the motor rotation onto the gate valve there by controlling the inflow of water. Hence the keypad console is given to the operator and the system is automated.

# Problem Specification

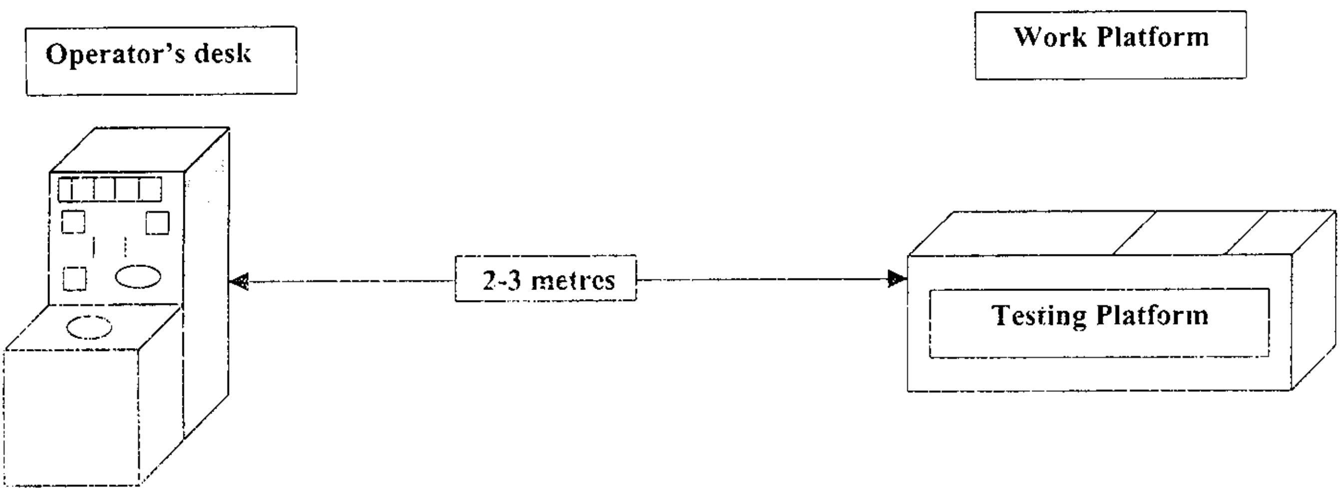



*Fig. 1.1 Pressure testing section of Jet Pumps*

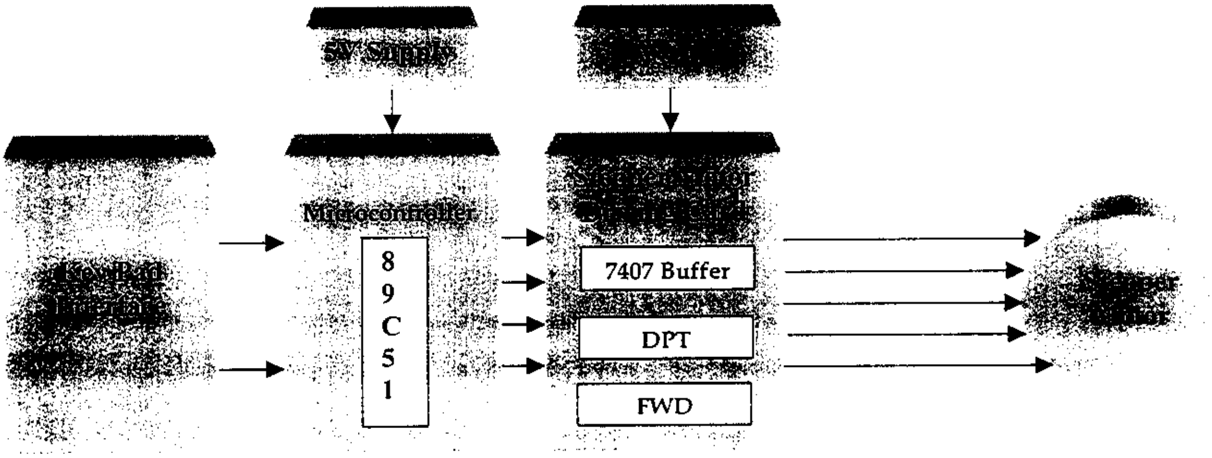



Fig. 1.2 *Microcontroller Technology*

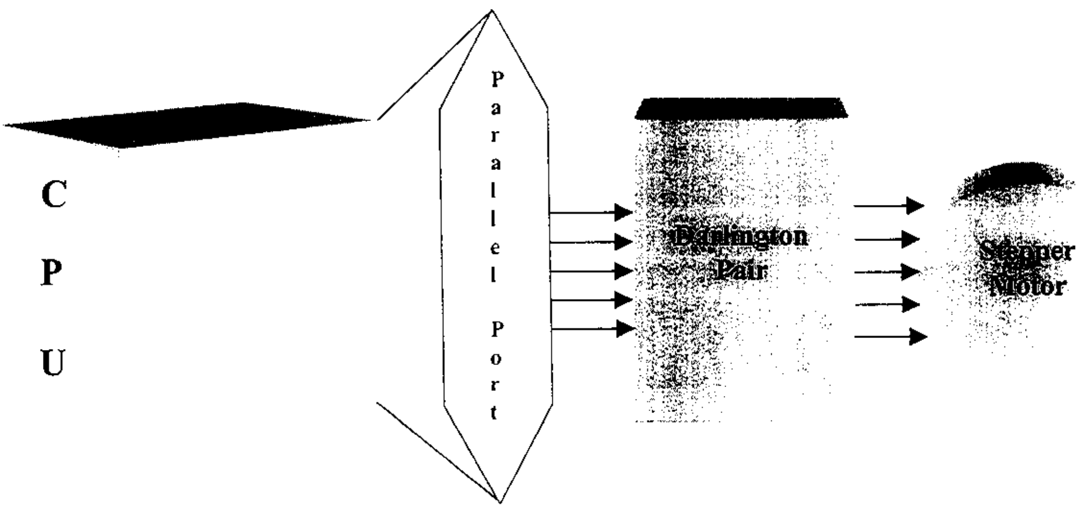



Fig. 1.3 *PC Based control of Stepper Motor*

CHAPTER 2

# POWER SUPPLIES

## 2.1 *Circuit Details*

Since all electronic circuits work only with low D.C. voltage we need a power supply unit to provide the appropriate voltage supply. This unit consists of transformer, rectifier, filter and regulator as depicted in **Fig.2.1**. A.C. voltage typically 230V RMS is connected to a transformer which steps that AC voltage down to the level to the desired AC voltage. A diode rectifier then provides a full-wave rectified voltage that is initially filtered by a simple capacitor filter to produce a DC voltage. This resulting DC voltage usually has some ripple or AC voltage variations. A regulator circuit can use this DC input to provide DC voltage that not only has much less ripple voltage but also remains the same DC value even the DC voltage varies some what, or the load connected to the output DC voltages changes. Power Supply circuit for microcontroller is shown in **Fig.2.2** and power supply circuit for stepper motor is referred in **Fig.2.3.**

### 2.1.1 *Transformer*

A transformer is a static (or stationary) piece of which electric power in one circuit is transformed into electric power of the same frequency in another circuit. It can raise or lower the voltage in a circuit but with a corresponding decrease or increase in current. It works with the principle of mutual induction. In our project we are using step down transformers for providing a necessary supply for the electronic circuits. In our project we are using a 230V / 9V transformer and a 15-0-15V center tapped transformer.

### 2.1.2 *Rectifier*

The DC level obtained from a sinusoidal input can be improved 100% using a process called full-wave rectification. It uses 4 diodes in a bridge configuration. From the basic bridge configuration we see that two diodes (say D2 & D3) are conducting while the other two diodes (D1 & D4) are in "off" state during the period t =0 to T/2. Accordingly for the negative of the input the conducting diodes are D1 & D4. Thus the polarity across the load is the same.

### 2.1.3 *Filter*

The filter circuit used here is the capacitor filter circuit where a capacitor is connected at the rectifier output, and a DC is obtained across it. The filtered waveform is essentially a DC voltage with negligible ripples, which is ultimately fed to the load.

### 2.1.4 *Regulator*

The output voltage from the capacitor is more filtered and finally regulated. The voltage regulator is a device, which maintains the output voltage constant irrespective of the change in supply variations, load variation and temperature changes. Here we use three fixed voltage regulators namely LM 7812, LM 7805 and LM7912. The IC 7812 is a +12V regulator IC 7912 is a -12V regulator and IC 7805 is a +5V regulator.

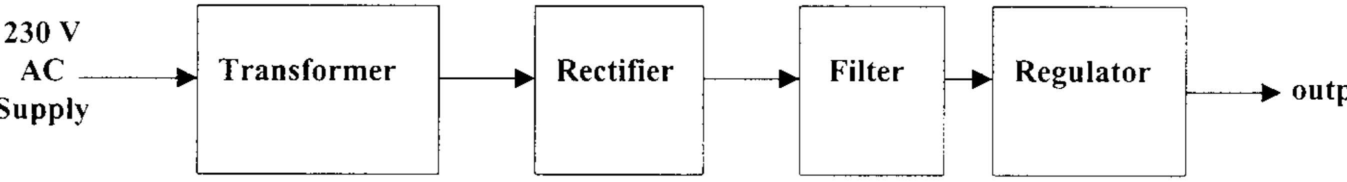



Fig.2.1 *Basic block diagram of Power Supply unit*

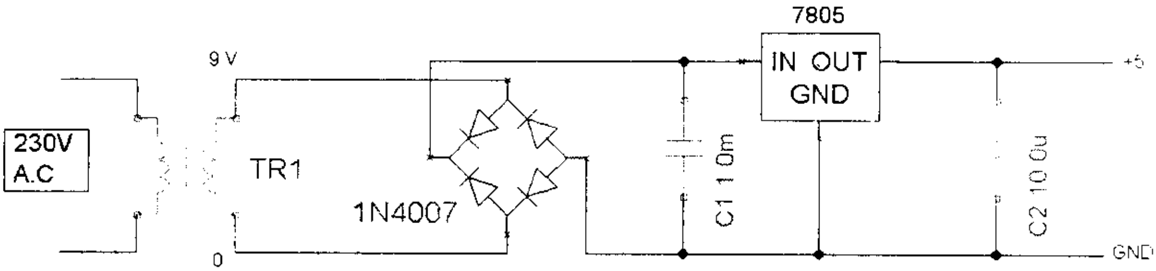



Fig.2.2 *Power supply circuit for Microcontroller*

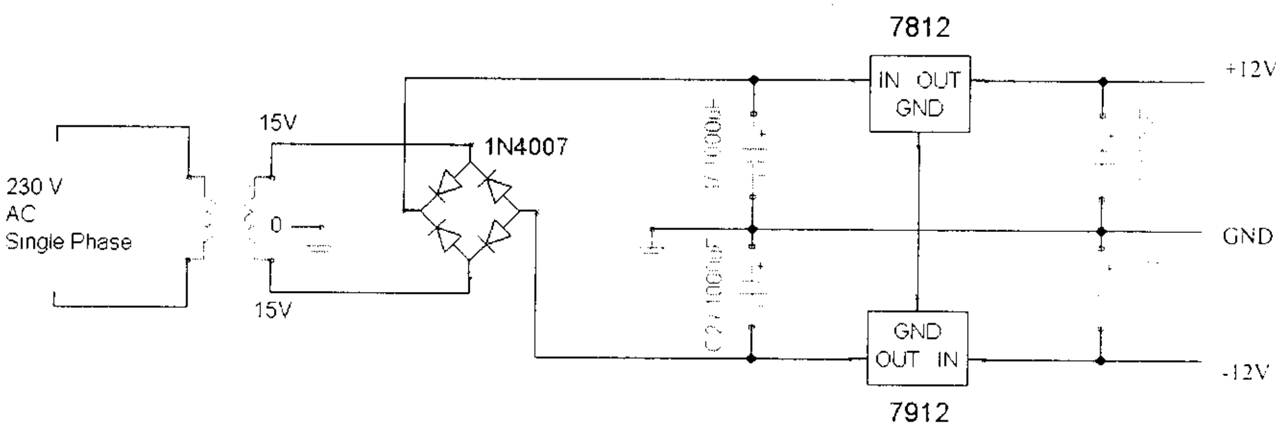



Fig 2.3 *Power Supply circuit for Stepper Motor*

CHAPTER 3

# DESCRIPTION OF ATMEL 89C51 MICROCONTROLLER

## 3.1 *Introduction*

The AT89C51 is a low-power, high-performance CMOS 8-bit microcomputer with 4K bytes of Flash programmable and erasable read only memory (EPROM). The device is manufactured using Atmel's high-density nonvolatile memory technology and is compatible with the industry-standard MCS-51 instruction set and pinout. The on-chip Flash allows the program memory to be reprogrammed in-system or by a conventional nonvolatile memory programmer. By combining a versatile 8-bit CPU with Flash on a monolithic chip, the Atmel AT89C51 is a powerful microcomputer which provides a highly-flexible and cost-effective solution to many embedded control applications.

### 3.1.1 *Features*

- 8 Bit CPU optimized for control applications
- Extensive Boolean processing (Single - bit Logic ) Capabilities.
- On - Chip Flash Program Memory
- On - Chip Data RAM
- Bidirectional and Individually Addressable I/O Lines
- Multiple 16-Bit Timer/Counters
- Full Duplex UART

- Multiple Source / Vector / Priority Interrupt Structure
- On - Chip Oscillator and Clock circuitry.
- On - Chip EEPROM
- SPI Serial Bus Interface
- Watch Dog Timer

## 3.2 *Pin Configuration And Description*

The AT89C51 provides the following standard features: 4Kbytes of Flash, 128 bytes of RAM, 32 I/O lines, two 16-bittimer/counters, a five vector two-level interrupt architecture, a full duplex serial port, on-chip oscillator and clock circuitry. In addition, the AT89C51 is designed with static logic for operation down to zero frequency and supports two software selectable power saving modes. The Idle Mode stops the CPU while allowing the RAM, timer/counters, serial port and interrupt system to continue functioning. The Power-down Mode saves the RAM contents but freezes the oscillator disabling all other chip functions until the next hardware reset. The details of the pin configuration are given in the **Appendix**.

## 3.3 *Memory Organization*

All ATMEL Flash micro controllers have separate address spaces for program and data memory as shown in **Fig3.2**. The logical separation of program and data memory allows the data memory to be accessed by 8 bit addresses, which can be more quickly stored and manipulated by an 8 bit CPU. Nevertheless 16 Bit data memory addresses can also be generated through the DPTR register.

Program memory can only be read. There can be up to 64K bytes of directly addressable program memory. The read strobe for external program memory is the Program Store Enable Signal (PSEN)

Data memory occupies a separate address space from program memory. Up to 64K bytes of external memory can be directly addressed in the external data memory space. The CPU generates read and write signals , RD and WR , during external data memory accesses.

External program memory and external data memory can be combined by a applying the RD and PSEN signals to the inputs of AND gate and using the output of the fate as the read strobe to the external program/data memory.

### 3.3.1 *Program Memory*

**Fig.3.3** shows the map for the lower part of the program memory. After reset, the CPU begins execution from location 0000h.

As shown in **Fig.3.3** each interrupt is assigned a fixed location in program memory. The interrupt causes the CPU to jump to that location, where it executes the service routine. External Interrupt 0 for example, is assigned to location 0003h. If external Interrupt 0 is used, its service routine must begin at location 0003h. If the Interrupt in not used its service location is available as general-purpose program memory.

The interrupt service locations are spaced at 8 byte intervals 0003h for External interrupt 0, 000Bh for Timer 0, 0013h for External interrupt 1,001Bh for Timer1, and so on. If an Interrupt service routine is short enough (as is often the case in control applications) it can reside entirely within that 8-byte interval. Longer service routines can use a jump instruction to skip over subsequent interrupt locations. If other interrupts are in use.

The lowest addresses of program memory can be either in the on-chip Flash or in an external memory. To make this selection, strap the External Access (EA) pin to either Vcc or GND.

