TEMPERATURE INDICATOR AND CONTROLLER USING LASER

PROJECT WORK

Submitted by

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In partial fulfilment of the requirements for the award of the degree
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BACHELOR OF ENGINEERING IN ELECTRICAL AND
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DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING
KUMARAGURU COLLEGE OF TECHNOLOGY
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DEDICATED

to our

Beloved Parents

OOTS CAST (P) LIMITED

To

The Head of Department
Dept. of Electrical & Electronic Engineering
Kumaraguru College of Technology
Coimbatore – 641 006

Dear Sir

This is to certify that the following students from Kumaraguru College of Technology, Electrical & Electronic Engineering Department

1. Shanthi.R
2. Senthil Kumar.M
3. Vijay Babu.I
4. Ranjit.J

have undergone the project work entitled **"TEMPERATUR INDICATOR AND CONTROLLER USING LASER"**. The involvement of the above students during the period of the project work was found to be excellent.

Date :13.3.2002
Station :Coimbatore

G.D.Gopalkrishnan,B.E., M.B.A
Director - Operations
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CERTIFICATE

This is to certify that the project report entitled

"TEMPERATURE INDICATOR AND CONTROLLER USING LASER"

has been submitted by

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In partial fulfillment for the award of the degree of Bachelor of Engineering with specialization in Electrical and Electronics Engineering of the Bharathiar University during the academic year 2001-2002.

Mrs.M.Sudha,B.E.,(Guide)
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Assistant Professor.

Certified that the candidate with university register number______________ was examined in project viva-voce on______________.

(Internal Examiner)

(External Examiner)

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ABSTRACT

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Temperature indicator and controller are almost an indispensable component in modern industries. They are required to indicate and in many cases to control the temperature of an object from distance so that the manager can have direct acknowledgement over the control of the machine. Conventional temperature indicator uses cables which are found to be uneconomical and less accurate and prone to losses.

Our project is used to measure the temperature from a distance. The thermocouple senses the temperature .The distance criterion is achieved by using laser as the travelling guide. Initially the temperature is indicated at work bench and transmitted to the processing unit. It can be controlled from the processing unit by presetting the temperature and by using a relay circuit. Our project is a highly versatile measuring device even for measuring temperature at elevated positions.

CHAPTER 1

INTRODUCTION

Roots is a leading industry in the manufacture of horns and a pioneer in the production of die casts. As a new addition to its range of products is the laser based temperature indicator and controller.

At present temperature is measured using thermocouple. Most digital devices in the modern era play an important role in various fields of temperature measurement. The microcontroller plays a significant role in every day functioning of industrialized societies. We use laser as the communication medium.

1.1 OVER VIEW :

The entire project can be divided into two modules. They are

- Temperature indicator
- Temperature controller

The block diagram of above two modules is shown in the fig 1.1

1.2 TEMPERATURE INDICATOR:

1.2.1 POWER SUPPLY:

The power supply for the entire circuit is provided by using step down transformer, bridge rectifier and IC regulators.IC 7805 is used for +5V supply.IC 7812 and IC 7912 are used for +12V and -12V supply respectively.

1.2.2 THERMOCOUPLE:

Thermocouple is used as the temperature sensing unit. This converts measured temperature to its corresponding voltage.

1.2.3 ANALOG TO DIGITAL CONVERTER:

The analog output of the thermocouple is converted to its digital equivalent using ADC 0809 which is fed to microcontroller Atmel 89C51.

1.2.4 LASER TRANSMITTER:

Laser transmitter is used to transmit the data from the microcontroller to the processing unit .Laser diode is made use of as the laser source.

1.2.5 LASER RECEIVER:

Laser receiver interprets the information contained in the optical signal. A photo detector is used receive the laser signal.

1.2.6 DISPLAY UNIT:

LED is used to display the measured temperature.

1.3 TEMPERATURE CONTROLLER:

Temperature controller module consists of relay unit. key board and microcontroller, laser transmitter and receiver.

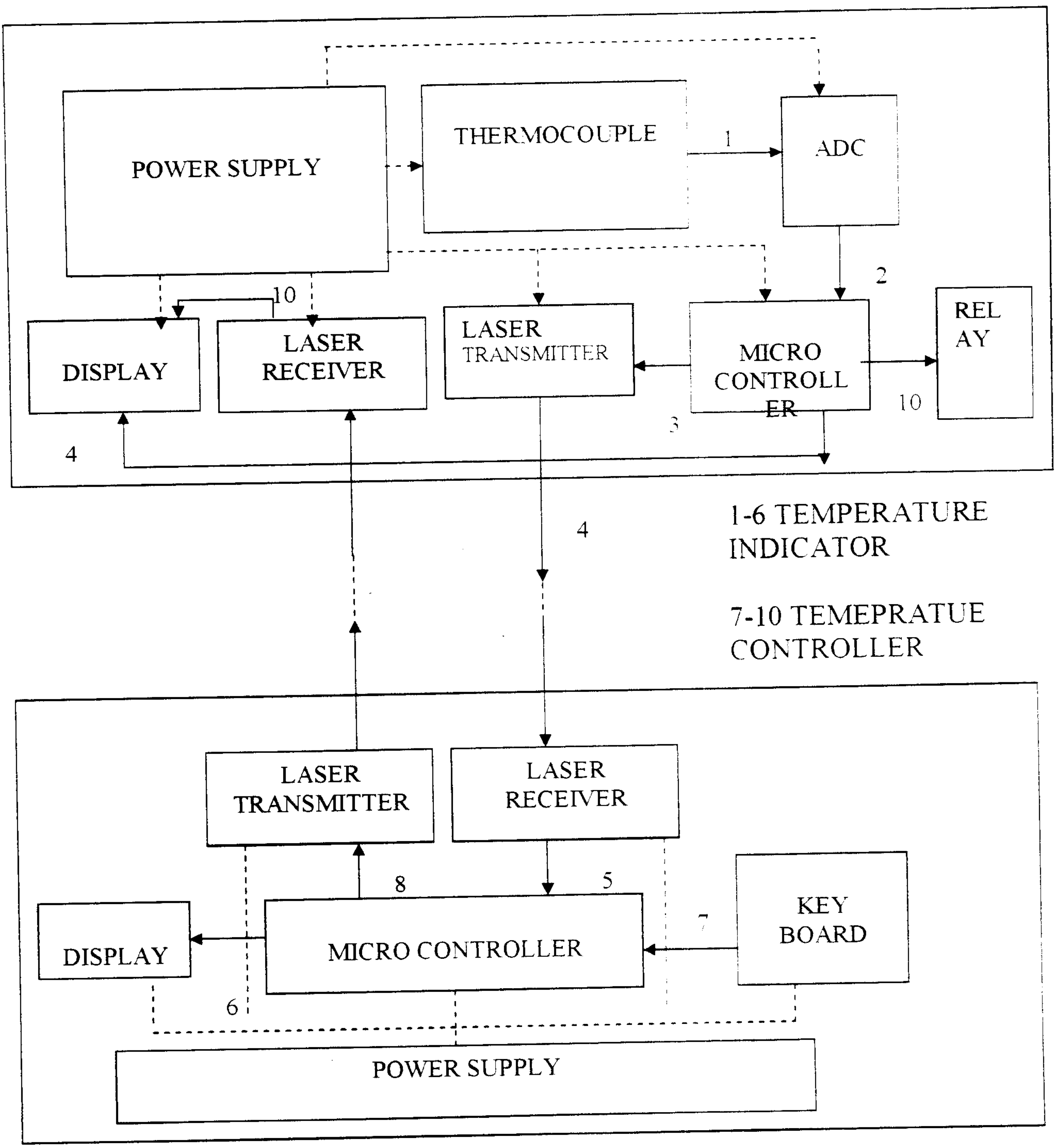
1.3.1 KEYBOARD:

The keyboard is the combination of switches which is used to preset the temperature to the required level. Keys for incrementing, decrementing and transmitting the preset value.

1.3.2 RELAY:

A relay is a switch worked by an electro magnet. The microcontroller compares the measured temperature with the preset value. If the measured temperature goes beyond the preset value the relay is tripped off. Hence the temperature can be controlled.

ENTIRE BLOCK DIAGRAM



CHAPTER 2

POWER SUPPLY UNIT

This chapter introduces the operation of power supply circuits. Since all the electronic circuits work only with D.C voltage we need a power supply unit to provide the appropriate voltage. This unit is built using filters, rectifiers, and then voltage regulators.

2.1 BLOCK DIAGRAM:

A block diagram containing the parts of a typical power supply is shown in fig 2.1. The AC voltage 120 V rms is connected to a transformer, which steps down the 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 ripples. The IC regulators are used to filter the ripple content.

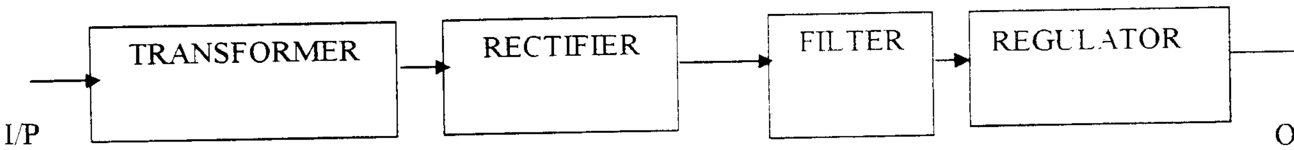


Fig 2.1 Block Diagram of
Power Supply Unit

2.1.1 TRANSFORMER:

A transformer is a static device in which electric power in one circuit is transformed into electric power of the same frequency in another circuit. Here we are using step down transformer for providing a necessary supply. In our project we are using a 15-0-15 centre tapped transformer, for +12V supply voltage and 0-9 transformer +5V supply voltage.

2.1.2 RECTIFIER:

Rectifier is a circuit to convert the AC voltage to DC voltage level. We use a full wave bridge rectifier. The diodes are of type IN4007.

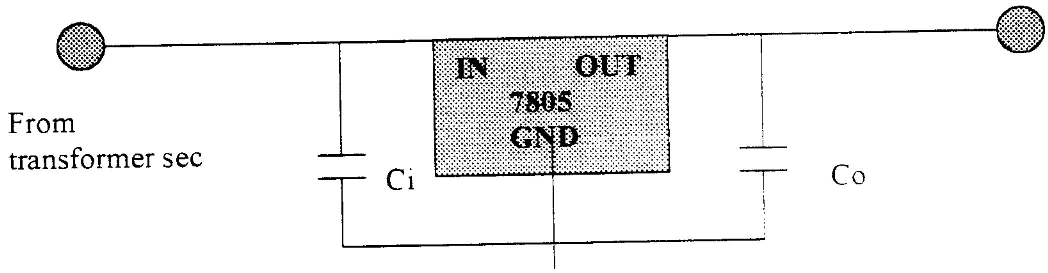
2.1.3 FILTER:

The filter circuit consists of a capacitor at the rectifier output, and a DC voltage is obtained across it. The filtered waveform is fed to the regulator

2.2 IC VOLTAGE REGULATORS:

The voltage regulator is a device, which maintains the output voltage constant irrespective of the change in supply variations. load variation and temperature changes. Regulator IC units contain the circuitry for reference source, comparator amplifier, control device. and overload protection all in a single IC. This gives low cost, reliability, reduction in size and excellent performance. Here we use the 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.

78XX series are three terminal positive fixed voltage regulators. Fig 2.2 shows the basic connection of a voltage regulator IC 7805 to a load. The fixed voltage regulator has an unregulated dc input voltage. Vi. applied to one input terminal, a regulated output dc voltage. Vo. from a second terminal, with the third terminal connected to ground.. The capacitor Ci connected between input terminal and ground is to cancel the inductive effects due to long distribution loads. The output to capacitor Co improves the transient response.



A table of positive voltage regulated ICs is provided in table 1.

