CHAPTER 9

SOFTWARE DESCRIPTION

9.1. Microcontroller (AT89C51)

The AT89C51 is a low-power, high-performance CMOS 8-bit microcomputer with 4K bytes of flash **programmable** and erasable read only memory (PEROM). The device is manufactured using Atmel's high-density nonvolatile memory technology and is compatible with the industry-standard MCS-51 instruction set and pin out. The **on-chip** flash allows the program memory to be reprogrammed in-system or by a conventional non-volatile 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.

The AT89C51 provides the following standard features: 4k bytes of flash, 128 bytes of RAM, 32 I/O lines, two 16 bit timer/counters, and five vector two-level interrupt architecture, a full duplex serial port, on-chip oscillator and clock circuit. 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, the timer/counters, serial port and interrupt system to continue functioning. Pin diagram of P89C51 is shown in Figure 9.1. The Power-down Mode saves the RAM contents, but freezes the oscillator disabling all other chip functions until the next hardware reset.

It has four ports viz.

a. PORT 0 is an 8-bit open-drain bi-directional I/O port.

b. PORT 1 is an 8-bit bi-directional I/O port with internal pull-ups.

c. PORT 2 is an 8-bit bi-directional I/O port with internal pull-ups.

d. PORT 3 is an 8-bit bi-directional I/O port with internal pull-ups with additional functions.
9.2 Block diagram of Power supply unit

All electronic circuits work only in low DC voltage, so a power supply unit is needed to provide the appropriate voltage supply for their proper functioning. It is shown in Figure 9.2. This unit consists of transformer, rectifier, filter, and regulator. AC voltage of typically 230v rms is connected to a transformer voltage down to the level to the desired ac voltage. A diode rectifier provides the 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 variation. 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 when the dc voltage varies somewhat, or the load connected to the output dc voltage changes.
The first section is the transformer. The transformer steps down the input line voltage and isolates the power supply from the power line. The rectifier section converts the alternating current input signal to a pulsating direct current. But the pulsating dc is not desirable.

For this reason a filter section is used to convert pulsating dc to a purer, more desirable form of dc voltage. In the final section, the regulator does just what the name implies. It maintains the output of the power supply at a constant level in spite of large changes in load current or input line voltages section of the power supply.

9.3 Step-down transformer

A transformer is a static piece in which electric power in one circuit is transformed into electric power of same frequency in another circuit. It can raise or lower the voltage in the circuit, but with a corresponding decrease or increase in current. It works with the principle of mutual induction. In this project a step down transformer is used to provide the necessary supply for the electronic circuits. Voltage is step down from 230V ac into 12v ac. Transformers convert AC electricity from one voltage to another with little loss of power. Transformers work only with AC and this is one of the reasons why mains electricity is AC. Most power supplies use a step-down transformer to reduce the dangerously high mains voltage (230V in UK) to a safer low voltage. The input coil is called the primary and the output coil is called the secondary.
There is no electrical connection between the two coils; instead they are linked by an alternating magnetic field created in the soft-iron core of the transformer. The two lines in the middle of the circuit symbol represent the core. The ratio of the number of turns on each coil, called the turn’s ratio, determines the ratio of the voltages. A step-down transformer has a large number of turns on its primary (input) coil which is connected to the high voltage mains supply, and a small number of turns on its secondary (output) coil to give a low output voltage. It is shown in Figure 9.3.

9.4 Bridge rectifier

A dc level obtained from a sinusoidal input can be improved 100% using a process called full wave rectification. In this work for full wave rectification, bridge rectifier is used. From the basic bridge configuration it is seen that two diodes (say D2 and D3) are conducting while the other two diodes (D1 and D4) are in off state during the period t = 0 to T/2.
Accordingly for the negative cycle of the input, the conducting diodes are $D_1$ & $D_4$. Thus the polarity across the load is the same.

In the bridge rectifier the diodes of variable types like 1N4001, 1N4003, 1N4004, 1N4005, 1N4007 etc... can be used. But here we use 1N4007 is used because it can withstand up to 1000v.