For example, in the AT89C51 with 4K bytes of on-chip Flash, if the EA pin is strapped to Vcc, the Program fetches to addresses 0000h through 0FFFh are directed to internal Flash and Program fetches to addresses 1000h through FFFFh are directed to external memory.

### 3.3.2 *Data Memory*

The Internal Data memory is divided into three blocks as shown in **Fig.3.1** namely:

1. The lower 128 Bytes of Internal RAM.
2. The Upper 128 Bytes of Internal RAM.
3. Special Function Register.

Internal Data memory Addresses are always 1 byte wide, which implies an address space of only 256 bytes. However, the addressing modes for internal RAM can in fact accommodate 384 bytes. Direct addresses higher than 7Fh access one memory space, and indirect addresses higher than 7Fh access a different memory space.

The lowest 32 bytes are grouped into 4 banks of 8 registers. Program instructions call out these registers as R0 through R7. Two bits in the Program Status Word (PSW) Select which register bank is in use. This architecture allows more efficient use of code space, since register instructions are shorter than instructions that use direct addressing.

The next 16-bytes above the register banks form a block of bit addressable memory space. The micro controller instruction set includes a wide selection of single - bit instructions and these instructions can directly address the 128 bytes in this area. These bit addresses are 00h through 7Fh.

All of the bytes in lower 128 bytes can be accessed by either direct or indirect addressing. The upper 128 can only be accessed by indirect addressing. The upper 128 bytes of RAM are only in the devices with 256 bytes of RAM.

The Special Function Register includes Port latches, timers, peripheral controls etc. These registers can only be accessed by direct addressing. In general, all ATMEL microcontroller have the same SFR's at the same addresses in SFR space as the AT89C51 and other compatible micro controllers. However, upgrades to the AT89C51 have additional SFR's.

Sixteen addresses in SFR space are both byte and bit Addressable. The bit Addressable SFR's are those whose address ends in 000B. The bit addresses in this area are 80h through FFh.

## 3.4 *Addressing Modes, Instruction And Interrupts*

### 3.4.1 *Addressing Modes*

DIRECT ADDRESSING

In Direct addressing, the operand specified by an 8-bit address field in the instruction. Only internal data RAM and SFR's can be directly Addressed.

INDIRECT ADDRESSING

In Indirect addressing, the instruction specifies a register that contains the address of the operand. Both internal and external RAM can indirectly addressed.

The address register for 8-bit addresses can be either the Stack Pointer or R0 or R1 of the selected register Bank. The address register for 16-bit addresses can be only the 16-bit data pointer register, DPTR.

INDEXED ADDRESSING

Program memory can only be accessed via indexed addressing This addressing mode is intended for reading look-up tables in program memory. A 16 bit base register (Either DPTR or the Program Counter ) points to the base of the table, and the accumulator is set up with the table entry number. The address of the table entry in program memory is formed by adding the Accumulator data to the base pointer.

Another type of indexed addressing is used in the" case jump " instructions. In this case the destination address of a jump instruction is computed as the sum of the base pointer and the Accumulator data.

### 3.4.2 *Instruction*

REGISTER INSTRUCTION

The register banks, which contains registers R0 through R7, can be accessed by instructions whose opcodes carry a 3-bit register specification. Instructions that access the registers this way make efficient use of code, since this mode eliminates an address byte. When the instruction is executed, one of four banks is selected at execution time by the row bank select bits in PSW.

REGISTER - SPECIFIC INSTRUCTION

Some Instructions are specific to a certain register. For example some instruction always operate on the Accumulator, so no address byte is needed to point. In these cases, the opcode itself points to the correct register. Instruction that register to Accumulator as A assemble as Accumulator - specific opcodes.

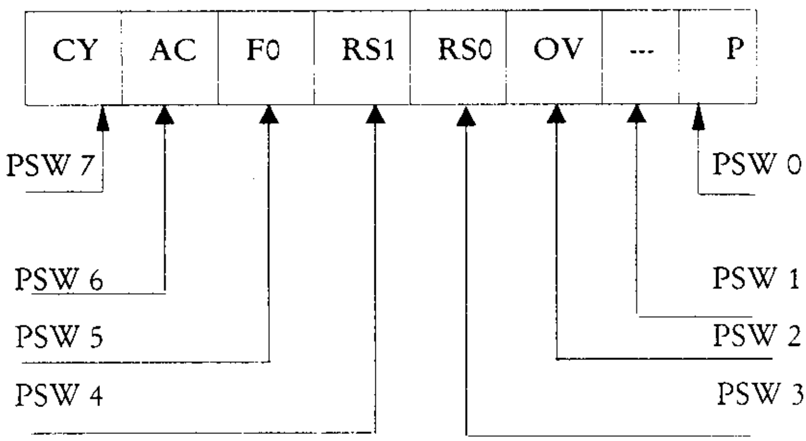
IMMEDIATE CONSTANTS

The value of a constant can follow the opcode in program memory For example: MOV A,#100

loads the Accumulator with the decimal number 100 . The same number could be specified in hex digit as 64h.

PROGRAM STATUS WORD

*Program Status Word Register in Atmel Microcontroller*




PSW 0 : Parity of Accumulator Set By Hardware To 1 if it contains an Odd number of 1s , Otherwise it is Reset to 0.

PSW1: User Definable Flag

PSW2: Overflow Flag Set By Arithmetic Operations

PSW3: Register Bank Select

PSW4: Register Bank Select

PSW5 : General Purpose Flag.

PSW6: Auxiliary Carry Flag Receives Carry Out from Bit 1 of Addition Operands

PSW7: Carry Flag Receives Carry Out From Bit 1 of ALU Operands.

The Program Status Word contains Status bits that reflect the current state of the CPU . The PSW shown if Fig resides in SFR space. The PSW contains the Carry Bit, The auxiliary Carry (For BCD Operations ) the two - register bank select bits, the Overflow flag, a Parity bit and two user Definable status Flags.

The Carry Bit, in addition to serving as a Carry bit in arithmetic operations also serves the as the "Accumulator" for a number of Boolean Operations .The bits RS0 and RS1 select one of the four register banks. A number of instructions register to these RAM locations as R0 through R7.The status of the RS0 and RS1 bits at execution time determines which of the four banks is selected.

The Parity bit reflect the Number of 1s in the Accumulator .P=1 if the Accumulator contains an even number of 1s, and P=0 if the Accumulator contains an even number of 1s. Thus, the number of 1s in the Accumulator plus P is always even.

Two bits in the PSW are uncommitted and can be used as general purpose status flags.

### 3.4.3 *Interrupts*

The AT89C51 provides 5 interrupts sources :Two External interrupts, two timer interrupts and a serial port interrupt.

The External Interrupts INT0 and INT1 can each either level activated or transition - activated, depending on bits IT0 and IT1 in Register TCON. The Flags that actually generate these interrupts are the IE0 and IE1 bits in TCON. When the service routine is vectored to hardware clears the flag that generated an external interrupt *only* if the interrupt was transition - activated. If the interrupt was level - activated, then the external requesting source(rather than the on-chip hardware) controls the requested flag.

The Timer 0 and Timer 1 Interrupts are generated by Tf0 and Tf1 , which are set by a rollover in their respective Timer/Counter Register (except for Timer 0 in Mode 3).When a timer interrupt is generated , the on-chip hardware clears the flag that generated it when the service routine is vectored to.

The Serial Port Interrupt is generated by the logical OR of RI and TI. Neither of these flag is cleared by hardware when the service routine is vectored to . In fact , the service routine normally must determine whether RI or TI generated the interrupt an the bit must be cleared in software.

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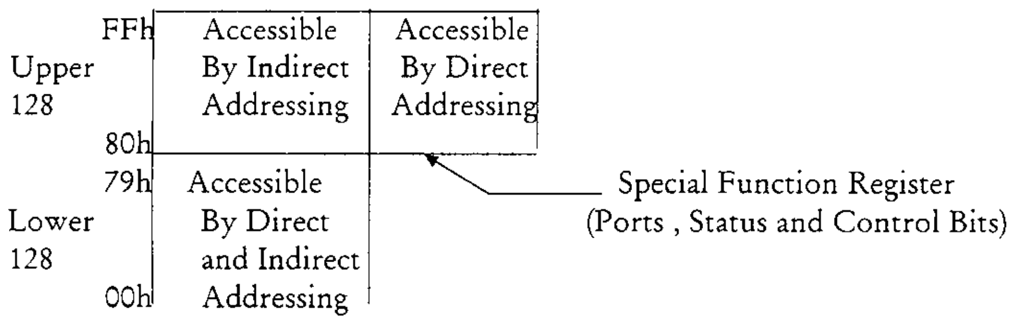



Fig.3.1    *Internal Data Memory*

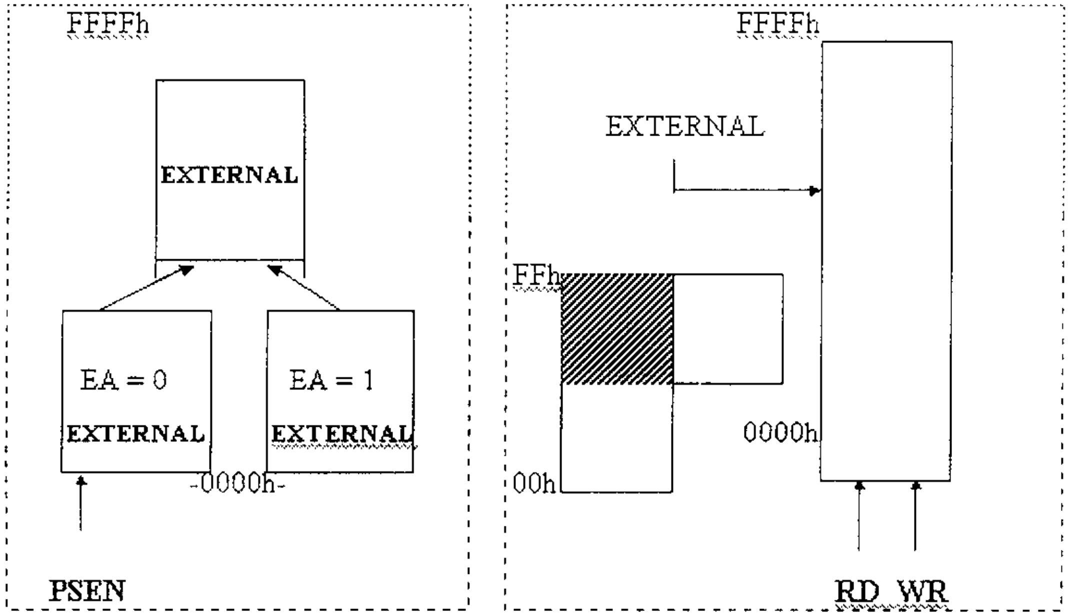



**Fig.3.2.** *AT89C51 Memory Structure*

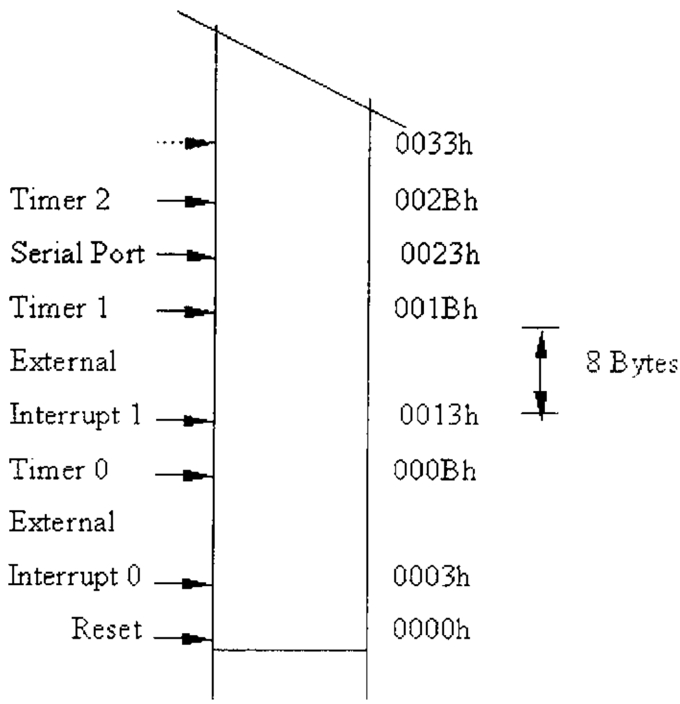



Fig.3.3. *Program Memory*

# CHAPTER 4

# STEPPER MOTOR

## 4.1 *Introduction*

A stepper motor is a digital electromagnetic device where each pulse input results in a discrete output i.e. a definite angle of shaft rotation. Stepper motors were first introduced in 1957. More than a decade clasped before these came to India. The production of stepper motors in India picked up only in the last decade or so with the growth of computer peripherals, office equipment and CNC machine tool industries. This led to the creation of a sizeable user-base in India. However, most users are faced with difficulties in selecting stepper motors of the right size, as very little information is available on them.

A stepper motor is defined in British standard specification as "a reversible brush less DC motor, the rotor of which rotates in discrete angular steps when its stator windings are energized in a programmed manner, Rotation occurs as a result of interaction between the rotor poles and the poles of the sequentially energized stator windings. The rotor carries no electrical windings but rather has salient soft or magnetized poles".

## 4.2 *Why Stepper Motors?*

The various motors available in the market for positioning and speed control are:

- Industrial Motors
- Servo Motors
- Stepper motors

### 4.2.1 *Industrial Motors*

The Industrial motors are used to convert electrical energy into mechanical energy but they cannot be uses for precision positioning of an object or precision control of speed without using closed -loop feedback.

### 4.2.2 *Servo Motors*

Servo Motors rotate at constant speed. But the disadvantage is we need separate auxiliary arrangement such as gear system has to be installed to obtain angular rotations.

### 4.2.3 *Stepper Motors*

Stepper motors are ideally suited for situations where either precise positioning or precise speed control or both are required in automation systems. The unique feature of stepper motor is that its output shaft rotates in a series of discrete angular intervals or steps, one step being taken each time a command pulse is received.

When a definite number of pulses are supplied, the shaft turns through a definite known angle. This fact makes the motor well suited for open-loop position control because no feedback need be taken from the output shaft.

Such motors develop torque ranging from 1μN-m up to 40 N-m in a motor of 15 cm diameter suitable for machine tool applications. The power output ranges from 1W to 2500W.The only moving part in a stepper motor is its rotor which has no windings, commutator or brushes .his feature makes the motor quite robust and reliable.

The angle through which the motor shaft rotates for each command pulse is called the step angle β. Smaller the step angle, greater the number of steps per revolution and higher the resolution or accuracy of positioning is obtained. The step angles can be as small as 0.72° or as large as 90°.But the most common step sizes are 1.8°, 2.5°, 7.5° and 15°.

The value of step angle can be expressed either in terms of the rotor and stator poles (teeth) $N_r$ and $N_s$ respectively or in terms of the number of stator phases(m) and the number of rotor teeth.

$$\beta = \frac{(N_s - N_r)}{N_s * N_r} * 360°$$

(or)

$\beta = 360°/(m*N_r) = 360°/(\text{No. of stator phases} * \text{No. of rotor teeth})$.

Resolution is given by the number of steps needed to complete one revolution of the rotor shaft. Higher the resolution, greater the accuracy of positioning of objects by the motor.

Resolution = No. of steps/revolution = $360°/\beta$

## 4.3 *Types Of Stepper Motors*

Stepper motors are of three basic types: (a) permanent magnet (PM) - utilizes a rotor having permanently magnetized salient poles of hard magnetic material; (b) Variable reluctance (VR) - soft magnetic material; and (c) hybrid (HY) - utilizes a rotor comprising an axial permanent magnet juxtaposed between two soft iron rotor discs having salient poles.

### 4.3.1 *Variable Reluctance Stepper Motor*

It has a wound stator poles but the rotor poles are made of a ferromagnetic materials as shown in **Fig.4.1**. It can be of the single stack type that gives smaller step angles. Direction of motor rotation is independent of the polarity of the stator current. It is called variable reluctance motor because the reluctance of the magnetic circuit formed by the rotor and stator teeth varies with angular position of the rotor.