TABLE 1 Positive Voltage Regulators in 7800 series

IC PART	OUTPUT VOLTAGE	MINIMUM Vi
7805	+5	7.3
7806	+6	8.3
7808	+8	10.5
7810	+10	12.5
7812	+12	14.6
7815	+15	17.7
7818	+18	21.0
7824	+24	27.1

POWER SUPPLY

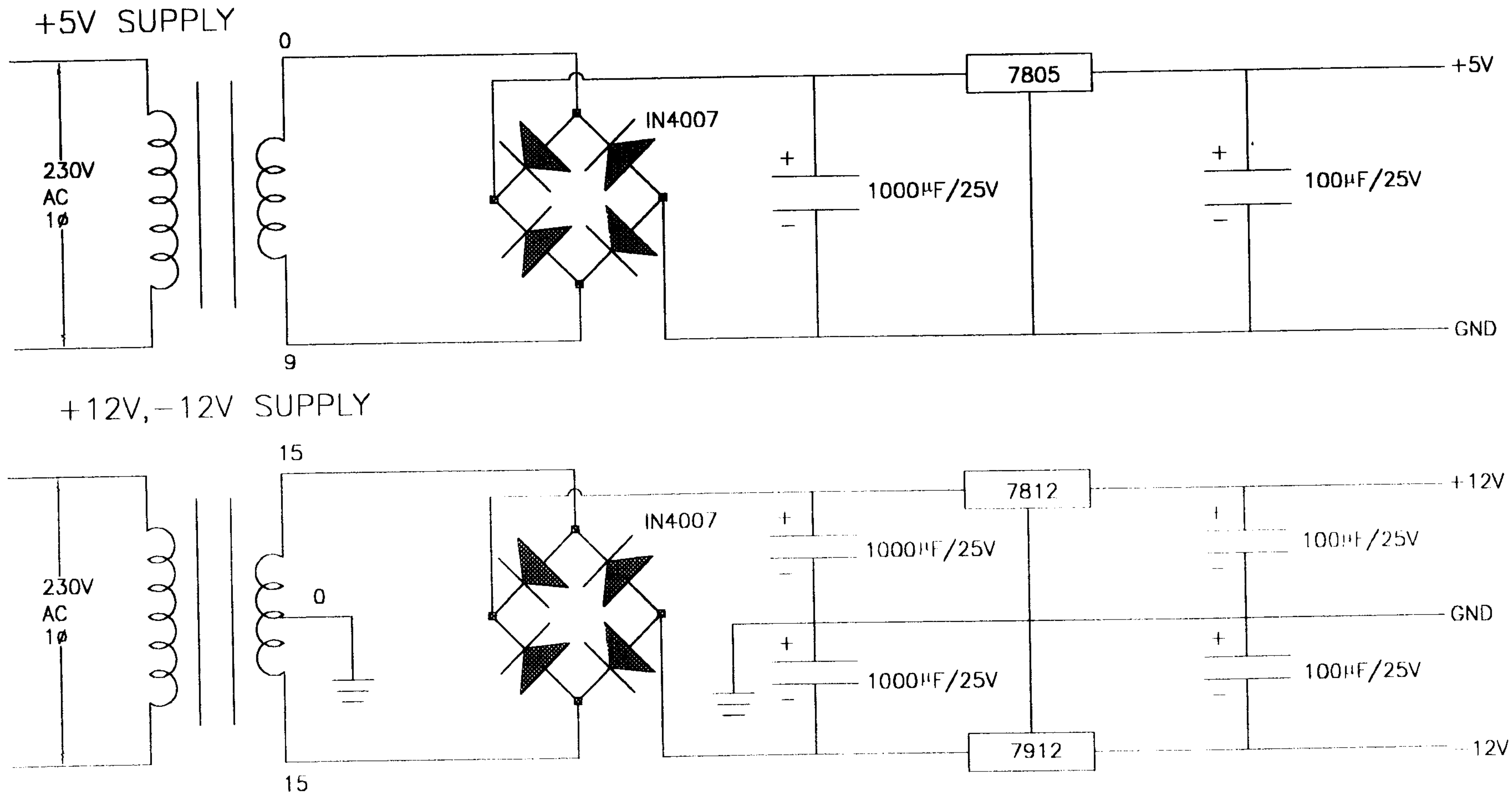


fig 2.2

CHAPTER 3

TEMPERATURE SENSING UNIT

There are various instruments to measure temperature. They are resistance thermometers, thermistors and thermocouples. Among these thermistor is used for low temperature measurements and thermocouple is used to measure high temperature and it has a low output signal. RTD is linear than thermocouple but it has low sensitivity. The disadvantages of RTD are listed below:

- Non-linear
- Limited temperature
- Fragile
- Current source Required
- Self-heating

3.1 THERMOCOUPLE:

A thermocouple is a transducer, which converts thermal energy into electrical energy. It is one of the commonly used methods of measuring process temperatures. The operation of a thermocouple is based upon the seebeck effect. It is a simple device consisting of two dissimilar metals joined at the ends when heat is applied to junction of two dissimilar metals an emf is generated which can be measured .The two dissimilar metals form the electric circuit and current flows as a result of the generated emf.

The emf produced is the function of the difference in temperature of two junctions. This measures only the difference in temperature. To measure the actual temperature of the object we ground one of the terminals.

$$E=a(t1-t2)+b(t1-t2)^2$$

Where t1, t2 = temperatures of the junctions K°

a, b = constants depending on the metals used.

Typical values of a and b are

a =45 μV/°C

b =few tens or hundreds of a.

Here in our project t2=0 and hence, $E=at1-bt1^2$

Also b<<<<a

Hence, b can be neglected.

Therefore E=at1.

So the emf produced is the direct measure of the temperature of the object.

In industrial applications the choice of materials used to make up a thermocouple depends upon the temperature range to be measured, the kind of atmosphere to which the material will be exposed to, the output emf and its stability, mechanical strength and the accuracy required in measurements. Several combinations of dissimilar metals make good thermocouples for industrial use. Thermal emf for various types of thermocouples are given in table 2.

TABLE 2: Thermal emf for various types of thermocouples

TYPE	*THERMOCOUPLE*	*USEFUL RANGE °C*	*SENSITIVITY μV °C*
T	Copper-constantin	-150 to +350	45
J	Iron-constantin	-150 to +1000	52
K	Chromel-alumel	-200 to +1200	40
S	Platinum-rhodium	0 to +1500	6.4

3.2 ADVANTAGES OF THERMOCOUPLE:

- Self-powered
- Simple

- Rugged
- Inexpensive
- Wide variety
- Wide temperature range
- Can be used for both AC and DC applications
- Can be used for measurements of current and voltages at very high frequencies.

3.3 K TYPE THERMOCOUPLE:

K type is the alloy of chromel and alumel.These combinations apart from having linear response and high sensitivity. should be physically strong to with stand high temperatures, rapid temperature changes and the effect of corrosive and reducing atmospheres. The characteristics of this type are

1. resistant to oxidizing
2. susceptible to attack by carbon bearing gases, sulphur and cyanide fumes.

3.4 CIRCUIT DESCRIPTION:

The entire circuit description is shown in the fig 3.1. In our project, we use a thermocouple with a voltage in the range of 0-5mV. For processing the signal we have to amplify this milli voltage into high level. This can be done by using multistage amplifier and is given to a comparator. The purpose of a comparator is compensation i.e. when the input temperature is

zero the output should be zero. Using a potential divider the reference voltage is given to the comparator. The output from the comparator is applied to an amplifier. In this stage proper gain adjustment is given. The output from the final stage amplifier is in the range of 0-5V. For ensuring this, we are using zener diode in reversed biased condition, so that it will not exceed 5V. Now the signal is given to the ADC for converting to digital form and further processing.

THERMOCOUPLE SENSING CIRCUIT

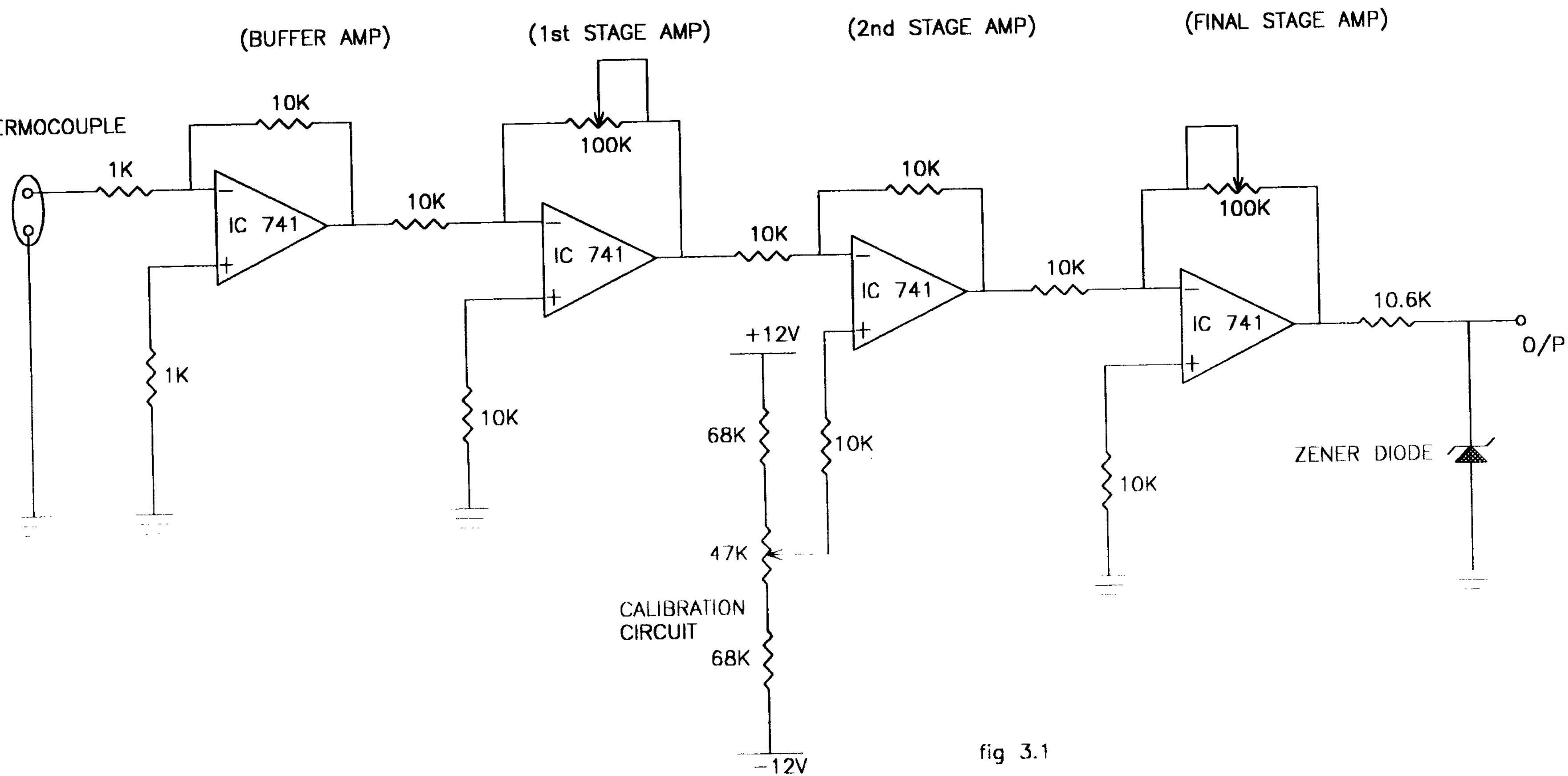


fig 3.1

CHAPTER 4

ANALOG TO DIGITAL CONVERTER-0809

The function of an ADC is to produce a digital word, which represents the magnitude of some analog voltage or current. The ADC 0809 is an 8-bit digital to analog converter with 8-channel inbuilt multiplexer. It is the monolithic CMOS device manufactured by the National semiconductors. It can be interfaced easily with any of the micro controllers.

4.1 ADC TYPES:

The ADCs can be classified into three main types. They are

1. Parallel comparator ADC
2. Dual slope
3. Successive approximation

4.1.1PARALLEL COMPARATOR ADC :

In a parallel comparator ADC the number of comparators needed to produce the result with a reasonable amount of resolution is more. To produce a converter with n bits of resolution we need (2^n-1) comparators.

4.1.2 DUAL SLOPE ADC:

The dual slope ADC integrates the input signal for a fixed time and provides the output.The main disadvantage in dual slope type converter is its long conversion time.

4.1.3 SUCCESSIVE APPROXIMATION ADC:

The successive approximation technique uses a very efficient code search strategy to complete n bit conversion in just n clock periods. This technique uses successive approximation register SAR to find the required value of each bit by trial and error method.

The 8-bit A/D converter uses successive approximation as the conversion technique. The 8-channel Multiplexer can directly access any of the 8-single-ended analog signals. The converter features a high impedance chopper stabilized comparator and a successive approximation register. It is free from external zero and full-scale adjustments. Easy interfacing to microcontrollers is provided by the latched and decoded multiplexer address inputs and latched TTL TRI-STATE outputs. The diagram depicting this technique is shown in the figure 4.1

4.2 THE FEATURES OF ADC 0809:

- High speed
- Minimal temperature dependence
- Excellent long term accuracy and repeatability
- Resolution of 8-bits
- Total adjustment errors = ±1/2 LSB and ± 1 LSB.
- No missing codes
- Conversion time = 100μsec. At 640 KHz.
- Supply voltage = +5V
- Easy interface to all microcontrollers or operates stand alone
- No zero or full-scale adjustment required
- Clock frequency 10KHz to 1280KHz
- Temperature range -40°C to +85°C or -55°C to +125°C
- Low power consumption ➔ 15mW
- Latched TRI-STATE output
- Conversion delay time.

These features make this device ideally suited to applications from process and machine control to consumer and automotive applications.