A bridge rectifier can be made using four individual diodes, but it is also available in special packages containing the four diodes required. It is called a full-wave rectifier because it uses the entire AC wave (both positive and negative sections). 1.4V is used in the bridge rectifier because each diode uses 0.7V when conducting and there are always two diodes conducting, as shown in Figure 9.4. Bridge rectifiers are rated by the maximum current they can pass and the maximum reverse voltage they can withstand.
9.5 Capacitive filter

The smoothing is performed by a large value electrolytic capacitor connected across the DC supply to act as a reservoir, supplying current to the output when the varying DC voltage from the rectifier is falling. Figure 9.5 shows the unsmoothed varying DC (dotted line) and the smoothed DC (solid line). In order to obtain a dc voltage of 0 Hz, a low pass filter has to be used. So that a capacitive filter circuit is used 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, and it is ultimately fed to the load.

![Circuit diagram of capacitive filter](image)

**Output smooth DC**

*Figure 9.5 Circuit diagram of capacitive filter*

The capacitor charges quickly near the peak of the varying DC, and then discharges as it supplies current to the output. DC output has a small ripple. It is suitable for most electronic circuits.
9.6 Power supply unit

Voltage regulator ICs are available with fixed (typically 5, 12 and 15V) or variable output voltages. They are also rated by the maximum current they can pass. Negative voltage regulators are available, mainly for use in dual supplies. Most regulators include some automatic protection from excessive current ('overload protection') and overheating ('thermal protection'). Circuit diagram of power supply unit is shown in Figure 9.6.

9.7 Rectifier Unit

In the power supply unit, rectification is normally achieved using a solid state diode. Diode has the property that will let the electron flow easily in one direction at proper biasing condition. As AC is applied to the diode, electrons only flow when the anode and cathode are negative. Reversing the polarity of voltage will not permit electron flow.

A commonly used circuit for supplying large amounts of DC power is the bridge rectifier. A bridge rectifier of four diodes (4*IN4007) is used to achieve full wave rectification. Two diodes will conduct during the negative cycle, and the other
two will conduct during the positive half cycle. The DC voltage appearing across the output terminals of the bridge rectifier will be somewhat less than 90% of the applied rms value. Normally, one alteration of the input voltage will reverse the polarities. Opposite ends of the transformer will therefore always be 180 degrees out of phase with each other. For a positive cycle, two diodes are connected to the positive voltage at the top winding and only one diode conducts.

At the same time, one of the other two diodes conducts for the negative voltage that is applied from the bottom winding due to the forward bias for that diode. In this circuit due to positive half cycle, D1 and D2 will conduct to give 10.8V pulsating DC. The DC output has a ripple frequency of 100Hz. Since each altercation produces a resulting output pulse, frequency = 2*50 Hz. The output obtained is not a pure DC and therefore filtration has to be done.

9.3 Filtering Unit

Filter circuit which is usually capacitor acting as a surge arrester always follows the rectifier unit. This capacitor is also called as a decoupling capacitor or a bypassing capacitor, which is used not only to ‘short’ the ripple with frequency of 120Hz to ground but also to leave the frequency of the DC to appear at the output. A load resistor R1 is connected so that a reference to the ground is maintained. C1R1 is for bypassing ripples. C2R2 is used as a low pass filter, i.e. it passes only low frequency signals and bypasses high frequency signals. The load resistor should be 1% to 2.5% of the load.

1000ccf/25v : for the reduction of ripples from the pulsating.
10ocf/25v  : for maintaining the stability of the voltage at the load side.
0.1 ocf     : for by passing the high frequency disturbances.