### 4.3.2 *Permanent Magnet Stepper Motor*

It also has wound stator poles but its rotor poles are permanently magnetized. It has a cylindrical rotor as shown in **Fig.4.2**. Its direction of rotation depends on the polarity of stator current.

### 4.3.3 *Hybrid Stepper Motor*

It has wound stator poles and permanently - magnetized rotor poles as shown in **Fig.4.3**. It is best suited when small step angles of 1.8°, 2.5° etc are required.

As a variable speed machine, VR motor is sometime designed as a switched -reluctance motor. Similarly, PM stepper motor is also called variable speed brush-less motor. The hybrid motor combines the features of VR stepper motor and PM stepper motor. Its stator construction is similar to the single-stack VR motor but the rotor is cylindrical and is composed of radially magnetized permanent magnets.

## 4.4 *Description of Hybrid Stepper Motor*

### 4.4.1 *Construction*

It combines the features of the variable reluctance and permanent–magnet motors. The rotor consists of permanent –magnet that is magnetized axially o create a pair of poles marked N and S in **Fig.4.4**. Two end caps are fitted at both ends of this axial magnet. These end-caps consists of equal number of teeth which are magnetized by the respective polarities of the axial magnet. The rotor teeth of one end-cap are offset by a half tooth pitch so that a tooth at one end-cap coincides with the slot at the other. The cross-sectional views perpendicular to the shaft along X-X' and Y-Y' AXES are shown in **Fig.4.4**. As seen, the stator consists of four stator poles which are excited by two stator windings in pairs. The rotor has five N-poles at one end and Five S-POLES at the other end of axial magnet.

### 4.4.2 *Working*

In **Fig.4.4** phase A is shown excited such that the top stator pole is a S-pole so that it attracts the top N-pole of the rotor and brings it in line with the A-A' axis. To turn the rotor, phase A is de-energized and phase B is excited positively. The rotor will turn in the CCC direction by a full step of 18°.

Next, phase A and B are energized negatively one after the other to produce further rotations of a8° each in the same direction. For producing clockwise rotation ,the phase sequence should be $A^+$,$B^-$,$A^+$,$B^-$ etc.

Practically hybrid stepper motors are built with more rotor poles. In order to give high resolution. Hence, the stator poles are often slotted or castleated to increase the number of stator teeth. Each of the eight stator poles has been allotted or castleated into five smaller poles making $N_s=8*5=40°$.If rotor has 50 teeth, then the step angle $=1.8°$.

$$(50-40)*360/50*40=1.8°.$$

Step angle can also be decreased and hence resolution can be increased by having more than two stacks on the rotor,

This motor achieves small step sizes easily and with a simple magnet structure whereas a purely PM motor requires a multiple permanent magnet. As compared to VR motor, hybrid motor requires less excitation to achieve given torque. However, like a PM motor, this motor also develops good detent torque provided by the permanent magnet flux. This torque holds the rotor stationary while the power is switched off. This fact is quite helpful because the motor can be left overnight without fear of being accidentally moved to new position.

## 4.5 *Characteristics and Selection*

### 4.5.1 *Characteristics*

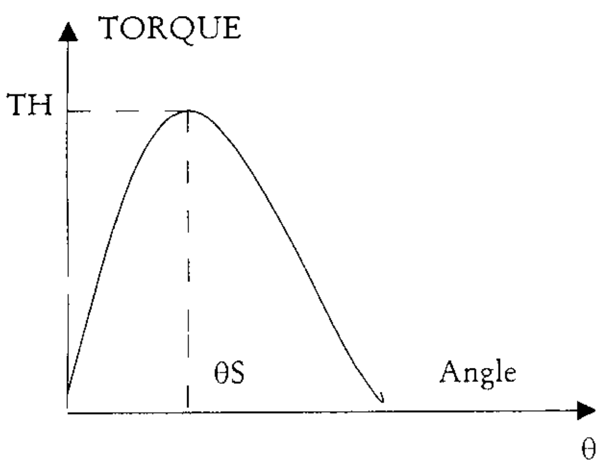
Characteristics that are of importance in the section of stepper motors are:

STEP ANGLE ($\theta s$)

It is the fixed angle through which the shaft of the unloaded stepper motor rotates when two adjacent stator phases are energized, singly in sequence. Step angle determines the resolution (least angular rotation that can be detected) and the positioning accuracy that can be achieved.

HOLDING TORQUE (TH)

It is the maximum steady state torque at a specified current that can be applied to the shaft of an energized stepper motor, without causing slipping of the rotor. It is determined from the torque-angle curve of the stepper motor as shown.



SYNCHRONISM

In stepper motor operation, synchronism means a strict one-to-one correspondence between the number of pluses applied to the motor controller and the number of steps through which the rotor actually moves. Synchronism is of vital importance in the design of incremental servo systems utilizing stepper motors.

PULL-IN RATE(FPI) It is the maximum stepping rate up to which the motor can start or stop without losing synchronism, at a specified output torque.

PULL-OUT RATE (FpO) It is the maximum stepping rate up to which the stepper motor can slew without losing synchronism, at a specified output torque.

PULL-IN TORQUE (TpI) It is the maximum torque against which the motor can start or stop without losing synchronism, at a specified stepping rate.

PULL-OUT TORQUE (TpO) It is the maximum torque at which the motor can slew without losing synchronism, at a fixed stepping rate.

These ratings are defined by the torque vs. stepping rate curves.

## INCREMENTAL SERVO SYSTEMS

As mentioned earlier, synchronism between the number of input pulses applied to the motor controller and the number of discrete angular steps through which the motor rotates is of vital importance in stepper motor application. It is on account of this synchronism that we can keep a track of the angular displacement ($\theta$) of the motor shaft by keeping a count of the number of input pulses.

There is no need for angular position sensor such as a potentiometer, synchro, resolver and encoder to determine $\theta$. This implies that it is possible to design an open loop system utilizing a stepper motor for controlling angular position $\theta$. Such a position control system, employing the stepper motor, is known as incremental servo; it is capable of yielding the same positioning accuracy as a closed loop system using DC or AC servomotor.

The main advantages of incremental servo over closed loop DC or AC servo are: (a) it is simple and inexpensive to design and develop; (b) there are no stability problems since it is an open loop system; and (c) even then, it is capable of yielding high positioning accuracy comparable to that of closed loop DC or AC servo systems. In this way, synchronism is the cardinal principle in the design of incremental servo systems. Naturally, stepper motor selection is also governed by the same principle of synchronism.

## 4.6. *Basic considerations in stepper motor selection*

In addition to synchronism, there are three further basic considerations for selecting stepper motors for a particular application. These are: (a) positioning accuracy ($\delta$) - expressed in degrees or minutes of arc (rotary motion) - mm or microns (linear motion); (b) speed of operation (V) - specified in degrees or rad/sec, or rpm (rotary motion) - mm or m per sec.(linear motion); and (c) acceleration ($\alpha$) - specified indirectly in terms of the time $\Delta t$ required to attain operating speed V.

It is possible to determine the step angle $\theta s$ of the motor from the positioning accuracy. Stepping rate Fs can similarly be determined from the operating speed V. Acceleration in rad/sec$^2$ is computed from the ratio V/ $\Delta t$, where V is the time required to attain it from rest.

The total inertia J reflected to the motor shaft is determined by the load and the drive used to couple it to the motor. Knowledge of J and $\alpha$ enables us to compute accelerating torque $J\alpha$. Adding friction and load torques yields the total torque T that must be developed by the motor.

Once these basic data are available, we may proceed to select a stepper motor of proper size in the following sequence.

1. Select at the outset a range of stepper motors having step angle $\theta s$, which meets positioning accuracy requirements.
2. Refer to torque Vs stepping rate curves of the above motors, and select a motor which is capable of developing a torque T (calculated above) at a pull-in rate of F steps/sec. Detailed procedure for stepper motor selection is shown.

### 4.6.1 *Selection of steppers used in typical drives*

Four typical drives are used in incremental servos to couple the motor or the load, namely, the direct drive, string and pulley drive, rack and pinion drive, and lead screw drive.

DIRECT DRIVE This is the simplest possible drive in which the stepper motor is directly connected to the load.

STRING AND PULLEY DRIVE This drive is used when the stepper motor has to raise a load.

RACK AND PINION DRIVE This drive is selected when the load is to be moved linearly in a horizontal plane.

LEAD SCREW DRIVE This drive is preferred in NC and CNC systems for machine tools such as milling machines, turret lathes, jig boring machines, and planning machines.

## 4.7 *Applications*

Stepper motors are employed in a variety of applications. These applications may be divided into the following classes.

- Instrumentation - electronic analogue watches, clocks on railway platforms/offices/factories, and camera shutter operation, photo printing machines etc.
- Computer peripherals - line printers, X - Y plotters, floppy disc and hard disc drives, paper reader and punch in a teletype, etc.
- Office electronics equipment - electronic typewriters, telex machines, teleprinters, computer typesetting machines, etc.
- Machine tool controls - NC milling machines and lathes, CNC systems, machines, etc.
- Heavy-duty applications - indexing tables, X-Y tables, X-ray table positioning, radiation treatment machine, CAT scanners, solar panel positioner in a satellite, etc.

## 4.8 *Specifications of the Stepper motor used*

The stepper motor utilized for the purpose of the automatic gate valve control has the following specifications.

| Specifications | Rated Values |
|---|---|
| Torque | 3kg /cm ^2 |
| Angular Steps | 1.8 |
| Resolution | 200 steps / revolution |
| Voltage | 12 V |
| Current | 0.61A |
| Power | 15W |

**Table 4.1**

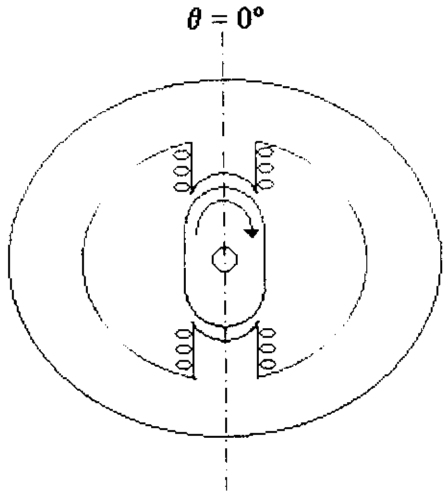



Fig. 4.1 *Variable Reluctance Stepper Motor*

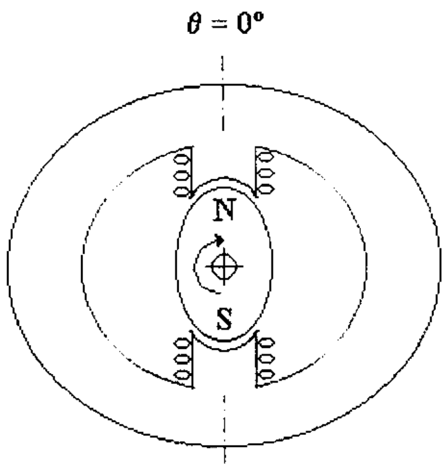



Fig. 4.2 *Permanent Magnet Stepper Motor.*

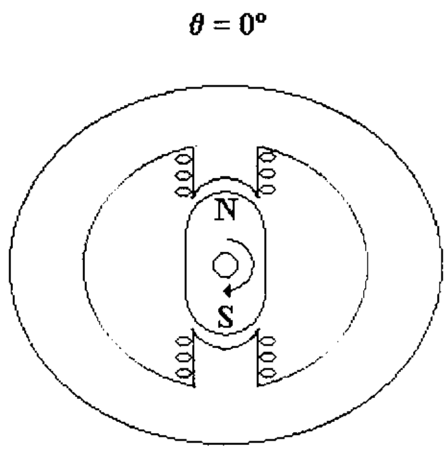



Fig .4.3 *Hybrid Stepper Motor*

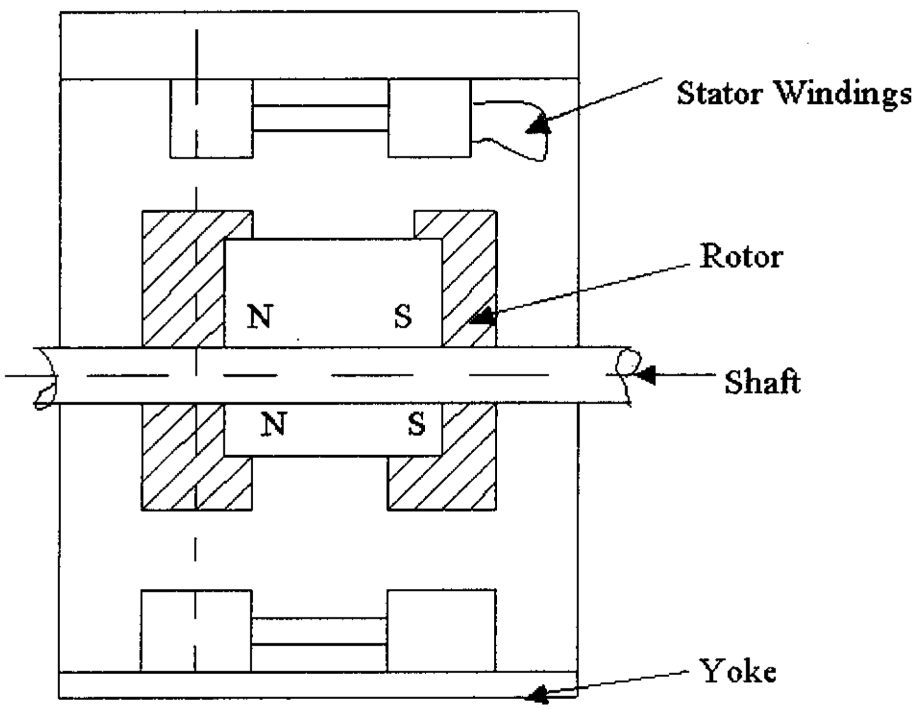



Fig.4.4 *Axial view of the permanent magnet hybrid stepper motor*

CHAPTER 5

# STEPPER MOTOR INTERFACING AND SOFTWARE DESCRIPTION

## 5.1 *Introduction*

The hardware portion of this project basically involves the

- Micro controller 89C51
- Stepper Motor Interface Card

The description of the Micro controller has been discussed previously in Chapter 3. The rotation of the stepper motor is controlled by its winding excitation. The windings are excited by the current pulses from the micro controller. Based on the delay between the current pulses from the micro controller the step angles of the motor can be varied. The step angle is of prime importance in the application point of view for precise positioning of the gate valve giving accurate readings of pressure. The bi-directional rotation of the stepper motor is achieved by means of the software.

This chapter gives the description of the interface circuitry and the software that is involved.

## 5.2 *Stepper Motor Interface*

### 5.2.1 *Introduction*

The Stepper motor rotations are controlled by means of the pulses from the Micro controller. Steppers don't simply respond to a clock signal, they have several windings that need to be energized in the correct sequence before the motor's shaft will rotate. Reversing the order of the sequence will cause the motor to rotate the other way. If the control signals are not sent in the correct order, the motor will not turn properly. It may simply buzz and not move, or it may actually turn, but in a rough or jerky manner. A circuit which is responsible for converting step and direction signals into winding energization patterns is called a *translator*. Most stepper motor control systems include a *driver* in addition to the translator, to handle the current drawn by the motor's windings.

The Micro controller communicates with the stepper motor through its output ports. This can be achieved by grounding the EA (active low pin). The Port 0 is used as the output port and Port 3 is used as the input port. The hardware details have been described in this section.

### 5.2.2 *Use of Micro controller*

The driver circuit used must be able to handle the current and voltage involved. Furthermore, because the load is inductive the drivers must be protected against the inductive voltage surge that occurs when a transistor switch tries to open up and discontinue the current flow through a winding of the stepper. The drivers include clamping diodes to alleviate this problem. Now when one of the drivers turns off, its diode permits the current which was flowing through the motor winding to continue, dying away at a rate determined by the L/R ratio of the motor winding. The voltage on the output of the driver is driven by the motor winding only slightly above +5V by an amount equal to the voltage drop across the diode. This protects the driver. Unfortunately, it also decreases the maximum stepping rate.