The heart of this ADC is the successive approximation register (SAR). On receipt of the 1st CLK, the SAR outputs a high on its MSB. The DAC converts this to an analog voltage and apply to one of the inputs of the comparator; the comparator will go low to indicate to the SAR to turn OFF that bit because it is too large. If the output voltage from DAC is less than the input voltage, the comparator output will be high to indicate to the SAR to keep that bit ON. On receipt of the next pulse, the SAR will turn ON the next MSB to DAC. Based on the answer, it produces from the comparator; the SAR will keep or RESET the bit. The SAR proceeds in this manner down to the LSB, adding each bit to the total in turn and using the signal from the comparator to decide whether to keep that bit in the result or not. Only 8-CLK pulses are needed to do the actual conversion signal to indicate the completion of the process. The EOC signal is used to strobe the binary result into some latches where it can be read by a microcontroller.

4.3 CLOCK FREQUENCY FOR ADC:

The clock for the ADC is taken from the crystal of the microcontroller i.e., the same crystal is used to provide clock for both ADC and microcontroller. This is done with the help of a decade counter which splits the frequency necessary for the ADC. The required clock frequency 0809 is 750 KHz. The decade counter used is 74LS393.

ADC 0809

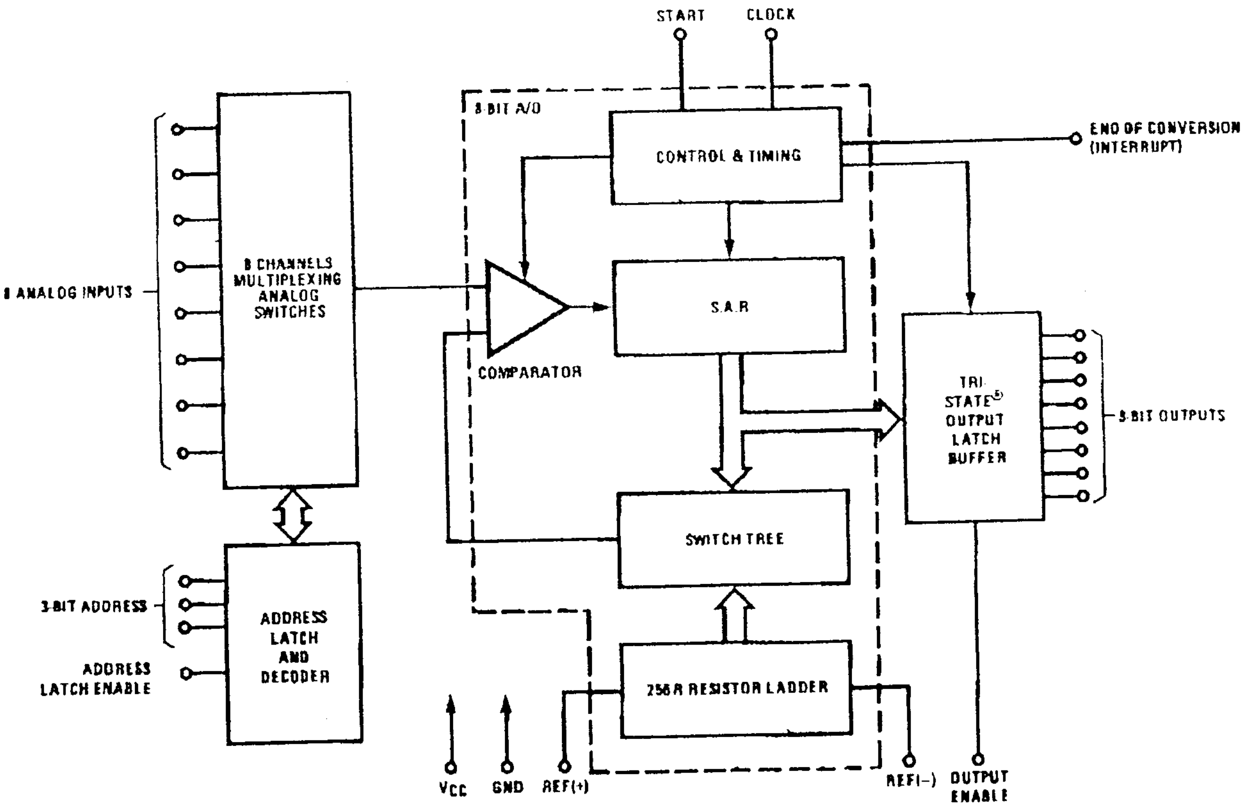


FIG 4.1 SUCCESSIVE APPROXIMATION TECHNIQUE

CHAPTER 5

MICROCONTROLLER

A microcontroller consists of a powerful CPU tightly coupled with RAM, ROM, or EPROM, various I/O features such as serial, parallel ports, timer/counters, interrupt controller, every thing integrated onto a single silicon chip.

The difference microprocessor and microcontroller is that the microprocessor can only process with the data. Microcontroller can control external device. The Microprocessor is concerned with the rapid movement of code and data from external addresses to the chip, whereas the Microcontroller is concerned with rapid movement of bits with in the chip. Also the microprocessor needs additional parts to be operated as digital computer but Microcontroller can function as a computer with the addition of no external digital parts. We use the microcontroller 89C51. It is manufactured by ATMEL, MC, USA.

5.1 ARCHITECTURE OF MICROCONTROLLER:

***Series:** 89C51 Family*

***Technology:** CMOS*

The architecture of 89C51 is shown in fig 5.1.

lock Diagram

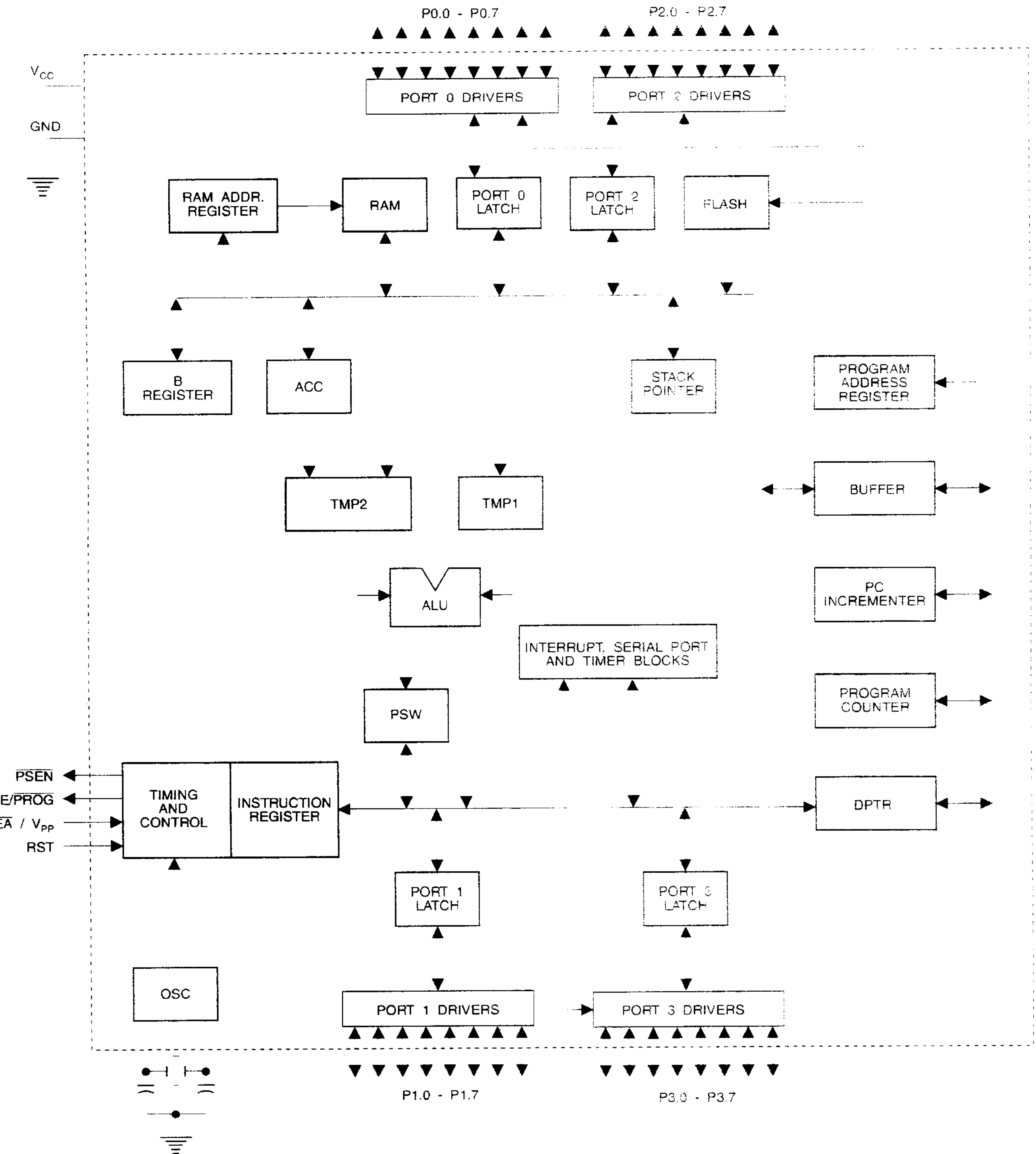


FIG 5.1 89C51 BLOCK DIAGRAM

5.2 SPECIAL FUNCTION REGISTERS:

The special functional registers (SFR's) are located in upper 128 bytes direct addressing area. The SFR memory is shown in the figure below. Not all the addresses are occupied. Unoccupied addresses are not implemented on the chip. User software should not write 1s to these unimplemented locations, since they may be used in future microcontrollers to invoke new features. In that case, the reset or inactive values of the new bits will always be 0, and their active values will be 1.the functions of the SFRs are outlined as follows

5.2.1 ACCUMULATOR (ACC):

ACC is the Accumulator register. The mnemonics for the accumulator specific instructions refer to the accumulator simply as A.

5.2.2 B REGISTER (B):

The B register is used during multiply and divide operations.

5.2.3 PROGRAM STATUS WORD (PSW):

The PSW register contains the program status information. It is bit addressable.

7	6	5	4	3	2	1	0
CY	AC	FO	RS1	RS0	OV	-	P

CY is the carry flag. AC is the auxiliary carry flag. FO is the flag available to the user for general purpose.RS1 and RSO are the register bank selector bit 1 and 0 respectively. OV is the overflow flag.PSW.1 is usable as general purpose flag is the parity flag.

5.2.4 STACK POINTER (SP):

The stack pointer is eight bits wide. It is incremented before data is stored during PUSH and CALL executions.

5.2.5 DATA POINTER (DPTR):

The data pointer consists of a high byte (DPH) and a low byte (DPL).its function is to hold a 16 bit address. It may be manipulated as a 16 bit register or as two independent 8 bit registers.

5.2.6 SERIAL DATA BUFFER (SBUF):

The serial data buffer is actually two separate registers, a transmit buffer and a receive buffer register. When data is moved to SBUF, it goes to the transmit buffer, where it is held for serial transmission. When data is moved from SBUF, it comes from the receive buffer.

5.2.7 TIMER REGISTERS:

Register pairs (TH0, TL0) and (TH1, TL1) are the 16 bit counter registers for timer/counters 0 and 1 respectively.

5.2.8 SCON SERIAL PORT CONTROL REGISTER:

It is bit addressable. The serial port can operate in the following four modes.

Mode 0: serial data enters and exits through RXD.TXD outputs the shift clock. Eight bits are transmitted/received, with the LSB first.

Mode 1: ten bits are transmitted (through TXD) or received (through RXD):A start bit(0) ,eight data bits(LSB first),and a stop bit(1).

Mode 2: eleven bits are transmitted (TXD) or received (RXD): a start bit(0),eight data bits, a programmable ninth data bit ans a stop bit(1).

Mode 3: same as mode 2 but the difference lies in the baud rate.

In all the 4 modes transmission is initiated by any instruction by any instruction that uses SBUF as the destination register.

5.2.9 TCON TIMER/COUNTER CONTROLS REGISTER:

It is bit addressable

TF1	TR1	TF0	TR0	IE1	IT1	IE0	IT0
7	6	5	4	3	2	1	0

TF1 and TF0 are timer 1 and timer 0 overflow flags.TR1 and TR0 are timer 1 and timer 0 run control bits.IE1 and IE0 are external interrupt 1 and interrupt 0 edge flags.IT1 and IT0 interrupt 1 and interrupt 0 type control bits.

5.2.10 TMOD TIMER/COUNTER MODE CONTROL REGISTER:

It is not bit addressable. There are 4 main parts in this. When TRx in TCON is set and GATE =1, timer/counterx will run while INTX(low) pin is high.when GATE =0 timer/counterx will run only TRX=1.timer or counter selector is cleared for timer operation and set for counter operation.M1 and M0 are mode selector bit.

5.3 ADDRESSING MODES:

The various addressing modes used in the microcontroller 89C51 are as follows:

5.3.1 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.

5.3.2 INDIRECT ADDRESSING:

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

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.