9.9 Voltage Regulators

The voltage regulators play an important role in any power supply unit. The primary purpose of a regulator is to aid the rectifier and filter circuit in providing a constant DC voltage to the device. Power supplies without regulators have an inherent problem of changing DC voltage values due to variations in the load or due to fluctuations in the AC liner voltage. With a regulator connected to the DC output, the voltage can be maintained within a close tolerant region of the desired output. IC7812 and 7912 are used in this project for providing +12v and -12v DC supply.
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 variations and temperature changes. Here fixed voltage regulator namely LM7805 is used. The IC LM7805 is a +5v regulator which is used for microcontroller.

**Specifications:**
Resistors R1 and R2 maintain line load regulation.
At the secondary side of the transformer,
Applied voltage = 15v
Conducting drop across the diodes = 2*0.6
= 1.2v

Without capacitor:
\[ V_{avg} = (15 - 1.2) \text{ v} = 13.8 \text{c pulsating DC} \]
Frequency = 100Hz
With capacitor:
\[ V = V_{avg} \times 1.414 (\text{form factor}) \]
= 19.51v
Frequency = 0 Hz
With 7812 voltage regulator:
\[ V_0 = +12v \]
With 7912 voltage regulator:
\[ V_0 = -12v \]

**9.10 Liquid crystal display**

A general purpose alphanumeric LCD display is having two lines of 16 characters. A liquid crystal display (LCD) is a thin, flat display device made up of any number of color or monochrome pixels arrayed in front of a light source or reflector. It is shown in Figure 9.7. It is praised by engineers because it uses very small amounts of electric power, and is therefore suitable for use in battery-powered electronic devices.
Figure 9.7 liquid crystal Display

1. Vertical filter film to polarize the light as it enters.

2. Glass substrate with ITO electrodes. The shapes of these electrodes will determine the dark shapes that will appear when the LCD is turned on. Vertical ridges are etched on the surface so the liquid crystals are in line with the polarized light.

3. Twisted pneumatic liquid crystals.

4. Glass substrate with common electrode film (ITO) with horizontal ridges to line up with the horizontal filter.

5. Horizontal filter film to block/allow through light.

Figure 9.8 Liquid crystal

6. Reflective surface to send light back to viewer.

Each pixel picture element consists of a column of liquid crystal molecules suspended between two transparent electrodes and two polarizing filters, the axes of polarity of which are perpendicular to each other. Without the
liquid crystals between them, light passing through one would be blocked by the other. The liquid crystal twists the polarization of light entering one filter to allow it to pass through the other. The molecules of the liquid crystal have electric charges on them. By applying small electrical charges to transparent electrodes over each pixel or sub pixel, the molecules are twisted by electrostatic forces. This changes the twist of the light passing through the molecules and allows varying degrees of light to pass (or not to pass) through the polarizing filters.

9.11 Current Transformer

Current Transformer is a type of instrument transformer designed to provide a current in its secondary winding proportional to the alternating current flowing in its primary. They are commonly used in metering and protective relaying in the electrical power industry where they facilitate the safe measurement of large currents, often in the presence of high voltages. The current transformer safely isolates measurement and control circuitry from the high voltages typically present on the circuit being measured.

9.12 Level Shifter

A level shifter circuit, which amplifies the amplitude of an input signal, includes a CMOS inverter which is composed of a p-type transistor and an n-type transistor, a first and a second capacitor one electrode of each of which is connected to the gate of the p-type transistor and that of the n-type transistor respectively, a first switch which supplies the input signal to the other electrodes of the first and second capacitors, a second switch which applies a direct-current voltage whose amplitude is nearly half of the amplitude of the input signal to the other electrodes of the first and second capacitors, and a third and a fourth switch which apply a first and a second preset voltage to one electrode of each of the first and second capacitors respectively.

9.13 Features and Description of Regulators

- Output Current up to 1A
- Output Voltages of 5, 6, 8, 9, 10, 12, 15, 18, 24V
* Thermal Overload Protection

- Short Circuit Protection

- Output Transistor Safe Operating Area Protection

The KA78XX/KA78XXA series of three-terminal positive regulator are available in the T0-220/D-PAK package and with several fixed output voltages, making them useful in a wide range of applications. Each type employs internal current limiting, thermal shut down and safe operating area protection, making it essentially indestructible.