When one of the windings of this actuator has +5V impressed across it, the DC current which flows through the winding. At that moment the driver is turned off, the current which is flowing through the actuator's winding is diverted through the Zener diode circuit. At this moment of switching, we never turn off more than one winding. The Zener Diode is added to increase the maximum stepping rate. Often a resistor is used in place of the Zener diode to speed up the maximum stepping rate. It decreases the cost, as resistor is a cheaper component than the Zener diode. The value of the resistance is chosen so that the surge voltage across each driver stays below the break down voltage of the driver.

### 5.2.3 *Circuit description*

The micro controller 89C51 is triggered to operate by the operator's key press in the keypad console. The circuit diagram of the Stepper Interface card consists of:

- Darlington Pair transistor ( DPT)
- Free Wheeling Diodes ( FWD )
- Buffer Inverter ( IC 7407 )

The circuit diagram for the stepper interface card is shown in **Fig.5.2**.

The Darlington pair transistors are utilized in order to serve as a buffer in between the controller and the motor load. This prevents over loading of the Micro controller chip. There is another feature that the DPT offers i.e. it helps in the current amplification of the pulses. The damage to the ATMEL chip is thus avoided. The transistor pair used is BC 547 and 2N3055.

The Free Wheeling diodes used are to retain continuous operation of the motor rotation after each step. The diode used is 1N4007.

The buffer inverter used helps to store the information of the Micro controller output in case of transmission over long lines of cable. The chip used is IC 7407. The circuit with the microcontroller is depicted in **Fig.5.1**

### 5.2.4 *Switching Sequences*

Driving either the stepper motor or a linear stepping actuator requires the same circuitry ( given the same voltage and current loads ) and the same sequencing for turning the current on and off to each winding. The sequencing of the signals are labeled SW1, SW2, SW3 and SW4 to step in either direction. For example, if SW1, SW2, SW3 and SW4 are presently 1,0,1 and 0 respectively, then to make the stepper motor move one step clockwise change SW3 and SW4 to 0 and 1 respectively. To move a second step clockwise change SW1 and SW2 to 0 and 1 respectively. The sequence for 1.8° angle step revolutions is illustrated in the **Table 5.1**

| Steps | SW1 | SW2 | [illegible] | [illegible] |
|---|---|---|---|---|
| 1 | 1 | 0 | 1 | 0 |
| 2 | 1 | 0 | 0 | 1 |
| 3 | 0 | 1 | 0 | 1 |
| 4 | 0 | 1 | 1 | 0 |

**Table 5.1**

The table shows the switching sequence required to turn the motor through one step ( typical step size is 1.8 °) , and 200 steps are used for one complete revolution, i.e. 360° turns. To step in the reverse direction, the switching sequence is reversed ( i.e. 4,3,2,1 ).

The stepper motor is capable of operating in a half step (0.9°) mode also. However that would require additional switching sequence and a different translational module circuitry. Further, the half - step reduces the holding torque of the motor. For present application, only the full step increment (i.e. 1.8°) is used .

## 5.3 *Analysis of the Software Module*

### 5.3.1 *Software description*

As mentioned earlier the micro controller program is used to control the rotation and direction of the shaft of the stepper motor. The program facilitates the time delay for the step angle requirement of the stepper application. The bi-directional rotation is regulated by changing the switching sequence controlled by the bit patterns assigned to the respective pins of the output port mentioned in the assembly level code. According to the bit sequence, the respective windings get excited which causes the rotation of the stepper motor either in clockwise or anti-clockwise direction depending on the bit sequence.

The problem specified was :

(i) The stepper motor should stop rotating when the control button is depressed.

(ii) The stepper motor should be able to rotate both in clockwise and anticlockwise direction.

(iii) The stepper motor should automatically come to rest during full close or full open position of the gate valve .

The above three facts were controlled using the micro controller program.

In the micro controller, port 3 acts as output port and port 1 acts as input port. A handy instruction to achieve the first task namely the stop and start control of motor was used. The instruction was jnb (jump on no bit). When the $0^{th}$ pin of port 3 is zero, the corresponding instruction gets activated.

The next task was to obtain forward and reverse rotations of stepper motor. This was achieved by writing two small subprograms ,one for forward rotation and other for reverse rotation.

To control angular rotations or time interval between each pulse, a delay program is called from main to achieve this task.

To sense the end or opening position of gate valve, a counter is established. When the count becomes 7 or 0 the motor automatically comes to rest.

### 5.3.2 *Algorithm*

*Main ( Fig.5.3)*

STEP 1: Initialise the ports of the micro controller.

STEP 2: Set port 3 as input port and port 1 as output port.

STEP 3: Jump on no bit to Step forward (subroutine) when pin 0 of port 3 is low activated

STEP 4: Jump on no bit to Step reverse (subroutine) when pin 1 of port 3

is low activated.

STEP 5. End

*Step Forward Subroutine (Fig.5.4)*

STEP 6: Move the data 55h to port1.

STEP 7: CALL the delay subroutine.

STEP 8: Move the data 99h to port1.

STEP 9: CALL the delay subroutine.

STEP 10: Move the data 0aah to port1.

STEP 11: CALL the delay subroutine

STEP 12: Move the data 66h to port1.

STEP 13: CALL the delay subroutine.

STEP 14: Jump on to main program to check which pin0 of port 3 is low activated.

### *Step Reverse Subroutine (Fig.5.5)*

STEP 15: Move the data 66h to port1.

STEP 16: CALL the delay subroutine.

STEP 17: Move the data 0aah to port1.

STEP 18: CALL the delay subroutine.

STEP 19: Move the data 99h to port1

STEP 20: CALL the delay subroutine.

STEP 21: Move the data 55h to port1.

STEP 22: CALL the delay subroutine.

STEP 23: Jump on to main program to check which pin1 of port 3 is low activated.

*Delay Subroutine (Fig5.6)*

STEP 24: Move 55h to pin 0 of port 1.

STEP 25: Move 55h to pin1 of port 1.

STEP 26: Decrement jump on non zero

STEP 27: Decrement jump on non zero

STEP 28: RETURN

The corresponding flow diagrams for the above algorithm is depicted in figures indicated within braces.

### 5.3.3 *Mnemonic Code*

```
        org    000h

main:
        jnb    p3.0,stp_fw
        jnb    p3.1,stp_rw
        ljmp   main
```

```
stp_fw:
        mov    p1,#55h
        lcall  delay
        mov    p1,#99h
        lcall  delay
        mov    p1,#0aah
        lcall  delay
        mov    p1,#66h
        lcall  delay
        ljmp   main

stp_rw:
        mov    p1,#66h
        lcall  delay
        mov    p1,#0aah
        lcall  delay
        mov    p1,#99h
        lcall  delay
        mov    p1,#55h
```

```
        lcall   delay
        ljmp    main


delay:
        mov     r0,#055h
del:
        mov     r1,#055h
dela:
        djnz    r1,dela
        djnz    r0,del
        ret
```

## 5.3.4. *Assembly Level Coding*

| Address | Op-code | Mnemonic | Comment |
|---|---|---|---|
| 0000 | 30 | jnb p3.0,stp_fw | Jump on no bit to Step forward subroutine |
| 0001 | B0 | | |
| 0002 | 06 | | |
| 0003 | 30 | jnb p3.1,stp_rw | Jump on no bit to Step reverse subroutine |
| 0004 | B1 | | |
| 0005 | 1E | | |
| 0006 | 02 | ljmp main | Jump on to 0000h |
| 0007 | 00 | | |
| 0008 | 00 | | |
| 0009 | 75 | mov p1,#55h | Move the address 55h to port 1. |

| | | | |
|---|---|---|---|
| 000A | 90 | | |
| 000B | 55 | | |
| 000C | 12 | lcall delay | Call Delay Subroutine |
| 000D | 00 | | |
| 000E | 3F | | |
| 000F | 75 | mov p1,#99h | Move the address 99h to port 1 |
| 0010 | 90 | | |
| 0011 | 99 | | |
| 0012 | 12 | lcall delay | Call Delay Subroutine |
| 0013 | 00 | | |
| 0014 | 3F | | |
| 0015 | 75 | mov p1,#aah | Move the address AAh to port 1 |
| 0016 | 90 | | |
| 0017 | AA | | |

| | | | |
|---|---|---|---|
| 0018 | 12 | lcall delay | Call Delay Subroutine |
| 0019 | 00 | | |
| 001A | 3F | | |
| 001B | 75 | mov p1,#66h | Move the address 66h to port 1 |
| 001C | 90 | | |
| 001D | 66 | | |
| 001E | 12 | lcall delay | Call Delay Subroutine |
| 001F | 00 | | |
| 0020 | 3F | | |
| 0021 | 02 | ljmp main | Jump to 000h |
| 0022 | 00 | | |
| 0023 | 00 | | |
| 0024 | 75 | mov p1,66h | Move the address 66h to port 1. |
| 0025 | 90 | | |

| | | | |
|---|---|---|---|
| 0026 | 66 | | |
| 0027 | 12 | lcall delay | Call Delay Subroutine |
| 0028 | 00 | | |
| 0029 | 3F | | |
| 002A | 75 | mov p1,#AAh | Move the address AAh to port 1 |
| 002B | 90 | | |
| 002C | AA | | |
| 002D | 12 | lcall delay | Call Delay Subroutine |
| 002E | 00 | | |
| 002F | 3F | | |
| 0030 | 75 | mov p1,#99h | Move the address 99h to port 1 |
| 0031 | 90 | | |
| 0032 | 99 | | |
| 0033 | 12 | lcall delay | Call Delay |

| | | | |
|---|---|---|---|
| | | | Subroutine |
| 0034 | 00 | | |
| 0035 | 3F | | |
| 0036 | 75 | mov p1,#55h | Move the address 55h to port 1 |
| 0037 | 90 | | |
| 0038 | 55 | | |
| 0039 | 12 | lcall delay | Call Delay Subroutine |
| 003A | 00 | | |
| 003B | 3F | | |
| 003C | 02 | ljmp main | Jump to 000h |
| 003D | 00 | | |
| 003E | 00 | | |
| 003F | 78 | lcall delay | Call Delay Subroutine |
| 0040 | 55 | mov r0,#055h | Move 55h to pin 0 port 1 |

| | | | |
|---|---|---|---|
| 0041 | 79 | | |
| 0042 | 55 | mov r1,#055h | Move 55h to pin1 of port 1 |
| 0043 | D9 | djnz r1,dela | Decrement till count becomes zero |
| 0044 | FE | | |
| 0045 | D8 | djnz r0,del | Decrement till count becomes zero |
| 0046 | FA | | |
| 0047 | 22 | RET | Return |