5.3.3 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. Adding the Accumulator data to the base pointer forms the address of the table entry in program memory.

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.

5.4 MEMORY ORGANISATION:

All Atmel micro controllers have separate address spaces for program and data memory . The program memory and data memory can be up to 64 K bytes long.

5.4.1 PROGRAM MEMORY :

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). When the device is executing code from the external program memory PSEN (low) is activated twice each machine cycle except that two PSEN (low) activations are skipped during each access to external data memory. PSEN(low) is not activated during fetched from internal data memory. The program memory organisation is shown in the figure 5.2.

After reset, the CPU begins execution from location 0000h. 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. 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. If an Interrupt service routine is short enough 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 is connected to either Vcc or GND.

5.4.2 DATA MEMORY:

The Internal Data memory is dived into three blocks namely,

- The lower 128 Bytes of Internal RAM
- The Upper 128 Bytes of Internal RAM.
- Special Function Register.

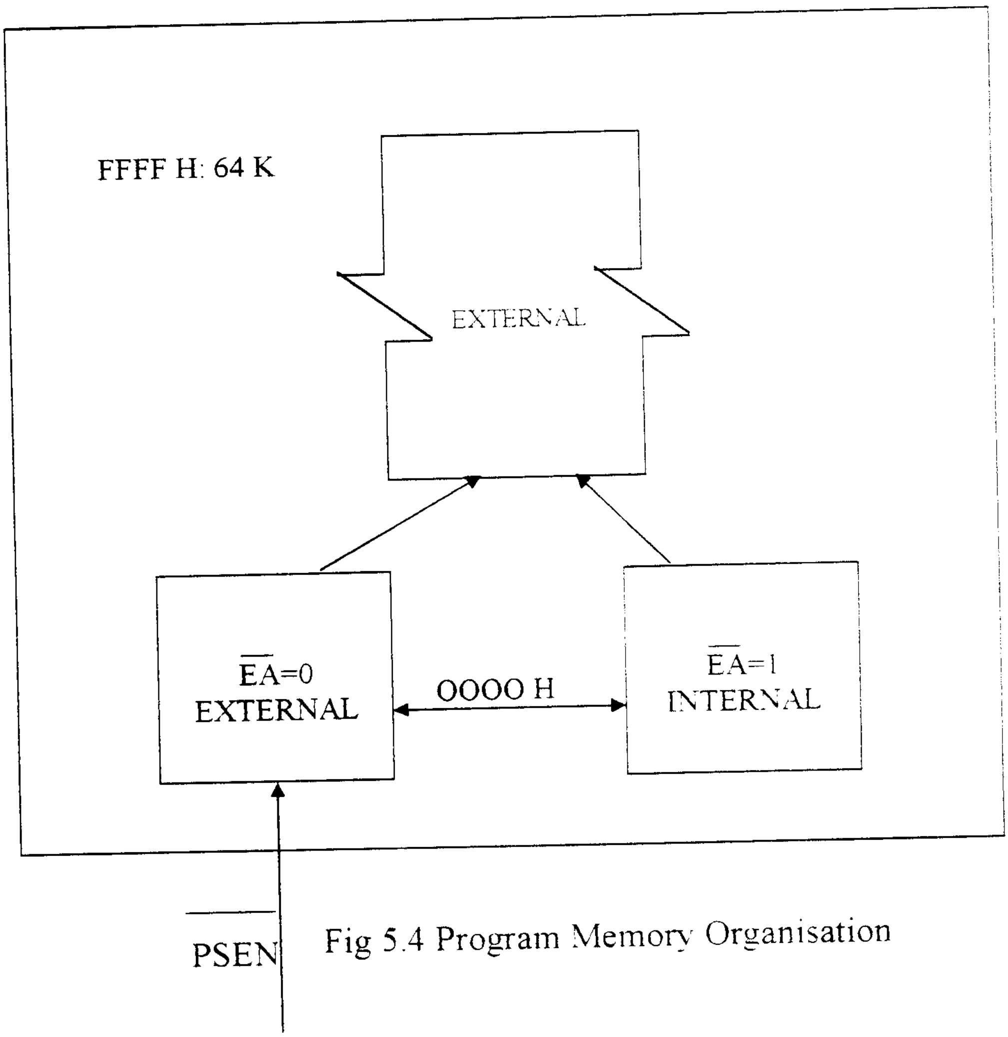


Fig 5.4 Program Memory Organisation

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.

Internal Data memory Addresses are always 1 byte wide, which implies an address space of only 256 bytes. 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 as shown in the fig 5.3.

The Special Function Register includes Ports.latches, timers, peripheral controls etc., direct addressing can only access these register. In general, all Atmel micro controllers have the same SFRs at the same addresses in SFR space as the AT89C51 and other compatible micro controllers. However, upgrades to the AT89C51 have additional SFRs. Sixteen addresses in SFR space are both byte and bit Addressable. The bit Addressable SFRs are those those address ends in 000B. The bit addresses in this area are 80h through FFh.

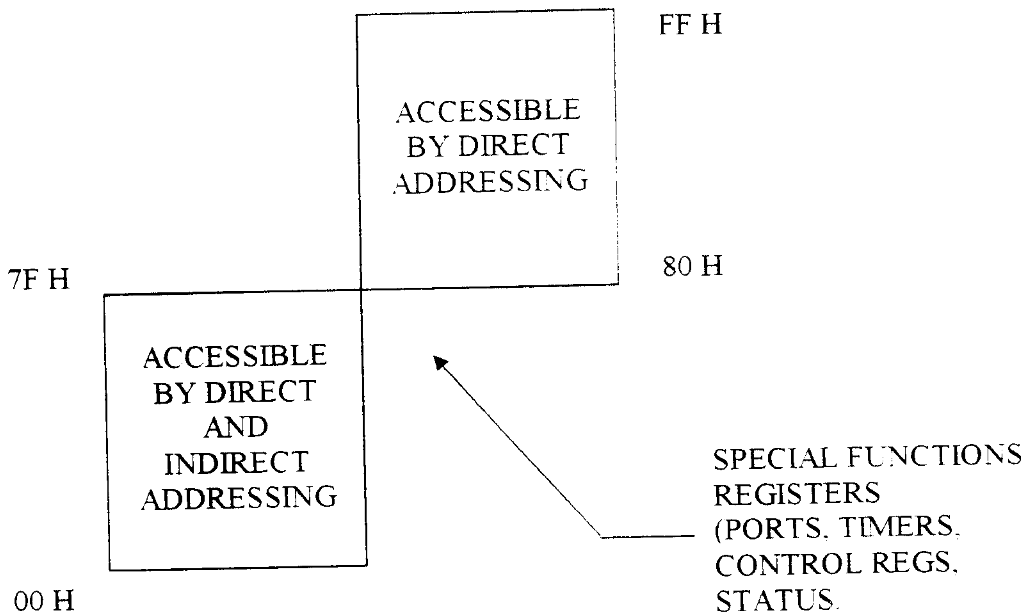


Fig 5.3 Data Memory Organisation

5.5 INTERRUPTS:

The AT89C51 provides 5 interrupt sources:

- ✓ Two External interrupts
- ✓ Two-timer interrupts
- ✓ One serial port interrupts.

5.5.1 EXTRNAL INTERRUPTS:

The External Interrupts INT0 and INT1 can each either level activated or transistion - 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 WA transition - activated. If the interrupt was level - activated, then the external requesting source (rather than the on-chip hardware) controls the requested flag.

5.5.2 TIMER INTERRUPTS:

TF0 and TF1 generate the Timer 0 and Timer 1 Interrupts, 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 logical

OR of RI and TI generate the Serial Port Interrupt. 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 and the bit must be cleared in software.

5.5.3 SERIAL INTERRUPT:

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

IE: Interrupt Enable Register

7	6	5	4	3	2	1	0
EA	-	ET2	ES	ET1	EX1	ET0	EX0

Enable bit = 1 enabled the Interrupt

Enable bit = 0 disables it.

IP: Interrupt Priority Register

It is bit addressable.

7	6	5	4	3	2	1	0
-	-	-	PS	PT1	PX1	PT0	PX0

The last three bits are reserved for future use.PS defines serial port interrupt priority level.PT1 defines timer 1 interrupt priority level.PX1 defines external interrupt 1 priority level.PT0 defines timer 0 interrupt priority level.PX 0 defines external interrupt 0 priority level.

5.6 OSCILLATOR AND CLOCK CIRCUIT:

XTAL1 and XTAL2 are the input and output respectively of an inverting amplifier which is intended for use as a crystal oscillator in the frequency range of 1.2 MHz.

XTAL 1: XTAL1 is the crystal 1. It is input to the inverting oscillator amplifier and input to the internal clock generator circuits.

XTAL2: XTAL 2 is the crystal2.It is the output from the inverting oscillator amplifier.

The on-chip oscillatory circuit of the IS89C51 is a single stage inverter. intended for use as a crystal-controlled, positive reactance oscillator. The circuit of the oscillator and clock frequency is shown in the fig 5.4 .In this application the crystal is operated in the fundamental response modes as an inductive reactance in parallel resonance with capacitance external to the crystal. The crystal applications and capacitance value C1 and C2 are not criticlal.20Pf and 30 pF can be used in these positions at a 12 MHz to 24 MHz frequency with a good quality crystals. A ceramic resonator can be used in place of the crystal in-cost sensitive application. When ceramic resonator is used C1andC2 are normally selected to be of some what high values.

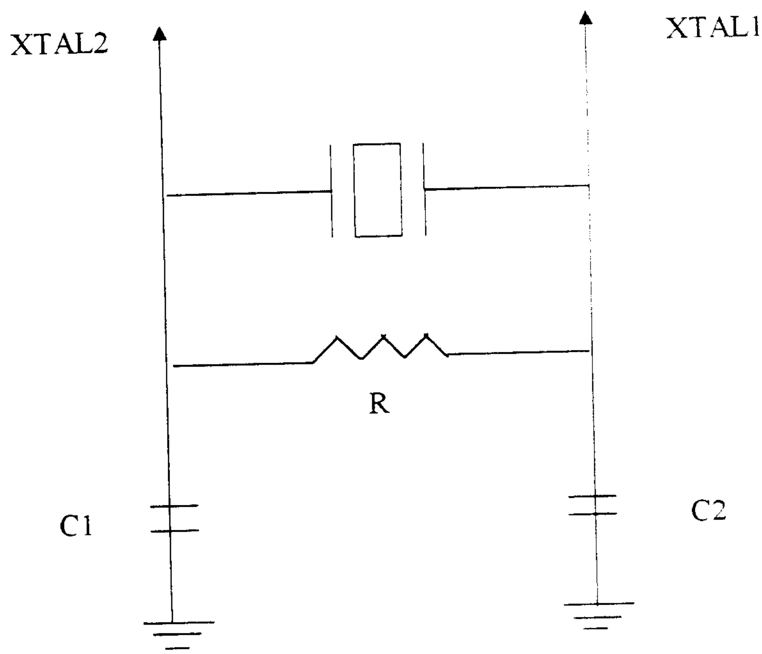


Fig 5.4 Oscillator and Clock Circuit

CHAPTER 6

DATA COMMUNICATION UNIT

Laser is the light. Extra ordinary light. Ruby laser can reach the moon and come back to earth and measure the distance between the moon and the earth. Laser is one of the outstanding achievements of optics. Today, due to the specific properties of laser radiation, laser systems find wide use in communication systems.

6.1 LASER CHARACTERISTICS:

Laser is an acronym for *"LIGHT AMPLIFICATION BY STIMULATED EMISSION OF RADIATION"*. Unlike other sources of light, lasers produce highly coherent, monochromatic radiation with highly regular light field directivity, high power density and focusability. They are explained as follows:

6.1.1 DIRECTIONALITY:

All the atoms in a laser beam travel in the same direction and have the same plane of polarization.

6.1.2 MONOCHROMATICITY:

The light waves have the same wavelength (or the same color).

6.1.3 HIGH INTENSITY:

The light waves in a laser beam have very high frequency. Thus, the energy of the laser beam is also very high.

6.1.4 COHERENCE:

All the light waves in a laser beam are in phase with each other. The word coherence means that the radiations emitted by atoms, molecules, or photons in the source have same phase, same direction, same plane of polarization, and same wavelength or color (monochromatic).

6.2 PRINCIPLES OF LASERS:

Lasers harness atoms to store and emit light in a coherent fashion. The electrons in the atoms of the laser medium are first pumped, or energized, to the excited state by an energy source. These are then stimulated by external photons to emit the stored energy in the form of photons. This process is known as stimulated emission.

The emitted photons have frequency characteristic of the atoms and travel in step with the stimulating photons. These photons, in turn, impinge on other excited atoms to release more photons. Light amplification is achieved as the photons move back and forth, triggering further stimulated emissions.

6.3 TYPES OF LASERS:

Based on the medium used, lasers are generally classified as solid-state, gas, semiconductor, or liquid lasers.