![Figure 9.9 Control regulator](image)

If adequate heat sinking is provided, they can deliver over 1A output current. Although designed primarily as fixed voltage regulators, these devices can be used with external components to obtain adjustable voltages and currents. It is shown in Figure 9.9.

### 9.14 Micro controller PIC 16F877A

The details of the Micro controller PIC 16F877A is shown in Figure 9.10. High performance RISC CPU

- Only 35 single word instructions to learn
- All single cycle instructions except for program branches which are two cycle
- Operating speed: DC - 20 MHz clock input DC - 200 ns instruction cycle
- Up to 8K x 14 words of FLASH Program Memory, up to 368 x 8 bytes of Data
Memory (RAM) Up to 256 x 8 bytes of EEPROM Data Memory

Figure 9.10 Micro controller PIC 16F877A

- Pin out compatible to the PIC 16C73B/74B/76/77
- Interrupt capability (up to 14 sources)
- Eight level deep hardware stack
- Direct, indirect and relative addressing modes
- Power-on Reset (POR)
- Power-up Timer (PWRT) and Oscillator Start-up Timer (OST)
- Watchdog Timer (WDT) with its own on-chip RC oscillator for reliable operation
- Programmable code protection
- Power saving SLEEP mode
- Selectable oscillator options
- Low power, high speed CMOS FLASH/EEPROM technology
- Fully static design
- In-Circuit Serial Programming (ICSP) via two pins
- Single 5V In-Circuit Serial Programming capability
- In-Circuit Debugging via two pins
- Processor read/write access to program memory
- Wide operating voltage range: 2.0V to 5.5V
- High Sink/Source Current: 25 mA
- Commercial, Industrial and Extended temperature ranges
- Low-power consumption

9.15 Advantages of Micro controller

If a system is developed with a microprocessor the designer has to go for external memory such as RAM, ROM or EPROM and peripherals, and hence the size of the PCB will be large enough to hold all the required peripheral. But the
microcontroller has got all three peripheral facilities on a single chip developed of a
similar system with a microcontroller reducing PCB size and cost of the design.

One of the major difference between a microcontroller and a microprocessor is
that a controller often deals with bits, not bytes as in the real world application, for
example switch contacts can only be open or close, indicators should be lit or dark
and motors can be either turned on or off and so forth.

The microcontroller has two 16 bits timer/counters built within it, which makes
it more suitable to this application since some accurate time delays need to be
produced.

This microcontroller has an 8 bit internal analog to digital converter with a 10 bit
resolution. This controller also has a higher erase cycle of 10,000 and for the
EPROM it is 1 lakh number of time.

I/O PORTS

Some pins for these 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. Additional information on I/O ports
may be found in the PIC micro™ Mid-Range Reference Manual, (DS33023).

9.16 PORTA and TRISA Registers

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 Timer 0 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).

PORTB and the TRISB Register

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. The **alternate functions** of these pins are described in the Special Features Section. Each of the PORTB pins has a weak internal pull-up. A single control bit can turn off 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. Four of the PORTB pins, RB7:RB4, have an interruption-change feature.

Only pins configured as inputs can cause this interrupt to occur (i.e., any RB7:RB4 pin configured as an output is excluded from the interruption-change comparison). The input pins (of RB7:RB4) are compared with the old value latched on the last read of PORTB. The “mismatch” outputs of RB7:RB4 are OR together to generate the RB Port Change Interrupt with flag bit RBIF (**INTCON0**).

**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 or with SM Bus levels by using the CKE bit (**SSPSTAT<6>**). When enabling peripheral functions, care should be taken in defining I **RIS** bits for each PORTC pin. Some peripherals override the TRIS bit to make a pin an output, while other peripherals override the TRIS bit to make a pin an input. Since the TRIS bit override is in effect while the peripheral is enabled, read-modify write instructions (BSF, BCF, and XORWF) with TRISC as destination, should be avoided. The user should refer to the corresponding peripheral section for the correct TRIS, bit settings.
9.17 PORTD and TRISD Registers

PORTD and TRISD are not implemented on the PIC16F873 or PIC16F876.