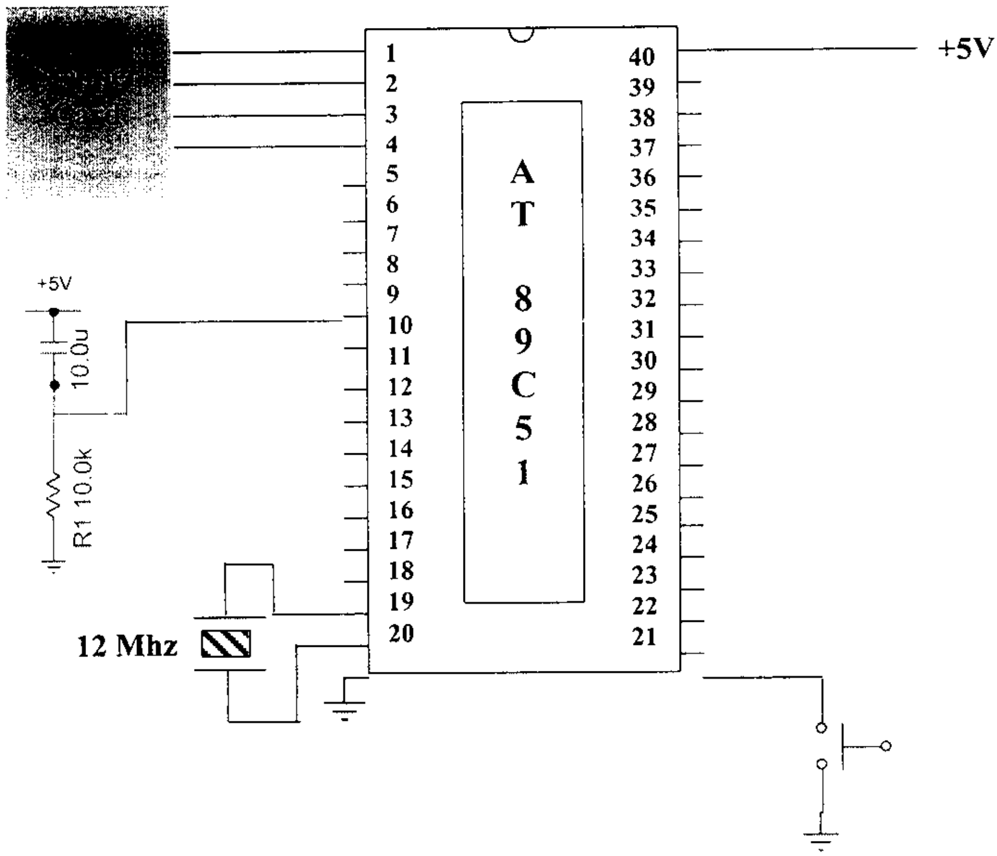



Fig. 5.1. *Micro controller with stepper interface card.*

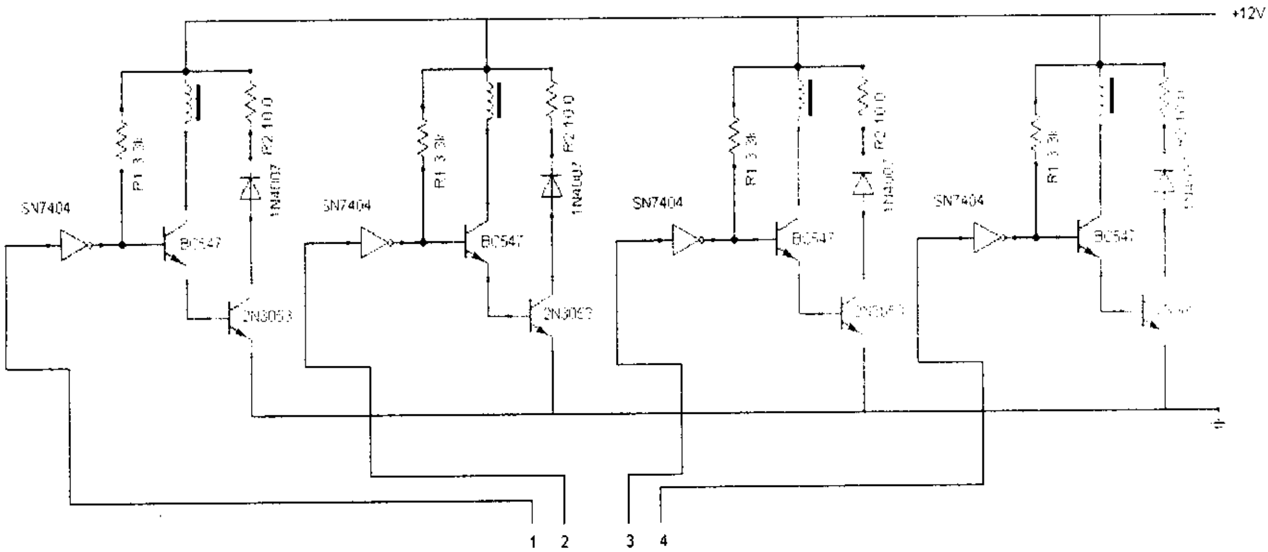



**Fig. 5.2** *Stepper Interface Card Circuitry*

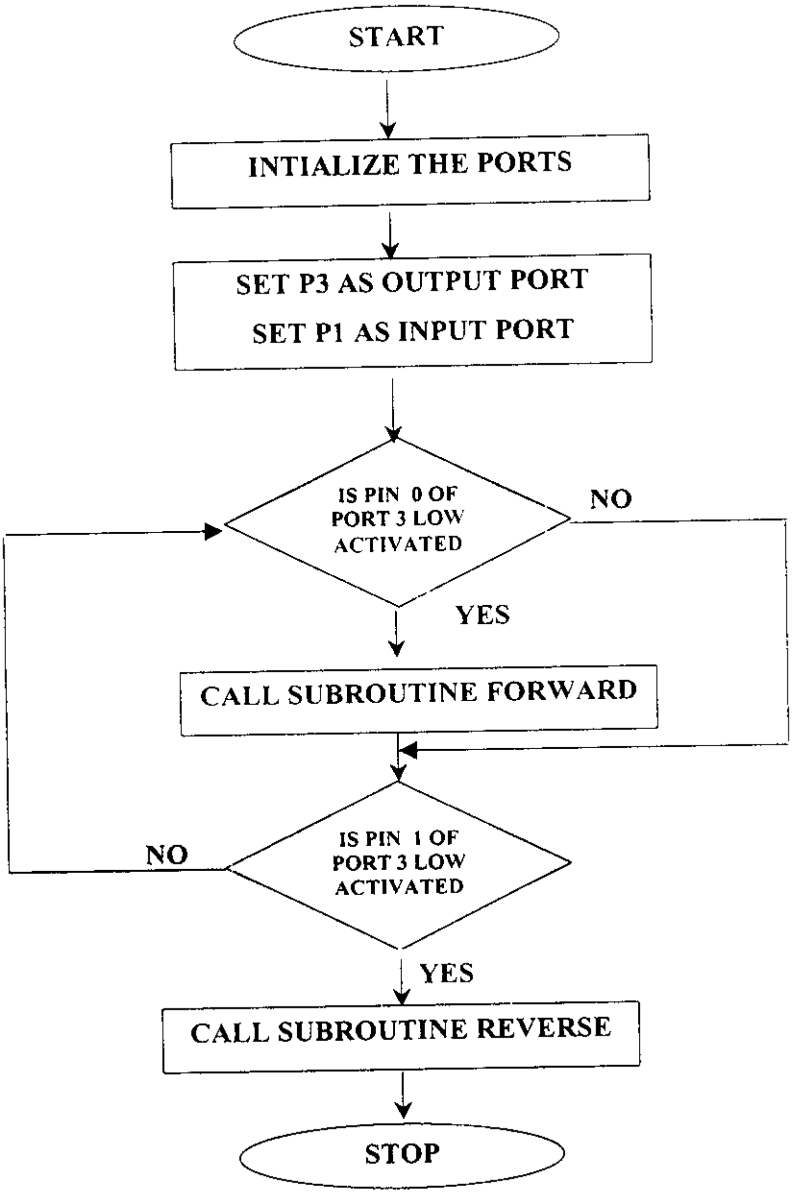



Fig.5.3 *Flow diagram (Main)*

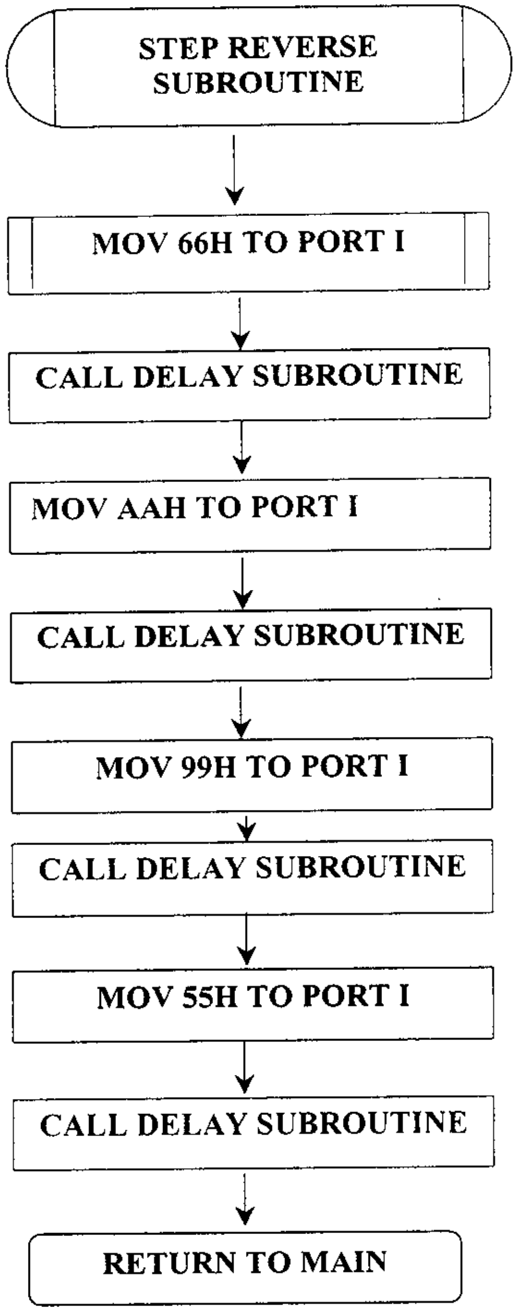



Fig.5.4 *Flow Diagram (Step Reverse Sub-routine)*

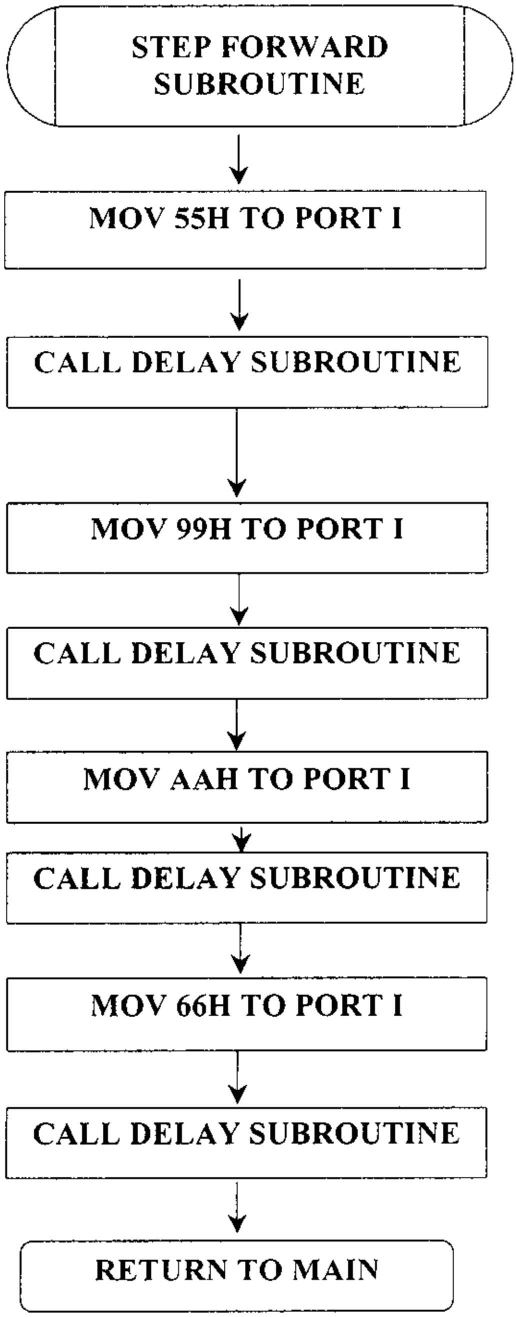



Fig.5.5 *Flow Diagram (Step Forward Sub-routine )*

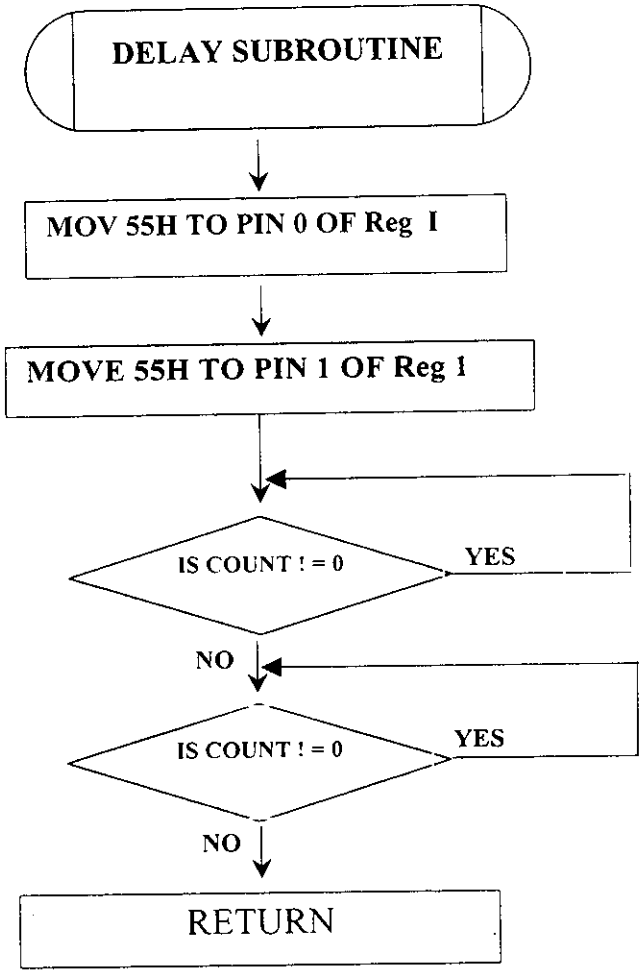



*Fig.5.6 Flow Diagram (Delay )*

CHAPTER 6

# MECHANICAL COUPLING

## 6.1 *Introduction*

The gate valve used for the pressure testing is to be adjusted by means of the rotation of the stepper motor. For this purpose the shafts are to be coupled. Hence a proper coupling element is to be chosen. It should facilitate the rotary motion between the motor's shaft and the gate valve. The selection of the material for coupling is of prime importance.

## 6.2 *Selection of the material for Coupling*

The coupling material should possess the following properties:

- It should withstand corrosion.
- It should be robust in construction.
- It should provide perfect mechanical balance.
- It should be able to take up the weight of the stepper motor.

The coupling material should be chosen such that it withstands corrosive effects. The Mechanical strength of the coupling should be high enough to hold the weight of the motor, which is held also by means of clamps to the pipe. Appropriate balance between both the motor shaft and the gate valve shaft should be maintained such that any sort of misalignment would be avoided. Imbalance causes excessive loading to the motor and affects it adversely. This might lead to missing of the stepping pulse and thus the accurate value of the pressure reading for the prescribed step cannot be attained. Hence accuracy is lost.

The weight of the motor is important for considering this balance. Thus in order to distribute the weight of the motor, clamps connected to the pipe are used. And the precise clamping helps to achieve the correct balance and prevent the adverse effects.

## 6.3 *Stainless steel Mechanical Coupling*

The mechanical coupling selected is a **Bi-terminal Stainless Steel coupling.** One end of the coupling is coupled to the motor shaft where the shaft advances through one angular step revolution. The other end of the coupling is coupled to the gate valve. The material used in the manufacture of the gate valve is a stainless steel one. This is chosen since it possesses all the above required properties.

The stepper motor is being supported by means stainless steel rods that are connected to the pipe since there is no nearby support. Bushings are provided in the coupling, which take care of the occurring vibrations.

The stepper motor coupled to the gate valve via the stainless steel coupling has been depicted in **Fig.6.1.** **Fig.6.2** indicates the overall dimensions involved in the design of the Mechanical coupling.

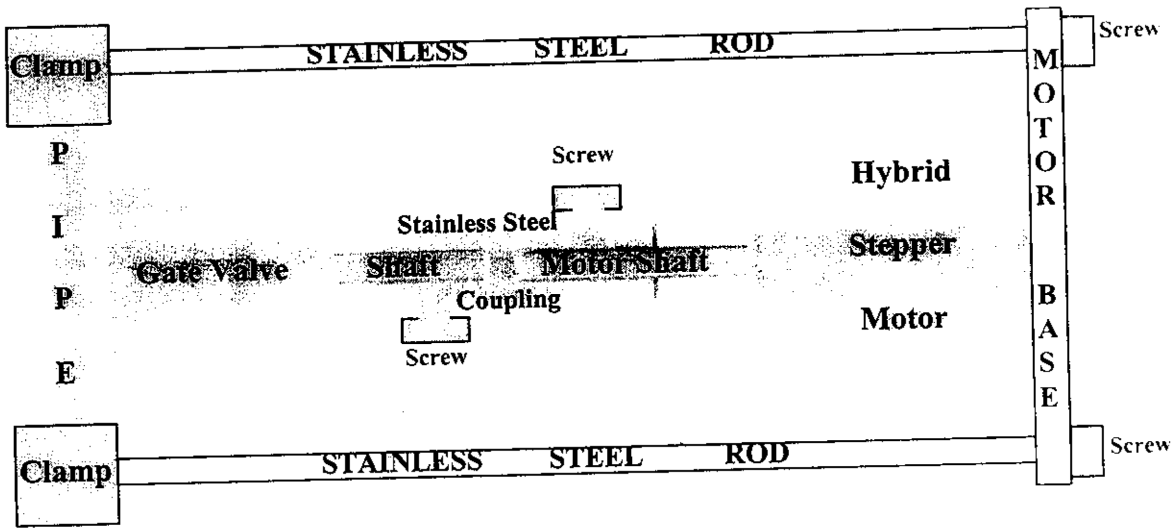



Fig. 6.1 *Stainless Steel Coupling*

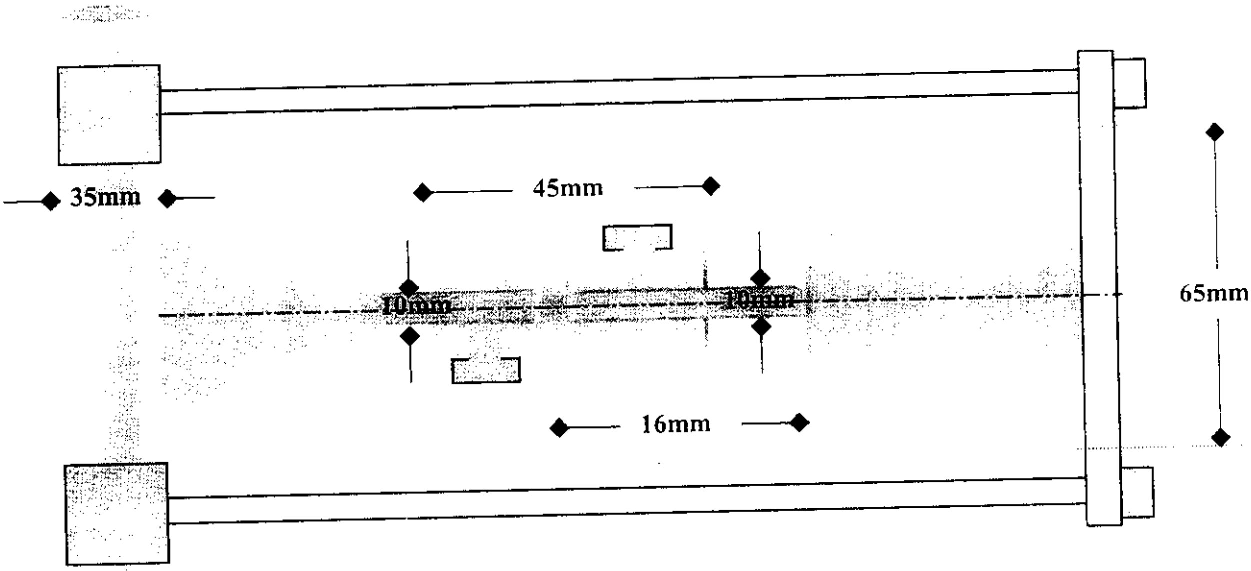



Fig. 6.2 *Overall Dimensions of the system*

CHAPTER 7

# JET PUMP TESTING

## 7.1 *Introduction*

Best Engineers is the prime manufacturer of Crompton Greaves Pumps. There is a separate section for the manufacture and testing of the pumps. The operation requires two personnel, the operator and the worker. Daily tests are performed at a specified time slot so as to keep the production rate uniform.