6.3.1 SOLID STATE LASERS:

The most common solid laser media are ruby crystal rods and neodymium doped glasses/crystals. The ends of the rod are fashioned into two parallel surfaces coated with a highly reflected nonmetallic film.These lasers offer the highest power output, and are usually operated in pulsed manner to generate bursts of light over a short time. Pumping is achieved with light from xenon flash tubes.

6.3.2 GAS LASER:

A gas laser contains pure gas, mixture of gases, or even metal vapour, usually in a cylindrical glass or quartz tube, as the medium. Two mirrors are located outside the ends of the tube to form the laser cavity. Pumping is achieved by ultraviolet light, electron beams, electric current, or chemical reactions.

6.3.3. SEMICONDUCTOR LASER:

Semiconductor laser, the most compact of lasers, usually incorporates a junction between layers of semiconductors with different electrical conducting properties. The laser cavity is confined to the junction region by means of two reflective boundaries. Gallium arsenide is the most common semiconductor used. Semiconductor lasers are pumped by direct application of electrical current across the junction.

In this project we have showed that laser can be effectively used as a communication medium between two microcontrolers.we have designed laser transmitter and receiver for communication.

6.4 LASER TRANSMITTER:

Semiconductor laser diodes are very versatile. high power source of optical energy. The semiconductor crystal is a hetero structure to encourage guiding of the light in the very narrow active region. Semiconductor lasers are the best for optical communication and they have paved the way for transition from (electronic) circuits to integrated optics. Laser diodes typically have response time less than 1ns.We need mechanical supports to hold the laser head. Aluminium or Brass supports have good thermal conductivity and is sufficient for supporting laser head.

LASER TRANSMITTER

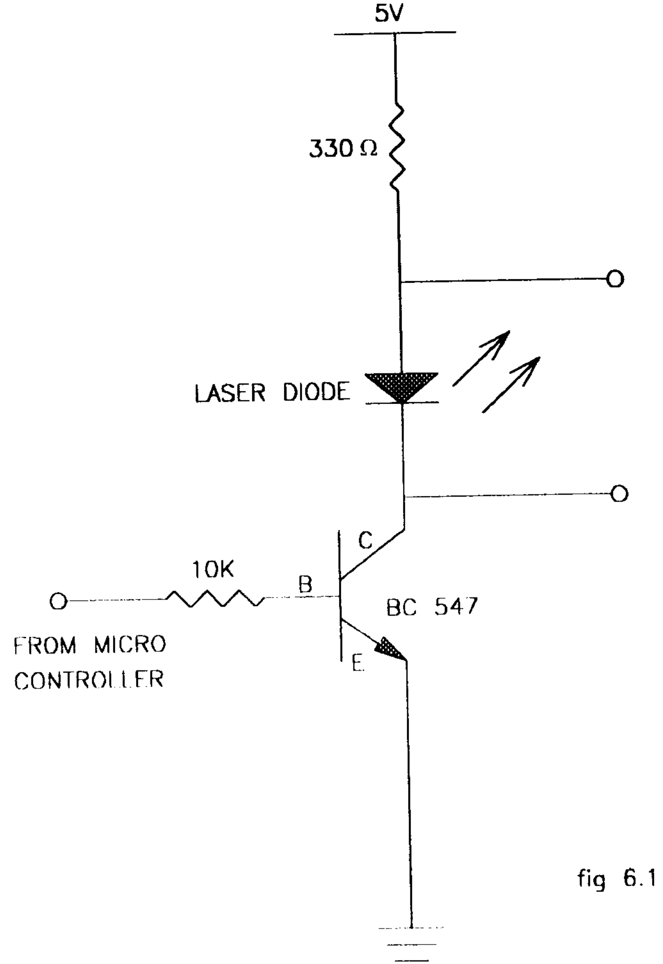


fig 6.1

6.4.1 FSO (FREE SPACE OPTICS):

It is a line of sight technology. This allows optical connectivity without overlapping fibre optic cable. Such propagation of optical capacity through air requires laser and optical transceiver (laser transmitter and receiver) to provide full duplex capability. Light responds through air faster than it does through glass.

6.4.2 CIRCUIT OPERATION:

Transmission of pulses through lasers is accomplished with the help of a transistor BC547.The output from the Microcontroller is in digital form. The bits enter the laser transmitter. When the data is 1, the transistor gets conducted and light is emitted from laser diode. When the data is 0 the transistor does not conduct and the laser diode is not activated. The transmission of bits are clearly shown in the figure fig 6.1. Thus 1's and 0's are transmitted. Data is transmitted at the rate of 110 bits/sec.

6.5 LASER RECEIVER:

The transmitted bits have to be received at some distance for processing. The receiver device interprets the information contained in the optical signal. The three basic stages of the receiver are a photo detector, an amplifier and comparator. The circuit is shown on the fig 6.2.

6.5.1 PHOTO DETECTOR:

The first element of this receiver is the photo detector. The photo detector senses the luminescent power falling upon it and converts the variation of this optical power into a correspondingly varying electric current. The features of the semiconductor based photo detectors are small size, high sensitivity and fast response time.

When light having photon is incident on a photo detector, the photons can give up their energy and excite electrons from valency band to conduction band. This generates the free electron-hole pairs, which are known as photo carriers. The resultant electric field in the device causes the carriers to separate. This gives rise to a current flow in an external circuit as photocurrent. The photo detector of the receiver must be accurately oriented towards the laser beam from the laser diode. If there is any obstruction in the laser beam data is not obtained in the laser receiver.

6.5.2 AMPLIFIER:

The current generated by the photo detector is generally very weak and hence amplification is needed.

LASER RECEIVER

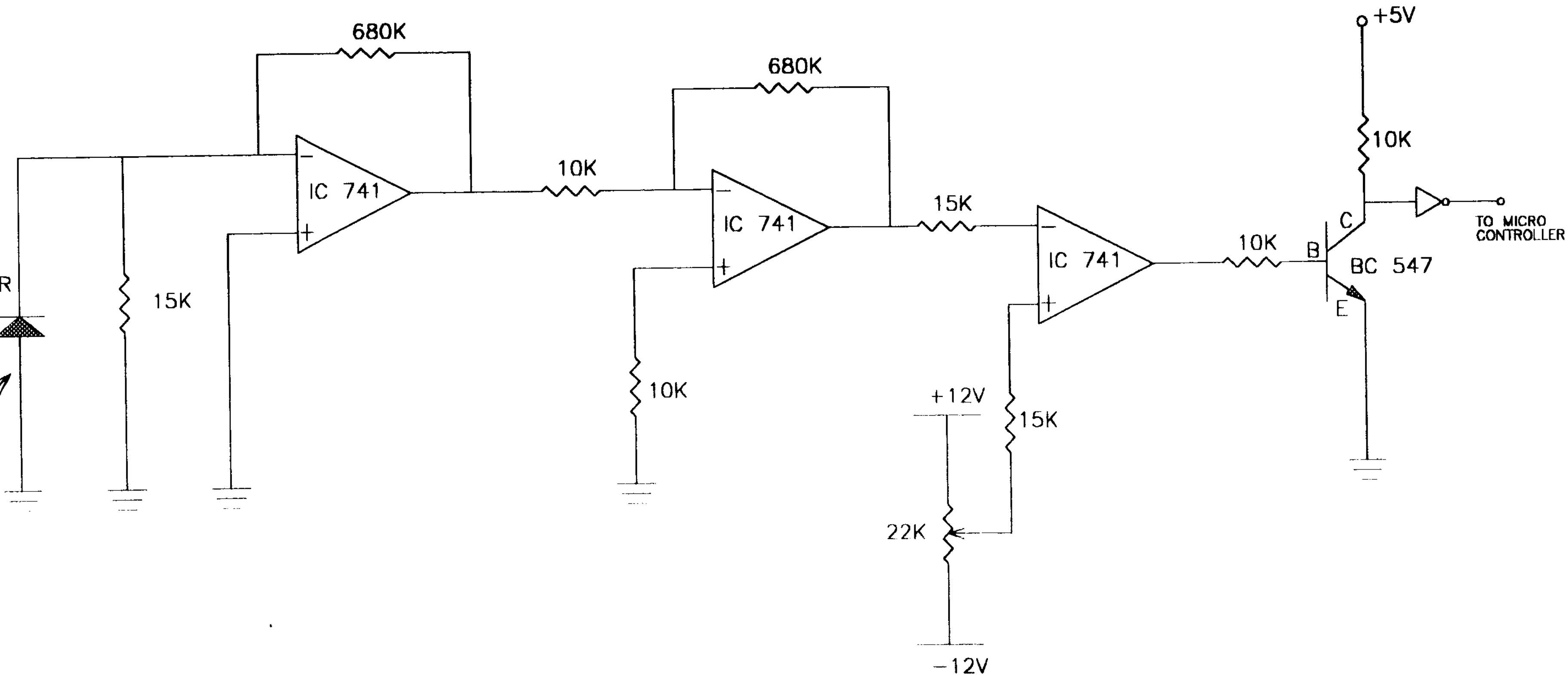


fig 6.2

6.5.3. COMPARATOR:

In a digital receiver the amplified signal is compared with the threshold level once per time slot to determine whether or not pulse is present at the photo detector in that time slot .Ideally the output signal would always exceed the threshold value when a 1 is present and would be less than the threshold when no pulse (a 0) was sent.

CHAPTER 7

TEMPERATURE CONTROLLER UNIT

The controller unit consists of a keyboard and a relay circuit. As soon as the power is turned on the thermocouple measures the temperature of the object. The measured temperature is indicated in the receiving side led display. Then the indicated temperature is passed to the microcontroller of the transmitting side. Here too the measured temperature is indicated. Hence temperature can be viewed at both processing part and the testing part.

7.1. KEY BOARD:

The required set value is fed using a keyboard to the microcontroller. The keyboard is a combination of switches. We have keys for incrementing, decrementing and transmitting the set value to the receiving side. The keys are connected to the port 1 of the microcontroller. We use a register for incrementing and decrementing set values. The transmit key is used to initiate the transmission of the set value to the receiving side. The buffered is cleared for every switch on the circuit. This is incorporated using a series combination of resistor and capacitor.

7.2. RELAY:

The receiving side led displays both the actual temperature of the object and also the set value with a time difference. The microcontroller compares the measured temperature and the set value. If the measured value goes beyond the set value the relay coil trips off. We can notice this change with the help of the led connected to it.

A relay is a switch worked by an electromagnet when the controlling current flows through the coil and the soft iron core is magnetized and attract the soft iron armature. This rocks on its pivot and opens closes or changes over the electrical contact in the circuit being controlled.

7.3 CIRCUIT DESCRIPTION:

In this circuit transistor (BC 547) is used as a switch. The control signal is given to the base of the transistor. The collector is attached to the relay coil. When the output from the microcontroller is high the transistor will be on the on state, so the relay will be energized. So according to the controller output the valve will open or close thus level is maintained. The circuit operation can be clearly shown in the fig 7.1.

RELAY DRIVER CIRCUIT

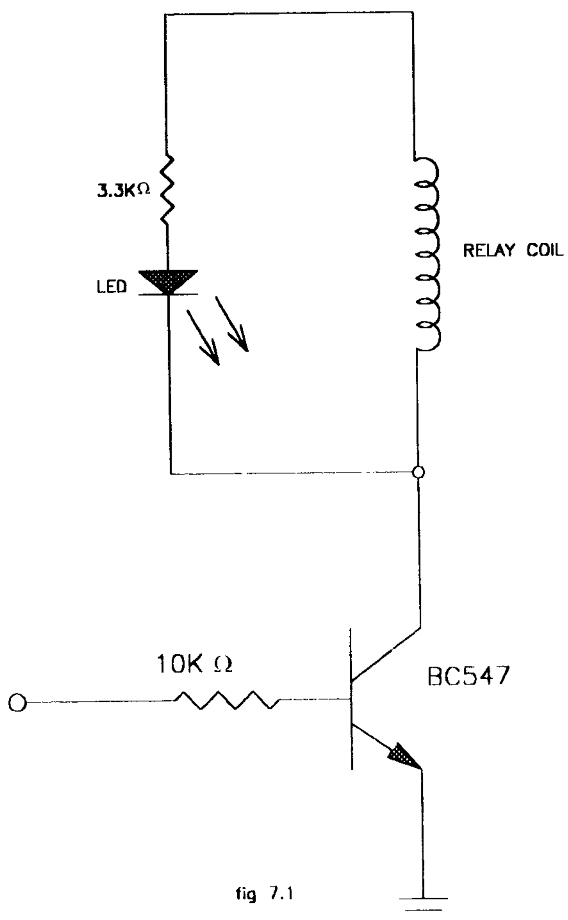


fig 7.1

CHAPTER 8

DISPLAY UNIT

The display unit consist of 7447 driver circuit and LED display. The entire circuit is shown in the fig 8.1.