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.

9.17.1 Data EEPROM and Flash Program Memory

The Data EEPROM and Flash Program Memory are readable and writable 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 is containing data that form an invalid instruction, result in the execution of a NOP instruction. The EEPROM Data memories are rated for high erase/write cycles (specification D120). The Flash program memory is rated much lower (specification D130), because EEPROM data memory can be used to store frequently updated values. An on-chip timer controls the write time, it will vary with voltage and temperature, as well as from chip to chip. Refer to the specifications for exact limits (specifications D122 and D133). 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 and interrupt events will be detected and essentially “queued” until the write is complete. When the write completes, the next instruction in the pipeline is executed and the branch to the interrupt vector will take place, if the interrupt is enabled and occurred during the write. Read and write access to both memories take place indirectly through a set of Special Function Registers (SFR). The six Special Function Registers used are:

- EEDATA
The Timer 0 module timer/counter has the following features:

- 8-bit timer/counter
- Readable and writable
- 8-bit software programmable pre scalar
- Internal or external clock select
- **Interrupt** on overflow from FFh to OOh
- Edge select for external clock

In the block diagram of the Timer 0 module and the pre-scalar shared with the WDT, additional information on the Timer 0 module is available in the PIC micro™ Mid-Range MCU Family Reference Manual (DS33023). Timer mode is selected by clearing bit TOCS (OPTION RFO* 5 -). In Timer mode, the Timer 0 module will increment every instruction cycle (without pre scalar). If the TMRO register is written, the increment is inhibited for the following two instruction cycles. The user can work around this by writing an adjusted value to the TMRO register.

9.17.3 Timer 1 Module

The Timer 1 module is a 16-bit timer/counter consisting of two 8-bit registers (TMR1H and TMR1L), which are readable and writable. The TMR1 Register pair (TMR1H.TMR1L) increments from OOOOh to Fifth and rolls over to OOGOh. The TMR1 Interrupt, if enabled, is generated on overflow, which is latched in interrupt flag bit TMR1IF (PIR1<0>). This interrupt can be enabled/disabled by setting/clearing TMR1 interrupt enable bit TMR1IE (PIE1<0>). Timer1 can operate in one of two modes:

- As a timer
- As a counter

The operating mode is determined by the clock select bit, TMR1CS (T1CQN<1>).

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9.17.4 Timer 2 Module

Timer2 is an 8-bit timer with a pre-scalar and a post-scalar. It can be used as the PWM time-base for the PWM mode of the CCP module(s). The TMR2 register is readable and writable and is cleared on any device RESET. The input clock (FOSC/4) has a pre-scale option of 1:1, 1:4, or 1:16 selected by control bits.

\[ \text{T2CKPS1 : T2CKPS0 (T2CC>N<1:0>)} \]

The Timer2 module has an 8-bit period register, PR2. Time \( r2 \) increments from \( 00h \) until it match PR2 and then resets to \( 00h \) on the next increment cycle. PR2 is a readable and writable register. The PR2 register is initialized to Fifth upon RESET. The match output of TMR2 goes through a 4-bit post scalar (which gives a 1:1 to 1:16 scaling inclusive) to generate a TMR2 interrupt (latched in flag bit TMR2IF, \( (\text{PIR1}<1>) \)). Timer2 can be shut-off by clearing control bit TMR20N (T2CON<2>) to minimize power consumption.

9.18 Software Description

In this work an 8-bit microcontroller is used. It requires opcodes to do any operations. The opcodes contain the command given by the user. This is called hex file. The ‘hex file’ may be generated by using the assembly language program or by any ‘c’ compiler. For generating the ‘hex file’ software is called ‘KEIL’ and used for burning the hex file into the chip, ‘Super pro-Universal Programmer’ software is used. In this chapter the KEIL and universal programmer software are discussed. The embedded C software is also discussed.