## 7.2 *Components of the testing unit*

The entire unit basically consists of:

- an operator desk
- a work platform
- an underground tank
- pipes to carry the pumped water
- Pressure gauges
- Gate Valve

The Operator's consists of a control panel unit which is used for monitoring purposes. The voltage, current, power, frequency and speed of the jet pumps are indicated in their respective digital meters.

The work platform is a plain base of metal over which the pump to be tested is placed. The pipes are connected and the motor is set ready for the testing operation. The placing of the motor and the connections are all taken care of by the worker.

There is a huge underground tank at the bottom of this entire unit for the purpose of storing the water necessary for testing and also for taking up the re-circulated or drained water.

The pipes connecting the tank and the pump are that of the suction and delivery. The suction and delivery pipes are fitted with pressure gauges to monitor the suction and delivery pressures.

The pressure of the water can be controlled using the gate valve connected to the delivery pipe.

The photograph of this entire testing system is shown in **Appendix.**

## 7.3 *Testing Process*

After the pump is setup for testing. The power supply is turned ON after ensuring that the gate valve is in completely closed position. The autotransformer is varied and the voltage is brought to 135V and the appropriate readings are tabulated and verified. The reason for performing such a test is to ensure the performance of the pump even during events of low voltages in rural areas. The autotransformer is now varied and the voltage is brought to 220V and the testing is performed. The readings for fully closed position of the gate valve is verified. The gate valve is rotated from close to open position and for the specified suction and delivery pressures, the readings of ammeter, frequency, voltmeter, RPM and power are noted. The test for each step is verified first by means of the difference between the suction and delivery pressure readings. The difference is to be maintained at within a range of 23- 25 metres. The readings obtained are all tabulated and then are compared with the standard readings that have been specified ( specified by Crompton Greaves ). If the test is successful then the pump is further sent for sealing and packaging else it is sent back to the production unit for rectification.

A sample set of values have been displayed here in **Table 7.1**

The following **Table 7.1** shows the sample test readings of taken at a particular time period at Best Engineers Pumps Pvt. Ltd.

| Speed in (RPM) | Suction Head (Meters) | Delivery Head (Meters) | Time for rise(s | Voltage | Current | Watts | Frequency |
|---|---|---|---|---|---|---|---|
| 2370 | 24 | 40 | --- | 135 | 4.2 | 570 | 48.1 |
| 2789 | 36 | 60 | --- | 220 | 2.65 | 550 | 48.1 |
| 2778 | 25 | 48 | 7.2 | 220 | 2.65 | 550 | 48.0 |
| 2780 | 15 | 38 | 15.1 | 220 | 2.6 | 545 | 48.1 |
| 2777 | 11 | 34 | 21.1 | 220 | 2.6 | 540 | 48.0 |
| 2779 | 07 | 30 | 24.5 | 220 | 2.55 | 535 | 48.0 |
| 2782 | 0 | 24 | 27.6 | 220 | 2.55 | 530 | 48.0 |

**Table 7.1**

The pump performance values are specified in the **Appendix.**

CHAPTER 8

# COMPUTERIZED CONTROL OF GATE VALVE

## 8.1 *Introduction*

Considering the future aspects, computerization plays a very important role in a firm's production. Best Engineers Pumps Pvt. Ltd., is one such firm where modernization has begun to procure its peak. The firm aims at computerizing the entire testing section. This greatly reduces the need for excessive labour and maintenance. Hence costs can be brought down by a great deal. The Gate Valve control is required to be computerized when a single PC is dedicated for the operation. This project proposes the design for the control of the gate valve using a PC.

## 8.2 *Control of Stepper Motor via Parallel Port*

### 8.2.1 *Requirements*

For controlling the stepper motor via parallel port, the following equipments are required :

1. A computer with the required software coding.
2. A 12-volt power supply (preferably a battery eliminator)
3. Stepper motor

The circuit can be easily assembled on a breadboard. It is very important to work with the smallest stepper motor available in the market, such as the one used in a floppy drive. If you go in for the large ones used in CNC machines, there is a chance of damaging the PC's parallel port. The second thing to mention is that the colours of the wires of the stepper motor are non-standard.

### 8.2.2 *Details of the Parallel Port*

The parallel port is generally used to interface printers, but here it has been used to interface the stepper motor. The parallel port consists of 25 pins, which can only transmit 8 bits of data at a time. The reason for the large number of pins is that every data pin has its own ground return pin. There are other pins for various other functions. Here only four data pins and a ground pin are used.

The functions of the various pins are given in **Table 8.1**. Pins 2 through 9 are data pins. The data pins 2 to 5, corresponding to data bits D0 through D3 of port 378(hex) for LPT1 or 278(hex) for LPT2 are used. Also, pin 25 is used as the ground pin.

The PC's parallel port will not sink much current. At the most, it can handle a few milliamperes. So, if the parallel port is connected directly to an electrical device, it will damage the parallel port. Thus, a current amplifier in between the parallel port and the electrical device is being connected. The ULN2003, used precisely for this purpose, has an array of Darlington transistor pairs. A Darlington configuration is a way of connecting two transistors in order to amplify current to many times the input current value.

### 8.2.3 *Translator module*

A circuit which is responsible for converting step and direction signals into winding excitation patterns is called a *translator*. Most stepper motor control systems include a *driver* in addition to the translator, to handle the current drawn by the motor's windings.

A basic example of the "translator + driver" type of configuration is shown in **Fig.8.1** and **Fig.8.2**. Notice the separate voltages for logic and for the stepper motor. Usually the motor will require a different voltage than the logic portion of the system. Typically logic voltage is +5V dc and the stepper motor voltage can range from +5V dc up to about +48V dc. The driver is also an "open collector" driver, wherein it takes its outputs to GND to activate the motor's windings. Most semiconductor circuits are more capable of sinking(providing a GND or negative voltage) than sourcing (outputting a positive voltage).

### 8.2.4. *Response of the Stepper Motor*

The stepper motor has various advantages over other motors, as far as controlling by a computer is concerned. It includes high precision of angular movement, speed of rotation, and high moving and holding torque. The uni-polar permanent magnet stepper motor that has four coils. They are arranged as follows :

Terminals 1 and 2 are common terminals (connected to ground or the positive supply) and the other four terminals are fed to the appropriate signals. When a proper signal is applied, the shaft turns by a specific angle, called the step resolution of the motor. On continuous application of the same signal, the shaft stays in the same position. Rotation occurs only when the signal is changed in a proper sequence. There are three modes of operation of a stepper motor, namely, single-coil excitation mode, dual-coil excitation mode, and half-step modes.

- **Single-coil excitation**. Each coil is energised successively in a rotary fashion. If the four coils are assumed to be in a horizontal plane, the bit pattern will be 0001, 0010, 0100, 1000, and 0001.

- **Dual-coil excitation**. Here, two adjacent coils are energised successively in a rotary fashion. The bit pattern will be 0011, 0110, 1100, 1001, and 0011.
- **Half-step mode**. Here, the stepper motor operates at half the given step resolution. The bit pattern is 0001, 0011, 0010, 0110, 0100, 1100, 1000, 1001, and 0001.

The method used for correct identification of the stepper motor coils involved is by measuring the winding resistance as well as their continuity in ohms x 1 scale, using any good multimeter. The resistance of individual coils with respect to the middle points will roughly be half the resistance of the combined coil pairs (L1 and L2 or L3 and L4 in the figure). After having identified the coils in this fashion, they are connected as per the circuit diagram shown in the **Fig.8.3**

If the sequence of input to the coils happens to be wrong, the shaft, instead of moving (clockwise or anti-clockwise), will only vibrate. This can be corrected by trial and error, by interchanging connection to the coils. The output waveforms for full-step single-coil mode, as seen on the oscilloscope, are shown in the **Fig.8.4**

### 8.2.5 *Software Program*

A software control program written in DOS is included below. The program for DOS can be used to run the motor in full- or half-step mode, or in single-coil or double-coil excitation mode.

```
#define FULLSTEP_SINGLECOIL
#define FULLSTEP_DOUBLECOIL
#define HALFSTEP unsigned char
  fullstep_singlecoil_val[]={1,2,4,8};
  unsigned char fullstep_doublecoil_val[]={3,6,12, 9};
  unsigned char halfstep_val[]={8,12,4,6,2,3,9};
```

```
void main()
        {
         unsigned int i=0;
              while(!kbhit())
              {
                #ifdef    FULLSTEP SINGLECOIL
outportb(0x378,fullstep_singlecoil_val[i%sizeof
                 (fullstep_singlecoil_val)]);
               #elif
                defined(FULLSTEP_DOUBLECOIL)
outportb(0x378,fullstep_doublecoil_val[i%ssizeof
(fullstep_doublecoil_val)]);
               #elif
defined(HALFSTEP) outportb(0x378,halfstep_val[i%sizeof(halfstep_val)]);
               #endif
                delay(10); i++; I
               f(i==65535u) i=0;
                }
                 outportb(0x378,0);
              }
```

This program can be run on any DOS compiler such as Turbo C.

| n No (D-type 25) | Signal | Direction (In/Out | Register | Hardware Inverted |
|---|---|---|---|---|
| 1 | Strobet | In/Out | Control | Yes |
| 2 thru 9 | D0 thru | Out | Data | — |
| 11 | Busy | In | Status | Yes |
| 12 | PE | In | Status | — |
| 13 | Select | In | Status | — |
| 14 | AFeed | Out | Control | Yes |
| 15 | Error | In | Status | — |
| 16 | Initialise | Control | Out | — |
| 17 | SLCT | Out | Control | Yes (Printer) |

Table 8.1 *Functions of the Pins of a Parallel Port*

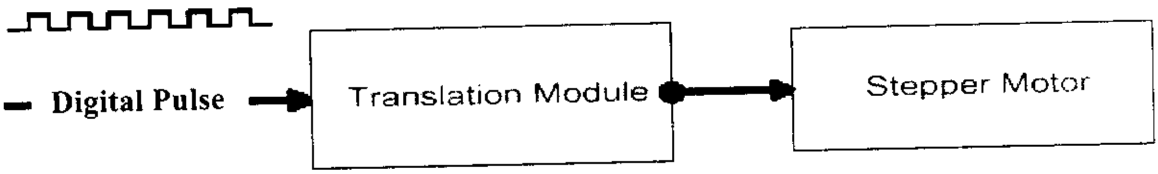



Fig 8.1 *A typical driver and translator connection*

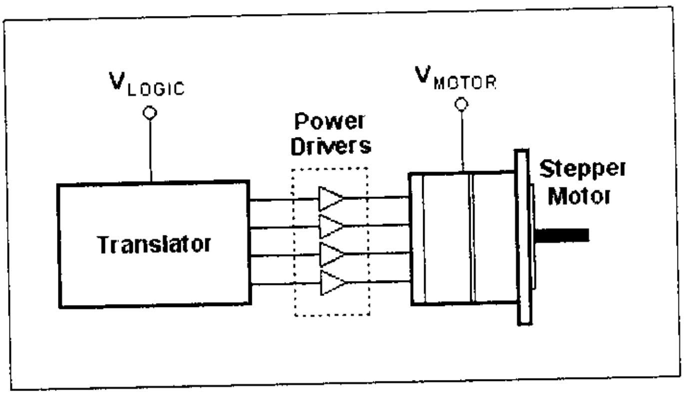



Fig 8.2 *Driver - Translator Connection*

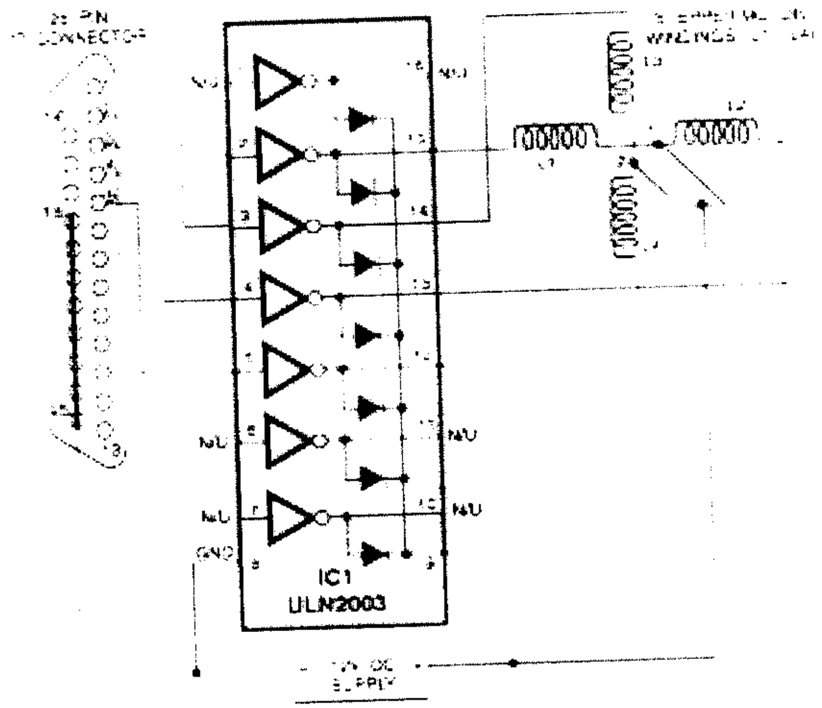



Fig. 8.3 *Circuit for Computerized control of Stepper motor.*

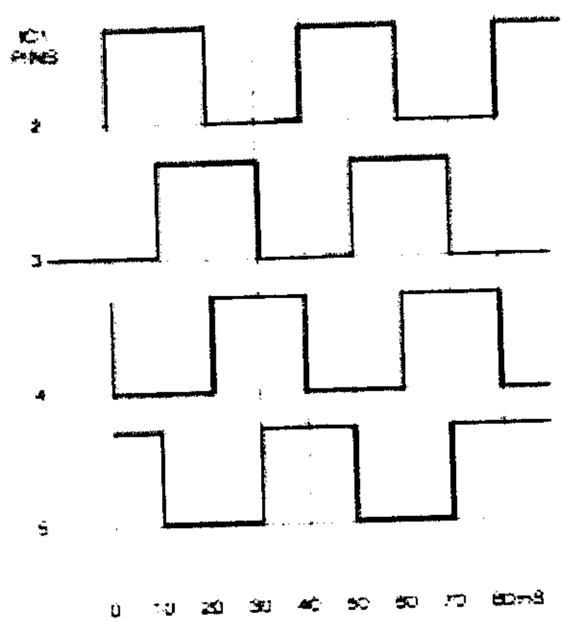



Fig. 8.4 *Output Waveforms for full-step single coil mode*

# CHAPTER 9

## CONCLUSION

An "Automatic Gate Valve Control System for Pressure testing of Jet Pumps" has been designed, fabricated and tested successfully using a micro controller. The pressure readings for testing can now be accurately controlled.

The developed system offers the following advantages:

- Accurate control over Pressure readings for testing
- Great reduction in testing time
- Maintenance Free
- Integration of the testing Unit.

The project will be of much use for various testing sections and of greater use when it comes to computerizing the testing section. The same setup, with alterations in the software program, can be made use of in future when the firm is computerized.