8.1 7447 DRIVER CIRCUIT:

7447 is used to drive a single seven segment common anode display. For a common anode display a low is applied to a segment to turn it on. When a BCD code is sent to the inputs of the 7447, it outputs lows on the segments required to display the number represented by the BCD code. The current limiting resistors (470ohm) are required in series with each segment.

8.2 LIGHT EMITTING DIODE (LED)

The transducers produce electrical signals from light; the opposite is done by a light-emitting diode. An LED consists of a junction diode made from the semi conducting compound gallium arsenide phosphide. It emits light when light when forward biased, the colour depending on the composition and impurity content of the compound. At present red, yellow and green LEDs are available.

The advantages of LEDs are small size, reliability long small current requirement and high operating speed.

MICROCONTROLLER AND ITS DISPLAY

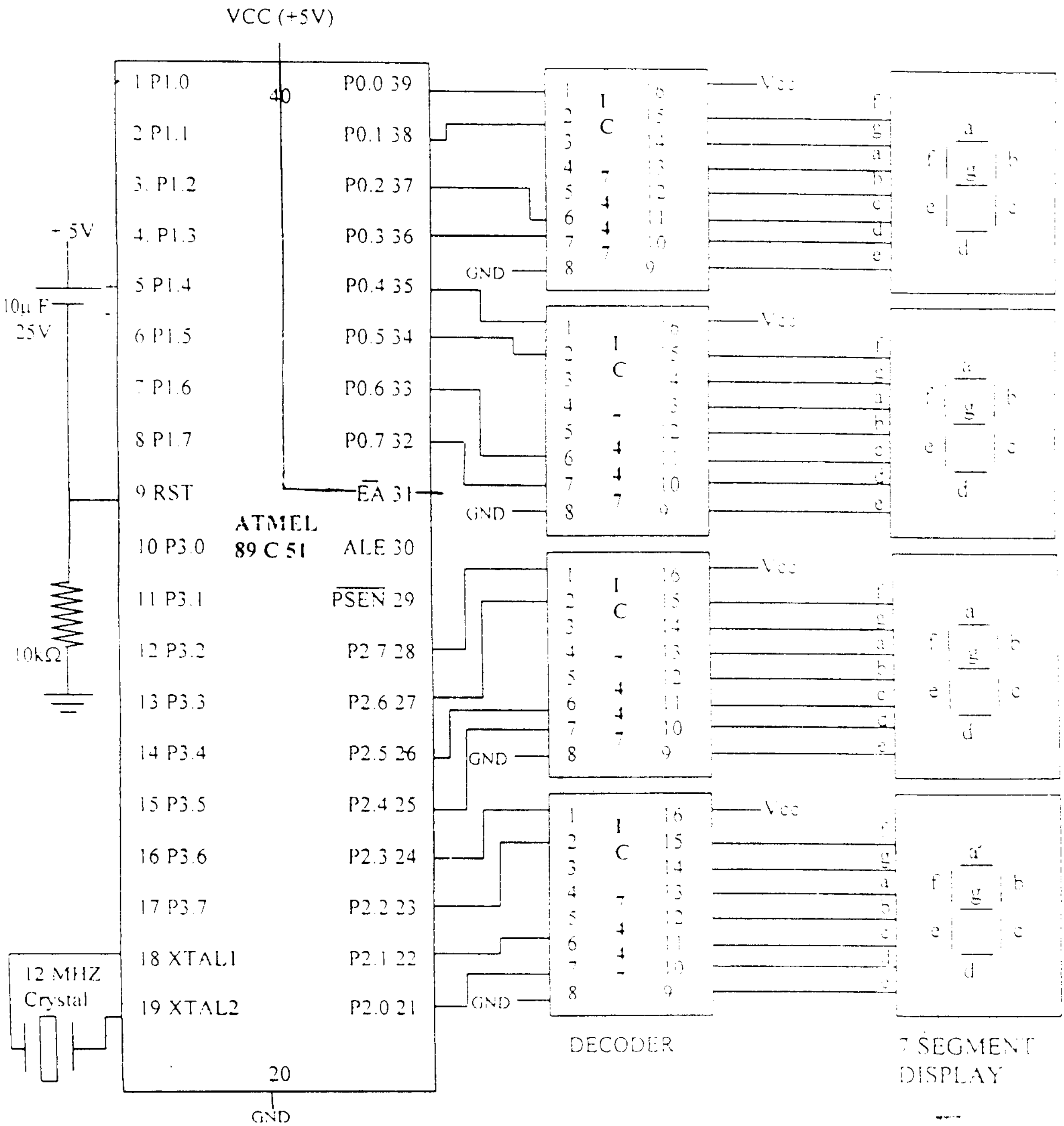


FIG 8.1 DISPLAY UNIT

CHAPTER 9

SOFTWARE

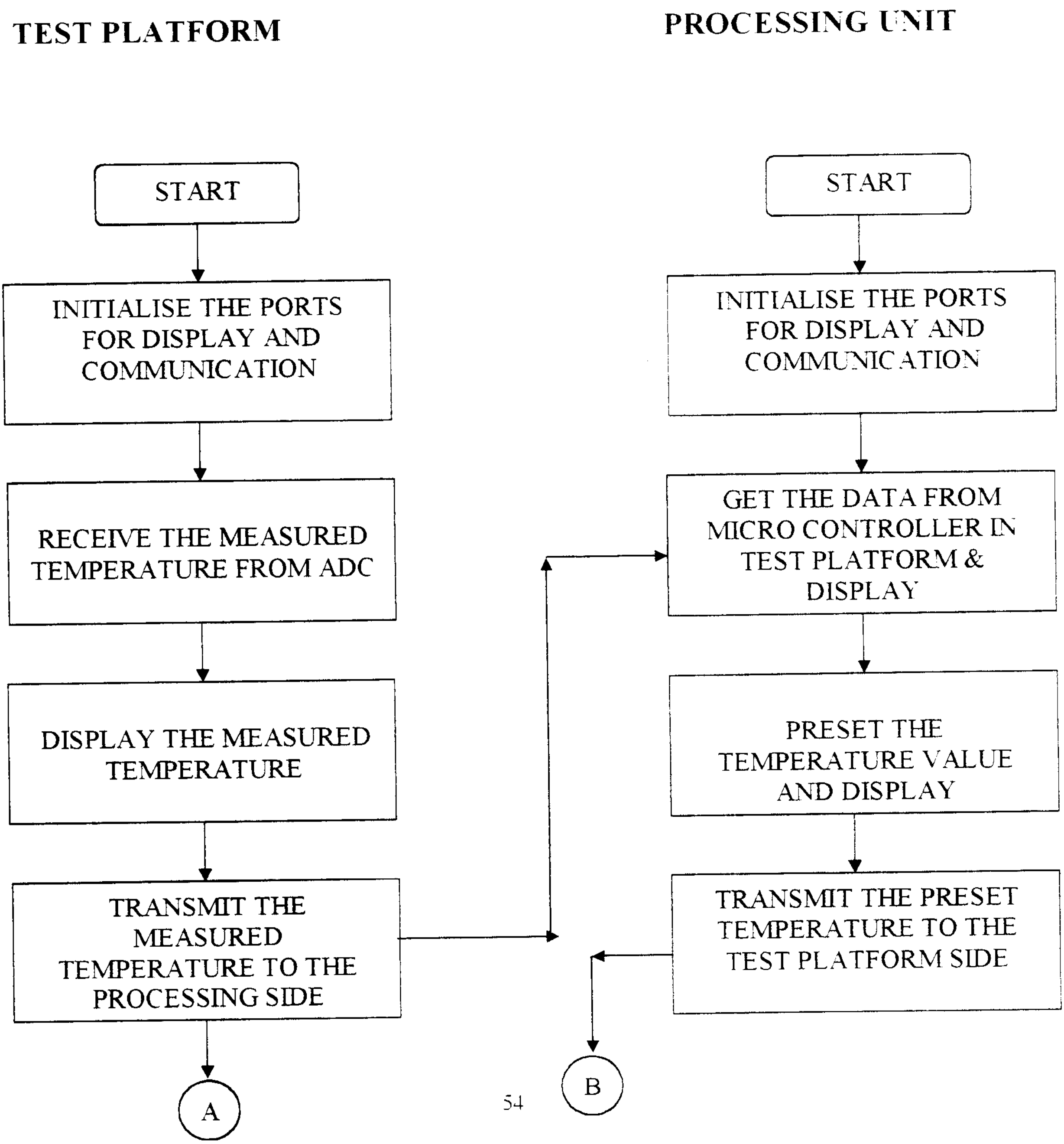
There are two microcontrollers used in our project one at the test platform side and other at the processing side .the first microcontroller in the test platform is programmed for performing the following tasks:

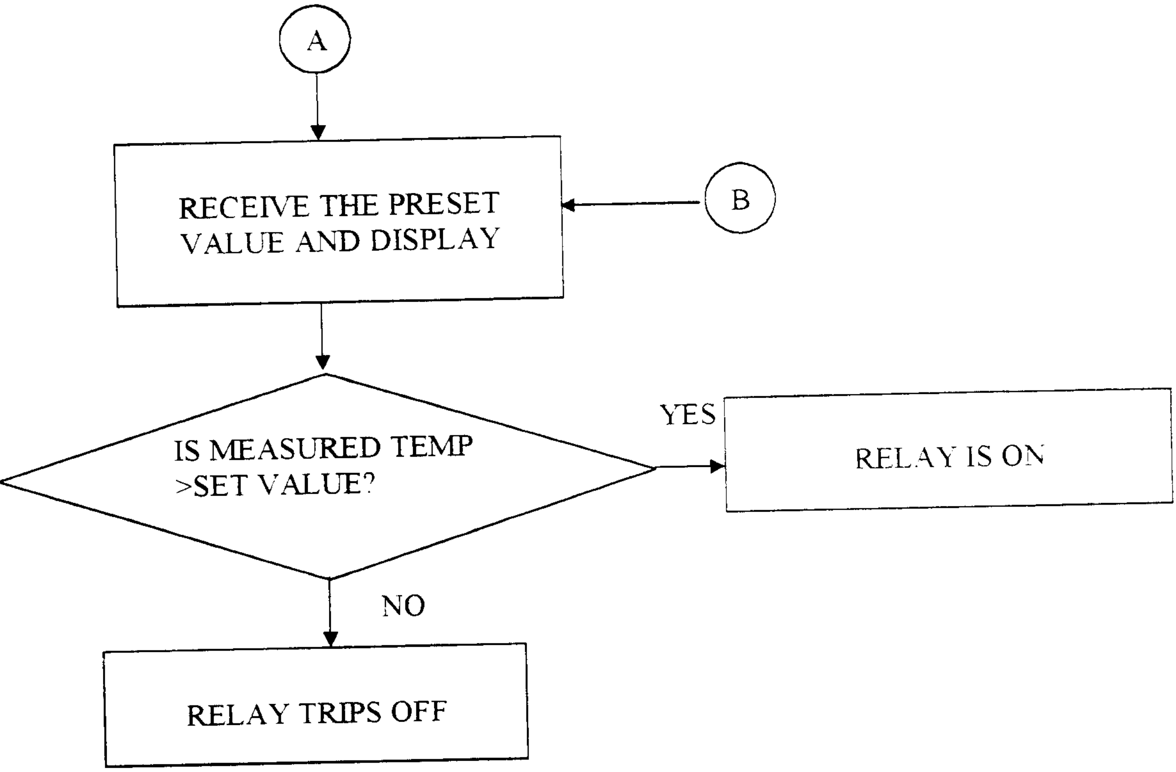
1. Displays the measured temperature.
2. Transmits the output of ADC to laser diode.
3. Receives the preset value and displays it.
4. Compares the measured temperature and the preset value which controls the operation of the relay.