9.19 KEIL Software Description

KEIL tiVision2 is an IDE (Integrated Development Environment) that helps us to write, compile and debug embedded programs. It encapsulates the following components. Its main window is shown in Figure 9.11.

- A project manager.
- A make facility.
- Tool configuration;
Figure 9.11 Keil Working View

- Editor.
- A powerful debugger

9.19.1 Creation of a New Project In μVision2

- Select Project → New Project.
- Select a directory and enter the name of the project file.
- Select Project → Select Device and select an 8051 device from the Device Database.
- Create source files to add to the project.
- Select Project → Targets, Groups, Files. Add/Files, select Source Group1, and add the source files to the project.
- Select Project → Options and set the tool options. Note when you select the target device from the Device Database all special options are set automatically. You typically only need to configure the memory map of your target hardware. Default memory model settings are optimal for most applications.
- Select Project → Rebuild all target files or Build target.
The environment of this software is shown in appendix. Figure 9.12 shows the parts of the software such as working area, tool bars.

9.19.2 Debugging an Application In μVision2

- Select Debug - Start/Stop Debug Session.
- Use the Step toolbar buttons to single-step through your program. You may enter G, main in the Output Window to execute to the main C function.
- Open the Serial Window using the Serial #1 button on the toolbar.
- Debug the program using standard options like Step, Go, Break, and so on.

9.20 Universal programmer Description

Universal programmer is the device designed to communicate through a USB or parallel port (model dependent) and to operate with most IBM-compatible desk top computers and note book computers. In this work super pro package is used to load hex files. In this chapter the Features of this software, how to create a hex file and how to use super pro functions are discussed.

![Figure 9.12 Keil in Debugging Mode](image)

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9.20.1 Features of universal programmer

- A programming module (40 pin)
- An AC adapter
- A USB or parallel connecting cable
- Supports formats in binary, Intel, Hex, Motorola S, Tektronix, Jed etc.
- Auto generation of electronic serial number.

9.20.2 Load of a hex file

- To select a data file to be loaded, enter the path and the file name into the name field. If the full path or the exact name of the file is unknown, then a partial path may be entered using wild cards.
- Based on the saving mode, the files are divided into various formats.
- We need to select the relevant data types after selecting the file so that the data can be loaded correctly.
- The file types include Binary, Intel Hex, Motorola, record and Tektronix hex.

9.20.3 Selection of device

- Select the device type through Type Selection button.
- Select the manufacturer column.
- Select the device name through device name column, click OK button.

9.20.4 Programming the microcontroller chip

- Chip is inserted at the bottom line of the socket with the nick upward.
- Verify the device ID.
- Program the chip by selecting ‘program’ button.
- Verify the chip whether it is programmed or not.
9.21 Program

9.21.1 Normal Start Operation of SRM

```
org 0000h
mov p1,#0fh
mov p1,#00h
here:   jnb p1.0,here
repeat: mov p2,#01h
        acall delay
        mov p2,#02h
        acall delay
        mov p2,#04h
        acall delay
here2:  jnb p1.0,here2
        sjmp repeat
delay:  mov r0,#10h
i3:     mov r1,#0fh
i2:     mov r2,#0fh
i1:     djnz r2,i1
        djnz r1,i2
        djnz r0,i3
        ret
        end
```