# REFERENCES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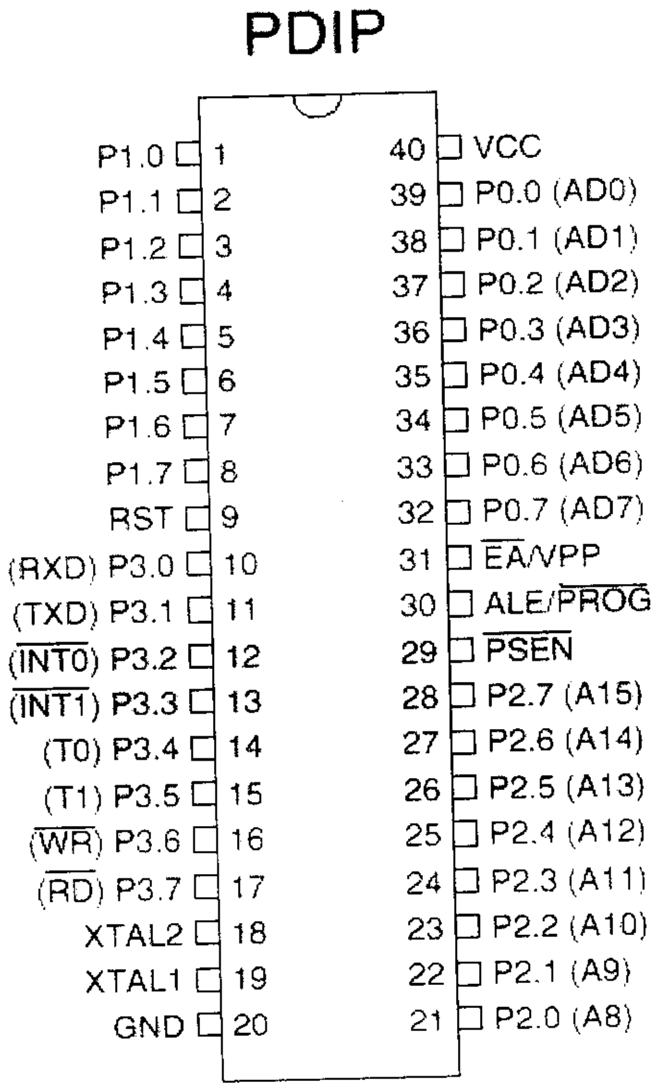
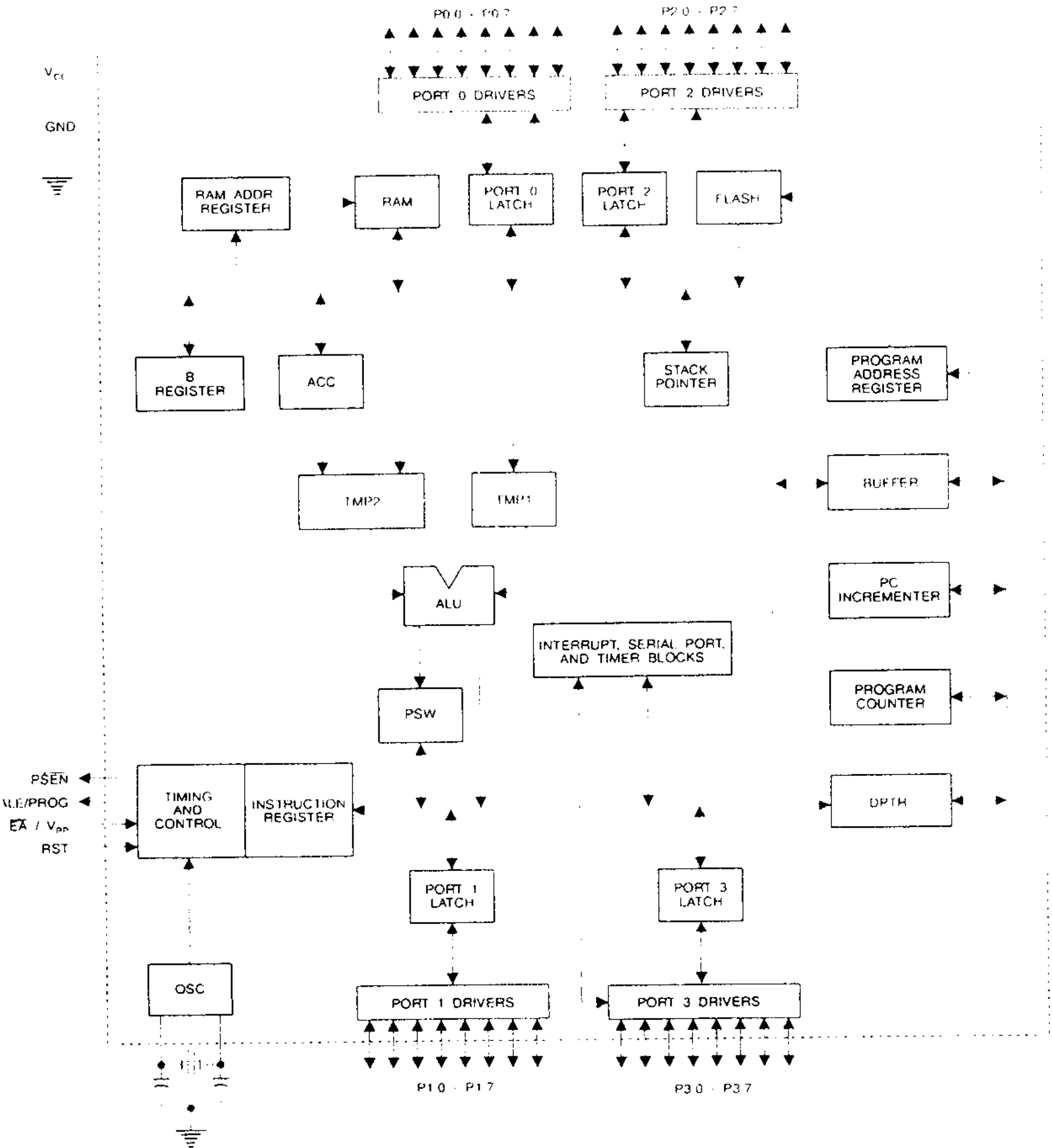



**Fig.A.1** *Pin Configuration of ATMEL 89C51*

## Block Diagram – AT89C51



## Absolute Maximum Ratings*

| | |
|---|---|
| Operating Temperature | -55°C to +125°C |
| Storage Temperature | -65°C to +150°C |
| Voltage on Any Pin with Respect to Ground | -1.0V to +7.0V |
| Maximum Operating Voltage | 6.6V |
| DC Output Current | 15.0 mA |

*NOTICE: Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

## DC Characteristics

$T_A$ = -40°C to 85°C, $V_{CC}$ = 5.0V ± 20% (unless otherwise noted)

| Symbol | Parameter | Condition | Min | Max | Units |
|---|---|---|---|---|---|
| $V_{IL}$ | Input Low-voltage | (Except $\overline{EA}$) | -0.5 | 0.2 $V_{CC}$ - 0.1 | V |
| $V_{IL1}$ | Input Low-voltage ($\overline{EA}$) | | -0.5 | 0.2 $V_{CC}$ - 0.3 | V |
| $V_{IH}$ | Input High-voltage | (Except XTAL1, RST) | 0.2 $V_{CC}$ + 0.9 | $V_{CC}$ + 0.5 | V |
| $V_{IH1}$ | Input High-voltage | (XTAL1, RST) | 0.7 $V_{CC}$ | $V_{CC}$ + 0.5 | V |
| $V_{OL}$ | Output Low-voltage[1] (Ports 1,2,3) | $I_{OL}$ = 1.6 mA | | 0.45 | V |
| $V_{OL1}$ | Output Low-voltage[1] (Port 0, ALE, $\overline{PSEN}$) | $I_{OL}$ = 3.2 mA | | 0.45 | V |
| $V_{OH}$ | Output High-voltage (Ports 1,2,3, ALE, $\overline{PSEN}$) | $I_{OH}$ = -60 µA, $V_{CC}$ = 5V ± 10% | 2.4 | | V |
| | | $I_{OH}$ = -25 µA | 0.75 $V_{CC}$ | | V |
| | | $I_{OH}$ = -10 µA | 0.9 $V_{CC}$ | | V |
| $V_{OH1}$ | Output High-voltage (Port 0 in External Bus Mode) | $I_{OH}$ = -800 µA, $V_{CC}$ = 5V ± 10% | 2.4 | | V |
| | | $I_{OH}$ = -300 µA | 0.75 $V_{CC}$ | | V |
| | | $I_{OH}$ = -80 µA | 0.9 $V_{CC}$ | | V |
| $I_{IL}$ | Logical 0 Input Current (Ports 1,2,3) | $V_{IN}$ = 0.45V | | -50 | µA |
| $I_{TL}$ | Logical 1 to 0 Transition Current (Ports 1,2,3) | $V_{IN}$ = 2V, VCC = 5V ± 10% | | -650 | µA |
| $I_{LI}$ | Input Leakage Current (Port 0, $\overline{EA}$) | 0.45 < $V_{IN}$ < $V_{CC}$ | | ±10 | µA |
| RRST | Reset Pull-down Resistor | | 50 | 300 | KΩ |
| $C_{IO}$ | Pin Capacitance | Test Freq. = 1 MHz, $T_A$ = 25°C | | 10 | pF |
| $I_{CC}$ | Power Supply Current | Active Mode, 12 MHz | | 20 | mA |
| | | Idle Mode, 12 MHz | | 5 | mA |
| | Power-down Mode[2] | $V_{CC}$ = 6V | | 100 | µA |
| | | $V_{CC}$ = 3V | | 40 | µA |

Notes: 1. Under steady state (non-transient) conditions, $I_{OL}$ must be externally limited as follows:
Maximum $I_{OL}$ per port pin: 10 mA
Maximum $I_{OL}$ per 8-bit port: Port 0: 26 mA
Ports 1, 2, 3: 15 mA
Maximum total $I_{OL}$ for all output pins: 71 mA
If $I_{OL}$ exceeds the test condition, $V_{OL}$ may exceed the related specification. Pins are not guaranteed to sink current greater than the listed test conditions.
2. Minimum $V_{CC}$ for Power-down is 2V.

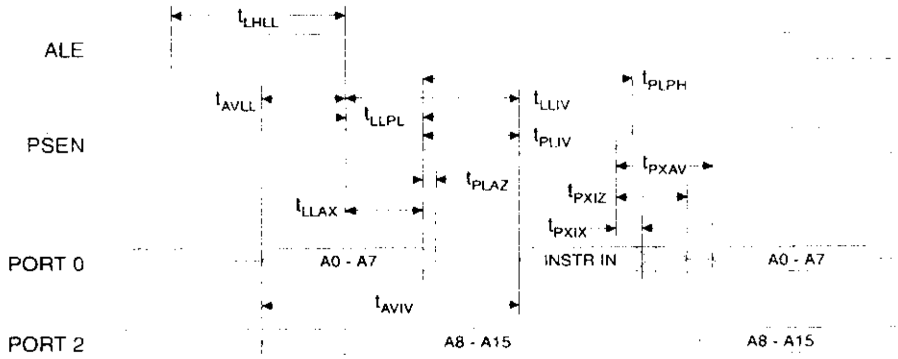
## AC Characteristics

Under operating conditions, load capacitance for Port 0, ALE/$\overline{PROG}$, and $\overline{PSEN}$ = 100 pF; load capacitance for all other outputs = 80 pF.

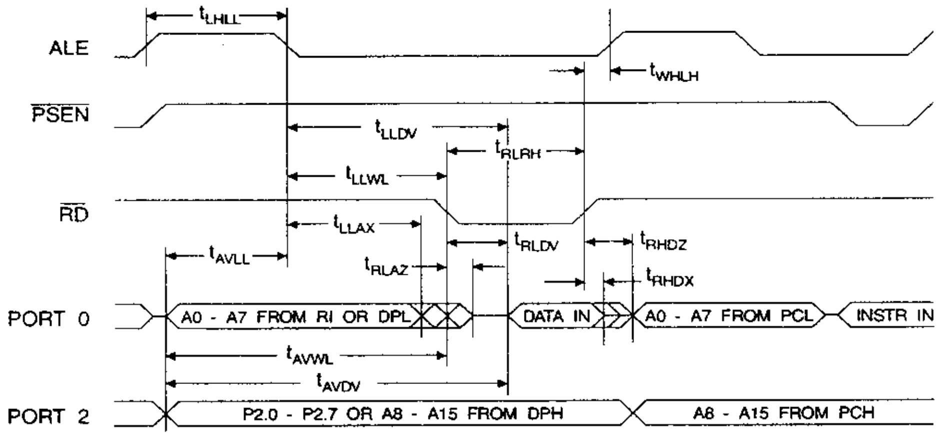
## External Program and Data Memory Characteristics

| Symbol | Parameter | 12 MHz Oscillator | | 16 to 24 MHz Oscillator | | Units |
|---|---|---|---|---|---|---|
| | | Min | Max | Min | Max | |
| $1/t_{CLCL}$ | Oscillator Frequency | | | 0 | 24 | MHz |
| $t_{LHLL}$ | ALE Pulse Width | 127 | | $2t_{CLCL}-40$ | | ns |
| $t_{AVLL}$ | Address Valid to ALE Low | 43 | | $t_{CLCL}-13$ | | ns |
| $t_{LLAX}$ | Address Hold After ALE Low | 48 | | $t_{CLCL}-20$ | | ns |
| $t_{LLIV}$ | ALE Low to Valid Instruction In | | 233 | | $4t_{CLCL}-65$ | ns |
| $t_{LLPL}$ | ALE Low to $\overline{PSEN}$ Low | 43 | | $t_{CLCL}-13$ | | ns |
| $t_{PLPH}$ | $\overline{PSEN}$ Pulse Width | 205 | | $3t_{CLCL}-20$ | | ns |
| $t_{PLIV}$ | $\overline{PSEN}$ Low to Valid Instruction In | | 145 | | $3t_{CLCL}-45$ | ns |
| $t_{PXIX}$ | Input Instruction Hold After $\overline{PSEN}$ | 0 | | 0 | | ns |
| $t_{PXIZ}$ | Input Instruction Float After $\overline{PSEN}$ | | 59 | | $t_{CLCL}-10$ | ns |
| $t_{PXAV}$ | $\overline{PSEN}$ to Address Valid | 75 | | $t_{CLCL}-8$ | | ns |
| $t_{AVIV}$ | Address to Valid Instruction In | | 312 | | $5t_{CLCL}-55$ | ns |
| $t_{PLAZ}$ | $\overline{PSEN}$ Low to Address Float | | 10 | | 10 | ns |
| $t_{RLRH}$ | $\overline{RD}$ Pulse Width | 400 | | $6t_{CLCL}-100$ | | ns |
| $t_{WLWH}$ | $\overline{WR}$ Pulse Width | 400 | | $6t_{CLCL}-100$ | | ns |
| $t_{RLDV}$ | $\overline{RD}$ Low to Valid Data In | | 252 | | $5t_{CLCL}-90$ | ns |
| $t_{RHDX}$ | Data Hold After $\overline{RD}$ | 0 | | 0 | | ns |
| $t_{RHDZ}$ | Data Float After $\overline{RD}$ | | 97 | | $2t_{CLCL}-28$ | ns |
| $t_{LLDV}$ | ALE Low to Valid Data In | | 517 | | $8t_{CLCL}-150$ | ns |
| $t_{AVDV}$ | Address to Valid Data In | | 585 | | $9t_{CLCL}-165$ | ns |
| $t_{LLWL}$ | ALE Low to $\overline{RD}$ or $\overline{WR}$ Low | 200 | 300 | $3t_{CLCL}-50$ | $3t_{CLCL}+50$ | ns |
| $t_{AVWL}$ | Address to $\overline{RD}$ or $\overline{WR}$ Low | 203 | | $4t_{CLCL}-75$ | | ns |
| $t_{QVWX}$ | Data Valid to $\overline{WR}$ Transition | 23 | | $t_{CLCL}-20$ | | ns |
| $t_{QVWH}$ | Data Valid to $\overline{WR}$ High | 433 | | $7t_{CLCL}-120$ | | ns |
| $t_{WHQX}$ | Data Hold After $\overline{WR}$ | 33 | | $t_{CLCL}-20$ | | ns |
| $t_{RLAZ}$ | $\overline{RD}$ Low to Address Float | | 0 | | 0 | ns |
| $t_{WHLH}$ | $\overline{RD}$ or $\overline{WR}$ High to ALE High | 43 | 123 | $t_{CLCL}-20$ | $t_{CLCL}+25$ | ns |