The second microcontroller at the processing side is programmed for performing the following tasks:

1. Displays the preset value and also the measured temperature.
2. Transmits the preset value to the test platform.

9.1 FLOW CHART




A
RECEIVE THE PRESET VALUE AND DISPLAY
B
IS MEASURED TEMP >SET VALUE?
YES
RELAY IS ON
NO
RELAY TRIPS OFF

9.2(a) CODINGS FOR THE MICROCONTROLLER

IN THE RECEIVER SIDE

```
        org    0000h              /*START OF THE PROGRAM*/
        mov    p0,#00h
        mov    p2,#00h
        lcall  ser_init
        setb   ie.7
        setb   ie.4
        clr    p3.7
        ljmp   main
        org    0023h
        ljmp   rec_data
main:   lcall  adc_in0            /*MAIN PROGRAM*/
        lcall  trans
        lcall  hex_dec0
        lcall  comp
        ljmp   main
```

```
ser_init:   mov   tmod,#21h        /*SERIAL DATA COMMUNICATION*/
            mov   th1,#0aah
            mov   tcon,#40h
            mov   scon,#58h
            lcall del
            ret
adc_in0:    clr   p3.2             /*CHANNEL INTIALIZATION FOR ADC*/
            clr   p3.3
            clr   p3.4
            setb  p3.5
            nop
            nop
            nop
            nop
            nop
            clr   p3.5
            lcall del
            mov   a,p1
            mov   32h,a
            ret
```

```
trans:      mov   a,32h      /*TRANSMISSION TO THE PROCCESING SIDE*/
            mov   sbuf,a
            lcall del
            mov   scon,#58h
            ret
hex_dec:    mov   a,70h             /* HEX TO DECIMAL  FOR DISPLAY*/
            mov   b,#64h
            div   ab
            mov   p2,a
            mov   a,b
            mov   b,#0ah
            div   ab
            swap  a
            orl   a,b
            mov   p0,a
            ret
hex_dec0:   mov   a,32h
            mov   b,#64h
            div   ab
            mov   p2,a
```

```
          mov     a,b
          mov     b,#0ah
          div     ab
          swap    a
          orl     a,b
          mov     p0,a
          ret
del:      mov     r1,#0ffh          /*DELAY PROGRAM*/
loops1:   mov     r2,#0ffh
loopd2:   djnz    r2,loopd2
          djnz    r1,loops1
          ret
rec_data: mov     a,sbuf            /*RECEIVE THE PRESET VALUE*/
          mov     70h,a
          mov     71h,a
          mov     scon,#58h
          lcall   hex_dec
          lcall   del
          lcall   del
```

```
        lcall   del
        lcall   del
        lcall   del
        lcall   del
        reti
comp:   mov     a,71h           /*RELAY OPERATION*/
        mov     b,32h
        subb    a,b
        jc      rel_off
        setb    p3.7
        ret
rel_off: clr    p3.7
        ret
```

9.2(b) CODINGS FOR THE MICROCONTROLLER IN THE TRANSMITTER SIDE

```
        org     0000h           /*START OF THE PROGRAM*/
        mov     p1,#0ffh
        mov     p0,#00h
        mov     p2,#00h
        mov     30h,#00h
        mov     31h,#00h
        mov     32h,#00h
        mov     33h,#00h
        lcall   ser_init
main:   lcall   key_chk   /*MAIN PROGRAM*/
        mov     a,21h
        cjne    a,#0eh,cnt1
        lcall   del             /*INCREMENT KEY*/
        inc     30h
        lcall   hex_dec
        ljmp    main
```

```
cntl:      cjne   a,#0dh,cnt2
           lcall  del
           dec    30h           /*DECREMENT KEY*/
           lcall  hex_dec
           ljmp   main
cnt2:      cjne   a,#0bh,cnt3
           lcall  del
           lcall  trans
           mov    p2,#0ffh
           mov    p0,#0ffh
           lcall  del
           lcall  del
           lcall  del
loop:      lcall  receive
           lcall  hex_dec0
           mov    p1,#0ffh
           lcall  key_chk
           ;lcall comp
           mov    a,21h
```

```
            cjne   a,#0fh,main
            ljmp   loop
cnt3:       ljmp   main
trans:      mov    a,30h   /*TRANSMIT DATA*/
            mov    sbuf,a
            lcall  del
            mov    scon,#58h
            ret
hex_dec0:   mov    a,70h   /*HEX TO DECIMAL FOR DISPLAY*/
            mov    b,#64h
            div    ab
            mov    p2,a
            mov    a,b
            mov    b,#0ah
            div    ab
            swap   a
            orl    a,b
            mov    p0,a
            ret
comp:       mov    a,30h
```

```
          mov    b,32h
          subb   a,b
          jc     rel_off
          ret
rel_off:  clr    p3.7
          ret
del:      mov    50h,#0ffh
lopp:     mov    r2,#0ffh
loppl:    djnz   r2,loppl
          djnz   50h,lopp
          ret
delay:    mov    r3,#0ffh
lop:      mov    r4,#0ffh
lopl:     djnz   r4,lopl
          djnz   r3,lop
          ret
key_chk:  mov    21h,#00h   /*detecting key press*/
          mov    c,p1.0
          mov    08,c
          mov    c,p1.1
```

```
         mov   09,c
         mov   c,p1.2
         mov   0ah,c
         mov   c,p1.3
         mov   0bh,c
         ret
hex_dec: mov   a,30h
         mov   b,#64h
         div   ab
         mov   p2,a
         mov   a,b
         mov   b,#0ah
         div   ab
         swap  a
         orl   a,b
         mov   p0,a
         ret
ser_init: mov  tmod,#21h
         mov   th1,#0aah
         mov   tcon,#40h
```

```
            mov   scon,#58h
            lcall del
            ret
receive:    mov   a,scon
            anl   a,#01h
            cjne  a,#01h,receive
            mov   a,sbuf
            mov   70h,a
            mov   scon,#58h
            ret
```

CONCLUSION

CONCLUSION

Temperature indicator and controller is implemented using 89C51 microcontroller with laser as communication medium. Using this temperature can be measured accurately with rapid speed also temperature can be measured from a distance of nearly 200m. The conventional temperature indicator shows a wide range of variation in the order of ±20°C whereas our project has little variation of ±5°C.Also the cost of laying the cables for such a long distances is avoided. The unique features of this project will make important inroads in the temperature testing community. Thus we conclude that laser based temperature indicator and controller is effective, fast and economical than the conventional method of using cables.

In this competitive world technology never comes to an end. We can design and implement various products based on our need. The simplest and cheapest products gain tremendous importance. In our project we have implemented data communication through laser .The future developments of this project are as follows:

- Use of laser for non contact temperature measurements can be developed.
- It can be extended to measure and control the negative temperature ranges.
- Data management software can be developed with it to organize, display and print temperature and time data.
- We can even increase the number of parameters like pressure, humidity and level of the object in the same unit.

APPENDIX

eatures

- Compatible with MCS-51™ Products
- 4K Bytes of In-System Reprogrammable Flash Memory
  - – Endurance: 1,000 Write/Erase Cycles
- Fully Static Operation: 0 Hz to 24 MHz
- Three-level Program Memory Lock
- 128 x 8-bit Internal RAM
- 32 Programmable I/O Lines
- Two 16-bit Timer/Counters
- Six Interrupt Sources
- Programmable Serial Channel
- Low-power Idle and Power-down Modes

8-bit Microcontroller with 4K Bytes Flash

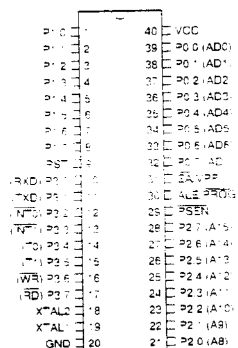
AT89C51

Description

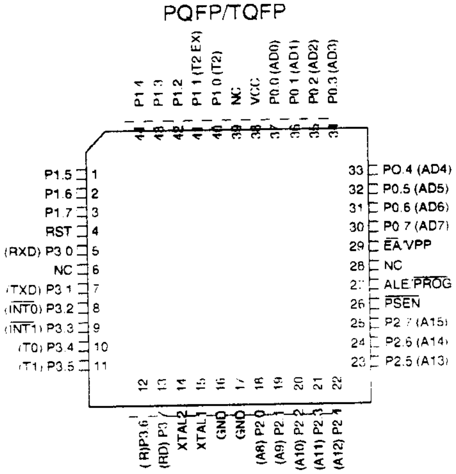
he AT89C51 is a low-power, high-performance CMOS 8-bit microcomputer with 4K ytes of Flash programmable and erasable read only memory (PEROM). The device s manufactured using Atmel's high-density nonvolatile memory technology and is ompatible with the industry-standard MCS-51 instruction set and pinout. The on-chip Flash allows the program memory to be reprogrammed in-system or by a conven-ional 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.