9.21.2 Speed Control of SRM

```
org 0000h
mov p1,#0ffh
all:     mov p1,#00h
here:    jnb p1.0,here
        jb p1.1,low1
        jb p1.2,medium
        jb p1.3,high1
high1:   mov p2,#01h
        acall delay
        mov p2,#02h
        acall delay
        mov p2,#04h
```
acall delay
jc p1.1,low1
jc p1.2,medium
here1: jnb p1.0, here1
sjmp high1
medium: mov p2,#01h
acall delay
acall delay
mov p2,#02h
acall delay
acall delay
mov p2,#04h
acall delay
acall delay
jb p1.3,high1
jb p1.1,low1
here2: jnb p1.0, here2
sjmp medium
low1:    mov p2,#01h
acall delay
acall delay
acall delay
mov p2,#02h
acall delay
acall delay
acall delay
acall delay
mov p2,#04h
acall delay
acall delay
acall delay
acall delay
acall delay
jb p1.3,high1
jb p1.2,medium
here3: jnb p1.0, here3
sjmp low1
delay:   mov r0,#10h
i3:      mov r1,#0ffh
i.2: movr2,#0ffh
i l: djnzr2, il
djnz rl ,i2
djnz rO,i3
ret
sjmp all
end

9.22 Testing of SRM

Testing of SRM involves, following tests
a) STAR connection test
b) Delta connection test

9.22.1 Star Connection Test

• In this test coil 4, 5, 6 are shorted and it is provided connection in ground terminal.
• Then Coil 1, 2, 3 are connected to corresponding phase
• Now, this test confirms whether required amount of current flows through the coil by making connection in this fashion.
• If energizing current flows through the coil in this fashion it self then supply can be provided by this fashion itself and no need to test it under Delta connection.

9.22.2 Delta Connection Test

• In this test short coil like this fashion 1 and 6, 2 and 4, 3 and 5 and provide supply to each connected coil in delta fashion.
• It will ensures the current required to energize the coils

9.22.3 Testing of the SRM

• The necessary amount of current needed to energize the coil by connecting coils in star fashion itself is supplied.
• During testing, coils 4, 5, 6 are connected to negative terminal.
• Coil 1, 2, 3 are connected to positive supply through Single Pole Single Throw (SPST) switch.
• And now supply is switched between coils 1, 2, 3 with a very small time delay.
• Due to the principle of SRM, rotor try to follow low reluctance path and it corresponds to rotation of rotor.
• So, thus by switching supply between each coil may be made to the rotor run by its reluctance property.
• By switching supply between each coil, run the motor may be run smoothly.
• SPST switches were used.
• High speed is got by using a microcontroller along with MOSFET switches to drive the motor.
• For high speed switching, a micro controller based MOSFET driver circuit was designed.
• For low frequency switching delay is large.
• For high frequency switching delay is small.
• Thus by varying delay, the frequency at which switching is varied takes place.
• Here, SRM is programmed to operate under various loads.
• The motor is tested at various speeds with all loads.

Table 9.1 Test Results of SRM at different Loads

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Voltage in volts</th>
<th>Current in amps</th>
<th>Input in Watts</th>
<th>Torque in Nm</th>
<th>Speed in rpm</th>
<th>Output in watts</th>
<th>Efficiency in %</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>230</td>
<td>0.3</td>
<td>69</td>
<td>0</td>
<td>14,900</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>02</td>
<td>230</td>
<td>0.9</td>
<td>207</td>
<td>0.058</td>
<td>14,800</td>
<td>89.87</td>
<td>43.4</td>
</tr>
<tr>
<td>03</td>
<td>228</td>
<td>1.4</td>
<td>319.2</td>
<td>0.1076</td>
<td>14,600</td>
<td>164.48</td>
<td>51.5</td>
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<tr>
<td>04</td>
<td>224</td>
<td>2.1</td>
<td>470.4</td>
<td>0.2648</td>
<td>14,000</td>
<td>388.14</td>
<td>82.5</td>
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<tr>
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<td>3.5</td>
<td>763</td>
<td>0.5</td>
<td>13,400</td>
<td>701.49</td>
<td>91.9</td>
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<tr>
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<td>869.4</td>
<td>0.58</td>
<td>12,800</td>
<td>777.29</td>
<td>89.4</td>
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<tr>
<td>07</td>
<td>206</td>
<td>5.4</td>
<td>1112.4</td>
<td>0.632</td>
<td>12,000</td>
<td>793.79</td>
<td>71.3</td>
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</tbody>
</table>