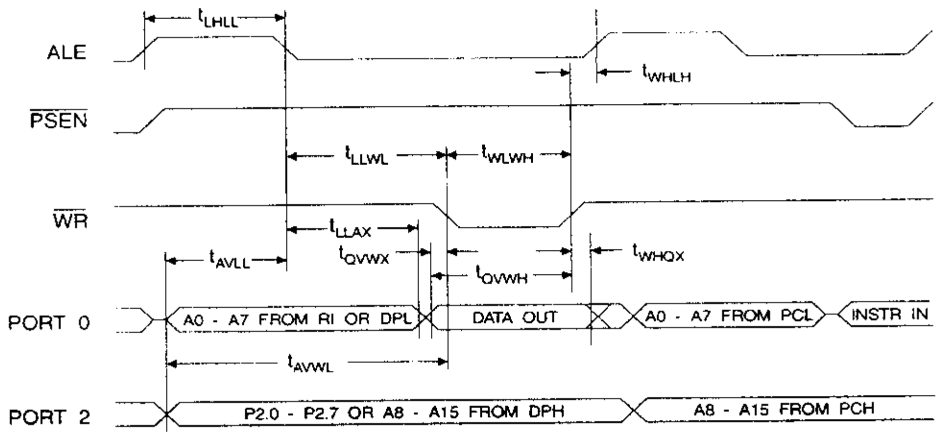
## External Program Memory Read Cycle



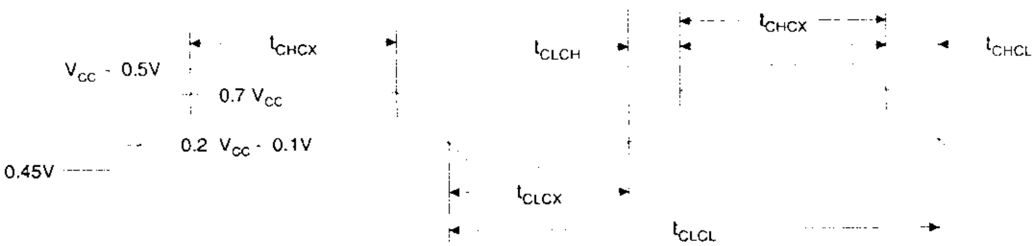

## External Data Memory Read Cycle



## External Data Memory Write Cycle




## External Clock Drive Waveforms




## External Clock Drive

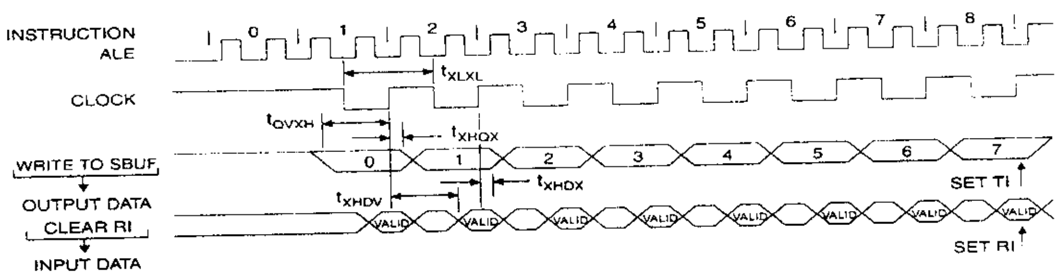
| Symbol | Parameter | Min | Max | Units |
|---|---|---|---|---|
| $1/t_{CLCL}$ | Oscillator Frequency | 0 | 24 | MHz |
| $t_{CLCL}$ | Clock Period | 41.6 | | ns |
| $t_{CHCX}$ | High Time | 15 | | ns |
| $t_{CLCX}$ | Low Time | 15 | | ns |
| $t_{CLCH}$ | Rise Time | | 20 | ns |
| $t_{CHCL}$ | Fall Time | | 20 | ns |

# Serial Port Timing: Shift Register Mode Test Conditions

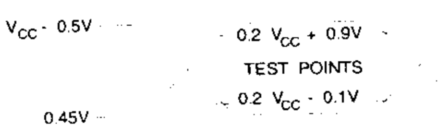
($V_{CC}$ = 5.0 V ± 20%; Load Capacitance = 80 pF)

| Symbol | Parameter | 12 MHz Osc Min | 12 MHz Osc Max | Variable Oscillator Min | Variable Oscillator Max | Units |
|---|---|---|---|---|---|---|
| $t_{XLXL}$ | Serial Port Clock Cycle Time | 1.0 | | $12t_{CLCL}$ | | µs |
| $t_{QVXH}$ | Output Data Setup to Clock Rising Edge | 700 | | $10t_{CLCL}$-133 | | ns |
| $t_{XHQX}$ | Output Data Hold After Clock Rising Edge | 50 | | $2t_{CLCL}$-117 | | ns |
| $t_{XHDX}$ | Input Data Hold After Clock Rising Edge | 0 | | 0 | | ns |
| $t_{XHDV}$ | Clock Rising Edge to Input Data Valid | | 700 | | $10t_{CLCL}$-133 | ns |

## Shift Register Mode Timing Waveforms




## AC Testing Input/Output Waveforms(1)




Note: 1. AC Inputs during testing are driven at $V_{CC}$ - 0.5V for a logic 1 and 0.45V for a logic 0. Timing measurements are made at $V_{IH}$ min. for a logic 1 and $V_{IL}$ max. for a logic 0.

## Float Waveforms(1)


Note: 1. For timing purposes, a port pin is no longer floating when a 100 mV change from load voltage occurs. A port pin begins to float when 100 mV change from the loaded $V_{OH}/V_{OL}$ level occurs.

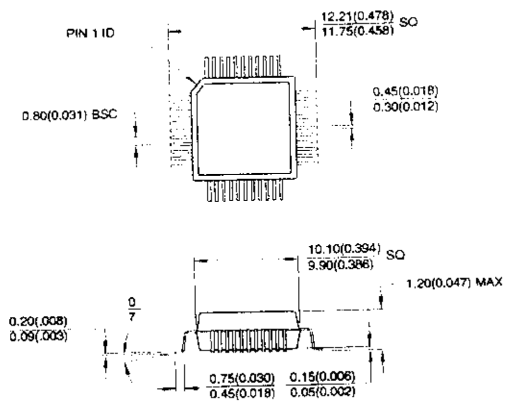
## Ordering Information

| Speed (MHz) | Power Supply | Ordering Code | Package | Operation Range |
|---|---|---|---|---|
| 12 | 5V ± 20% | AT89C51-12AC | 44A | Commercial (0°C to 70°C) |
| | | AT89C51-12JC | 44J | |
| | | AT89C51-12PC | 40P6 | |
| | | AT89C51-12QC | 44Q | |
| | | AT89C51-12AI | 44A | Industrial (-40°C to 85°C) |
| | | AT89C51-12JI | 44J | |
| | | AT89C51-12PI | 40P6 | |
| | | AT89C51-12QI | 44Q | |
| 16 | 5V ± 20% | AT89C51-16AC | 44A | Commercial (0°C to 70°C) |
| | | AT89C51-16JC | 44J | |
| | | AT89C51-16PC | 40P6 | |
| | | AT89C51-16QC | 44Q | |
| | | AT89C51-16AI | 44A | Industrial (-40°C to 85°C) |
| | | AT89C51-16JI | 44J | |
| | | AT89C51-16PI | 40P6 | |
| | | AT89C51-16QI | 44Q | |
| 20 | 5V ± 20% | AT89C51-20AC | 44A | Commercial (0°C to 70°C) |
| | | AT89C51-20JC | 44J | |
| | | AT89C51-20PC | 40P6 | |
| | | AT89C51-20QC | 44Q | |
| | | AT89C51-20AI | 44A | Industrial (-40°C to 85°C) |
| | | AT89C51-20JI | 44J | |
| | | AT89C51-20PI | 40P6 | |
| | | AT89C51-20QI | 44Q | |
| 24 | 5V ± 20% | AT89C51-24AC | 44A | Commercial (0°C to 70°C) |
| | | AT89C51-24JC | 44J | |
| | | AT89C51-24PC | 40P6 | |
| | | AT89C51-24QC | 44Q | |
| | | AT89C51-24AI | 44A | Industrial (-40°C to 85°C) |
| | | AT89C51-24JI | 44J | |
| | | AT89C51-24PI | 40P6 | |
| | | AT89C51-24QI | 44Q | |

| Package Type | |
|---|---|
| 44A | 44-lead, Thin Plastic Gull Wing Quad Flatpack (TQFP) |
| 44J | 44-lead, Plastic J-leaded Chip Carrier (PLCC) |
| 40P6 | 40-lead, 0.600" Wide, Plastic Dual Inline Package (PDIP) |
| 44Q | 44-lead, Plastic Gull Wing Quad Flatpack (PQFP) |

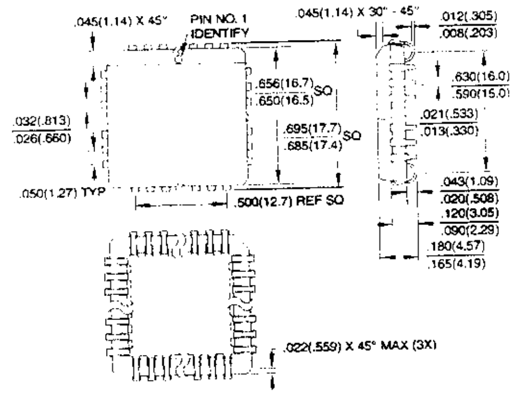
# Packaging Information

**44A,** 44-lead, Thin (1.0 mm) Plastic Gull Wing Quad Flatpack (TQFP)
Dimensions in Millimeters and (Inches)*
JEDEC STANDARD MS-026 ACB

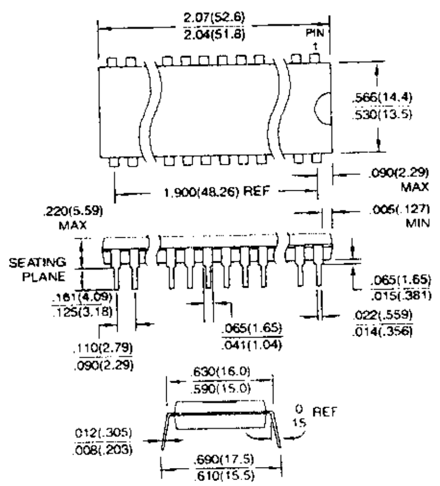



Controlling dimension: millimeters

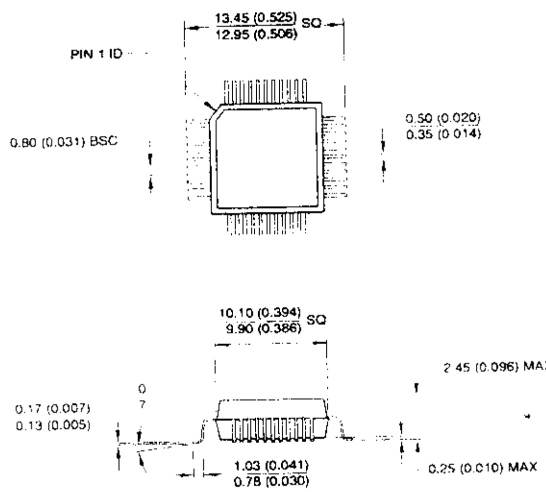
**44J,** 44-lead, Plastic J-leaded Chip Carrier (PLCC)
Dimensions in Inches and (Millimeters)
JEDEC STANDARD MS-018 AC




**40P6,** 40-lead, 0.600" Wide, Plastic Dual Inline Package (PDIP)
Dimensions in Inches and (Millimeters)




**44Q,** 44-lead, Plastic Quad Flat Package (PQFP)
Dimensions in Millimeters and (Inches)*
JEDEC STANDARD MS-022 AB




Controlling dimension: millimeters

**Table 2: Pin Connection and Description for Parallel interface to IBM PC (Hall, 1991)**

| Pin # | Signal | Description | Signal Direction |
|---|---|---|---|
| 1 | STROBE | STROBE pulse to read data in | IN/OUT |
| 2 | DATA 1 | These signals represent information of the 1st to 8th bits of parallel data respectively. Each signal is at 'high' level when data is logical '1' and 'low' when logical '0'. | IN/OUT |
| 3 | DATA 2 | | IN/OUT |
| 4 | DATA 3 | | IN/OUT |
| 5 | DATA 4 | | IN/OUT |
| 6 | DATA 5 | | IN/OUT |
| 7 | DATA 6 | | IN/OUT |
| 8 | DATA 7 | | IN/OUT |
| 9 | DATA 8 | | IN/OUT |
| 10 | ACKNLG | A 'low' indicates that data has been received & printer is ready to accept other data. | OUT |
| 11 | BUSY | A 'high'signal indicates that the printer cannot receive data. | OUT |
| 12 | PE | A 'high' signal indicates that the printer is out of paper. | OUT |
| 13 | SLCT | This signal indicates that the printer is in the selected state. | OUT |
| 14 | AUTO FEED XT | This signal being at 'low' level, the paper is automatically fed one line after printing. | IN |
| 15 | NC | Not used | - |
| 16 | OV | Logic GND level | - |
| 17 | CHASIS GND | Printer chassis GND | - |
| 18 | NC | Not used | - |
| 19 | GND | Ground | - |
| 20 | GND | | - |
| 21 | GND | | - |
| 22 | GND | | - |
| 23 | GND | | - |
| 24 | GND | | - |
| 25 | GND | | - |

The sequence of these two statements activate the flip-flop gate to flip. This causes the motor to move one step.

Similarly, the sequence of following two statements move the motor in reverse direction (counterclockwise) one step. The first statement reverses the direction of the rotation. The second statement activates the flip-flop circuit and sends a signal to the stepper motor.

```
outp(0x378, 255); // binary representation of 255 = 11111111
outp(0x378, 0);   // binary representation of 0 = 00000000
```

## 2.2 Translation Module

The translation module generates pulse signals as and when it receives the control data from the computer. The pulse in (from high to low state) activates the circuit and sends signals to two sets of windings on the stepper motor. The first set of signals changes the 1st winding polarity and the 2nd set of signals changes the 2nd winding polarity, causing the motor to rotate one step (1.8°). When the circuit is powered, it supplies the power to the windings even if it is not turning. The translation module circuit diagram is shown in Figure 2.

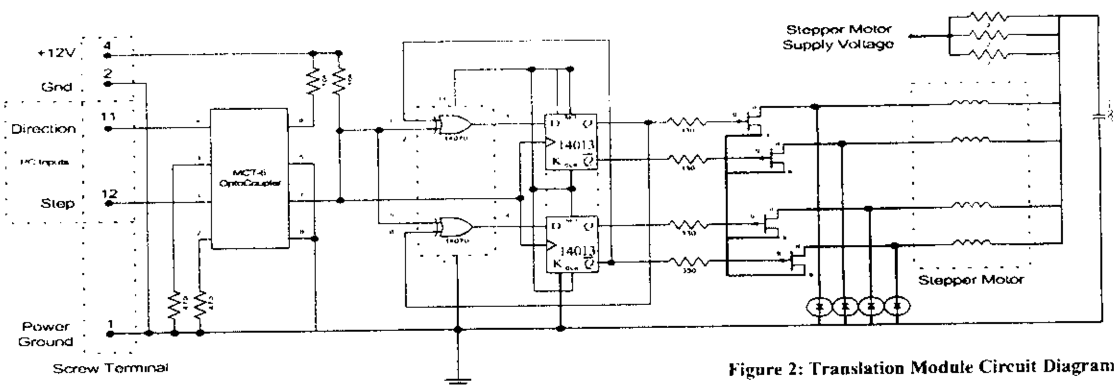



**Figure 2: Translation Module Circuit Diagram**

# PUMP PERFORMANCE VALUES

*Declared Values*

| | | |
|---|---|---|
| Type | : | JTM1 |
| HP/KW | : | 1/0.75 |
| Rated speed | : | 2820 rpm |
| Pipe size | : | 1/4" (inches) |
| Casing size | : | 5.5" (inches) |
| Impeller size | : | 138 mm |
| Tube/nozzle dia | : | 9/6.5 mm |
| Orifice | : | 25 m |
| Delivery Pressure | : | 19.64/14.74 mm |
| DLWL range | : | 15/36 m |
| DLWL | : | 20 m |
| T.Head | : | 36 m |
| Discharge | : | 21 lpm |
| PI | : | 1.21 kw |
| DLWL min | : | 18.4 m |
| Tank Head min | : | 33.12 m |
| Discharge min | : | 19.32 lpm |
| PI max | : | 1.331 kw |
| IL max | : | 5.9 |
| Discharge Pipe Area | : | 17 x 31 cm |