Pin Configurations

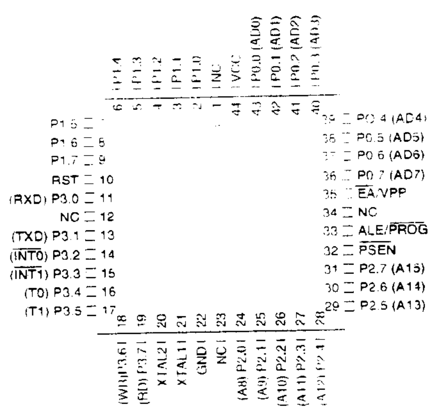
PDIP



PQFP/TQFP

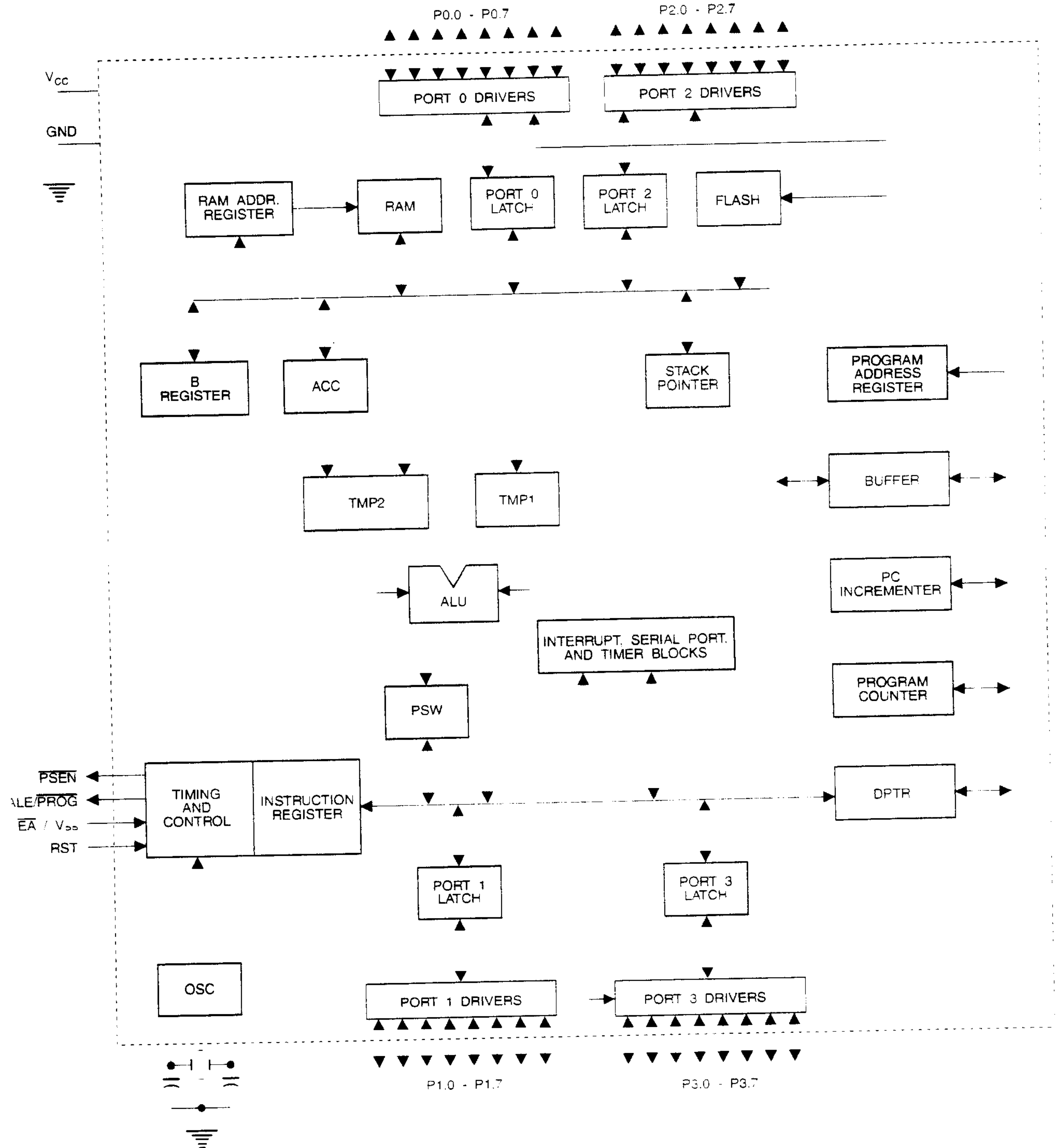


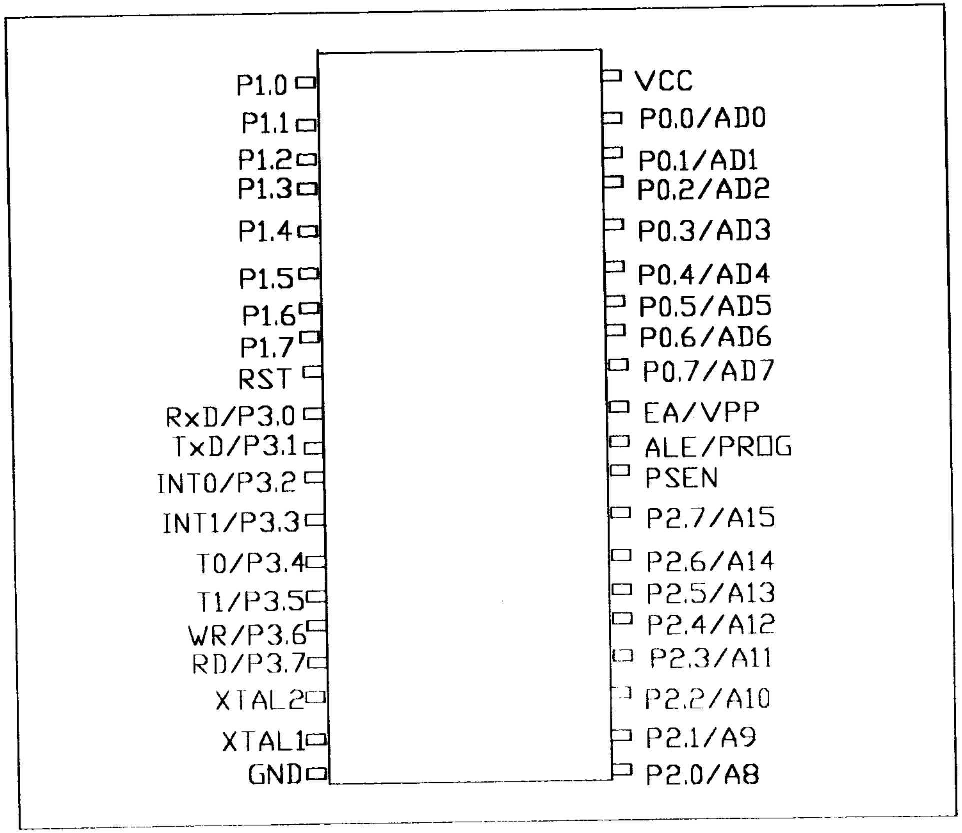
PLCC



Rev. 0265G–02/00

Block Diagram





IC89C51 PINCONFIGURATION

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

October 1999

National Semiconductor

ADC0808/ADC0809
8-Bit µP Compatible A/D Converters with 8-Channel Multiplexer

General Description

The ADC0808, ADC0809 data acquisition component is a monolithic CMOS device with an 8-bit analog-to-digital converter, 8-channel multiplexer and microprocessor compatible control logic. The 8-bit A/D converter uses successive approximation as the conversion technique. The converter features a high impedance chopper stabilized comparator, a 256R voltage divider with analog switch tree and a successive approximation register. The 8-channel multiplexer can directly access any of 8-single-ended analog signals.

The device eliminates the need for external zero and full-scale adjustments. Easy interfacing to microprocessors is provided by the latched and decoded multiplexer address inputs and latched TTL TRI-STATE® outputs.

The design of the ADC0808, ADC0809 has been optimized by incorporating the most desirable aspects of several A/D conversion techniques. The ADC0808, ADC0809 offers high speed, high accuracy, minimal temperature dependence, excellent long-term accuracy and repeatability, and consumes minimal power. These features make this device ideally suited to applications from process and machine control to consumer and automotive applications. For 16-channel multiplexer with common output (sample/hold port) see ADC0816 data sheet. (See AN-247 for more information.)

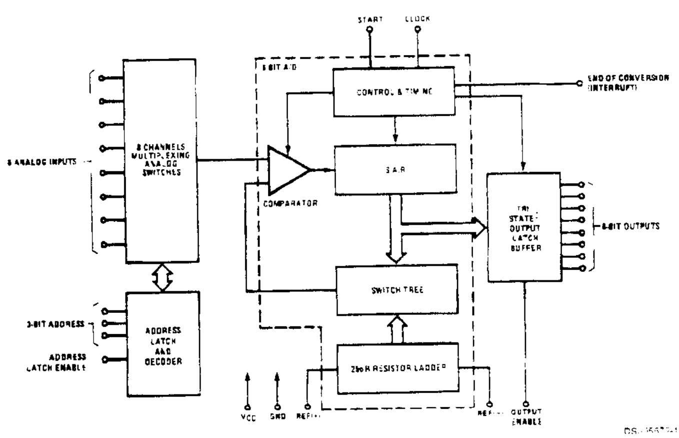
Features

- Easy interface to all microprocessors
- Operates ratiometrically or with 5 V_{DC} or analog span adjusted voltage reference
- No zero or full-scale adjust required
- 8-channel multiplexer with address logic
- 0V to 5V input range with single 5V power supply
- Outputs meet TTL voltage level specifications
- Standard hermetic or molded 28-pin DIP package
- 28-pin molded chip carrier package
- ADC0808 equivalent to MM74C949
- ADC0809 equivalent to MM74C949-1

Key Specifications

■ Resolution	8 Bits
■ Total Unadjusted Error	±½ LSB and ±1 LSB
■ Single Supply	5 V_{DC}
■ Low Power	15 mW
■ Conversion Time	100 µs

Block Diagram



See Ordering Information

TRI-STATE® is a registered trademark of National Semiconductor Corp.

Absolute Maximum Ratings (Notes 2, 1)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/ Distributors for availability and specifications.

Supply Voltage (V_{CC}) (Note 3)	6.5V
Voltage at Any Pin	−0.3V to (V_{CC}+0.3V)
Except Control Inputs	
Voltage at Control Inputs	−0.3V to +15V
(START, OE, CLOCK, ALE, ADD A, ADD B, ADD C)	
Storage Temperature Range	−65°C to +150°C
Package Dissipation at T_A=25°C	875 mW
Lead Temp. (Soldering, 10 seconds)	
Dual-In-Line Package (plastic)	260°C
Dual-In-Line Package (ceramic)	300°C
Molded Chip Carrier Package	
Vapor Phase (60 seconds)	215°C
Infrared (15 seconds)	220°C
ESD Susceptibility (Note 8)	400V

Operating Conditions (Notes 1, 2)

Temperature Range (Note 1)	$T_{MIN} \le T_A \le T_{MAX}$
ADC0808CCN, ADC0809CCN	$-40°C \le T_A \le +85°C$
ADC0808CCV, ADC0809CCV	$-40°C \le T_A \le +85°C$
Range of V_{CC} (Note 1)	4.5 V_{DC} to 6.0 V_{DC}

Electrical Characteristics

Converter Specifications: V_{CC}=5 V_{DC}=V_{REF+}, $V_{REF(-)}$=GND, $T_{MIN} \le T_A \le T_{MAX}$ and f_{CLK}=640 kHz unless otherwise stated.

Symbol	Parameter	Conditions	Min	Typ	Max	Units
	ADC0808 Total Unadjusted Error (Note 5)	25°C			±½	LSB
		T_{MIN} to T_{MAX}			±¾	LSB
	ADC0809 Total Unadjusted Error (Note 5)	0°C to 70°C			±1	LSB
		T_{MIN} to T_{MAX}			±1¼	LSB
	Input Resistance	From Ref(+) to Ref(−)	1.0	2.5		kΩ
	Analog Input Voltage Range	(Note 4) V(+) or V(−)	GND−0.10		V_{CC}+0.10	V_{DC}
$V_{REF(+)}$	Voltage, Top of Ladder	Measured at Ref(+)		V_{CC}	V_{CC}+0.1	V
$\frac{V_{REF(+)}+V_{REF(-)}}{2}$	Voltage, Center of Ladder		V_{CC}/2-0.1	V_{CC}/2	V_{CC}/2+0.1	V
$V_{REF(-)}$	Voltage, Bottom of Ladder	Measured at Ref(−)	−0.1	0		V
I_{IN}	Comparator Input Current	f_c=640 kHz, (Note 6)	−2	±0.5	2	μA

Electrical Characteristics

Digital Levels and DC Specifications: ADC0808CCN, ADC0808CCV, ADC0809CCN and ADC0809CCV, $4.75 \le V_{CC} \le 5.25V$, $-40°C \le T_A \le +85°C$ unless otherwise noted

Symbol	Parameter	Conditions	Min	Typ	Max	Units
ANALOG MULTIPLEXER						
$I_{OFF(+)}$	OFF Channel Leakage Current	V_{CC}=5V, V_{IN}=5V, T_A=25°C		10	200	nA
		T_{MIN} to T_{MAX}			1.0	μA
$I_{OFF(-)}$	OFF Channel Leakage Current	V_{CC}=5V, V_{IN}=0, T_A=25°C	−200	−10		nA
		T_{MIN} to T_{MAX}	−1.0			μA
CONTROL INPUTS						
$V_{IN(1)}$	Logical "1" Input Voltage		V_{CC}−1.5			V
$V_{IN(0)}$	Logical "0" Input Voltage				1.5	V
$I_{IN(1)}$	Logical "1" Input Current (The Control Inputs)	V_{IN}=15V			1.0	μA
$I_{IN(0)}$	Logical "0" Input Current (The Control Inputs)	V_{IN}=0	−1.0			μA
I_{CC}	Supply Current	f_{CLK}=640 kHz		0.3	3.0	mA

Electrical Characteristics (Continued)

Digital Levels and DC Specifications: ADC0808CCN, ADC0808CCV, ADC0809CCN and ADC0809CCV, $4.75 \le V_{CC} \le 5.25V$, $-40^{\circ}C \le T_A \le +85^{\circ}C$ unless otherwise noted

Symbol	Parameter	Conditions	Min	Typ	Max	Units
DATA OUTPUTS AND EOC (INTERRUPT)						
$V_{OUT(1)}$	Logical "1" Output Voltage	V_{CC} = 4.75V I_{OUT} = −360µA I_{OUT} = −10µA		2.4 4.5		V(min) V(min)
$V_{OUT(0)}$	Logical "0" Output Voltage	I_O=1.6 mA			0.45	V
$V_{OUT(0)}$	Logical "0" Output Voltage EOC	I_O=1.2 mA			0.45	V
I_{OUT}	TRI-STATE Output Current	V_O=5V V_O=0	 −3		3	µA µA

Electrical Characteristics

Timing Specifications $V_{CC}=V_{REF(+)}=5V$, $V_{REF(-)}$=GND, $t_r=t_f$=20 ns and $T_A=25^{\circ}C$ unless otherwise noted.

Symbol	Parameter	Conditions	Min	Typ	Max	Units
t_{WS}	Minimum Start Pulse Width	(*Figure 5*)		100	200	ns
t_{WALE}	Minimum ALE Pulse Width	(*Figure 5*)		100	200	ns
t_s	Minimum Address Set-Up Time	(*Figure 5*)		25	50	ns
t_H	Minimum Address Hold Time	(*Figure 5*)		25	50	ns
t_D	Analog MUX Delay Time From ALE	R_S=0Ω (*Figure 5*)		1	2.5	µs
t_{H1}, t_{H0}	OE Control to Q Logic State	C_L=50 pF, R_L=10k (*Figure 8*)		125	250	ns
t_{1H}, t_{0H}	OE Control to Hi-Z	C_L=10 pF, R_L=10k (*Figure 8*)		125	250	ns
t_c	Conversion Time	f_c=640 kHz, (*Figure 5*) (Note 7)	90	100	116	µs
f_c	Clock Frequency		10	640	1280	kHz
t_{EOC}	EOC Delay Time	(*Figure 5*)	0		8+2 µS	Clock Periods
C_{IN}	Input Capacitance	At Control Inputs		10	15	pF
C_{OUT}	TRI-STATE Output Capacitance	At TRI-STATE Outputs		10	15	pF

Note 1: Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. DC and AC electrical specifications do not apply when operating the device beyond its specified operating conditions.

Note 2: All voltages are measured with respect to GND, unless othewise specified.

Note 3: A zener diode exists, internally, from V_{CC} to GND and has a typical breakdown voltage of 7 V_{DC}.

Note 4: Two on-chip diodes are tied to each analog input which will forward conduct for analog input voltages one diode drop below ground or one diode drop greater than the V_{CC}n supply. The spec allows 100 mV forward bias of either diode. This means that as long as the analog V_{IN} does not exceed the supply voltage by more than 100 mV, the output code will be correct. To achieve an absolute $0V_{DC}$ to $5V_{DC}$ input voltage range will therefore require a minimum supply voltage of 4.900 V_{DC} over temperature variations, initial tolerance and loading.

Note 5: Total unadjusted error includes offset, full-scale, linearity, and multiplexer errors. See *Figure 3*. None of these A/Ds requires a zero or full-scale adjust. However, if an all zero code is desired for an analog input other than 0.0V, or if a narrow full-scale span exists (for example: 0.5V to 4.5V full-scale) the reference voltages can be adjusted to achieve this. See *Figure 13*.

Note 6: Comparator input current is a bias current into or out of the chopper stabilized comparator. The bias current varies directly with clock frequency and has little temperature dependence (*Figure 6*). See paragraph 4.0.

Note 7: The outputs of the data register are updated one clock cycle before the rising edge of EOC.

Note 8: Human body model, 100 pF discharged through a 1.5 kΩ resistor.

Functional Description (Continued)

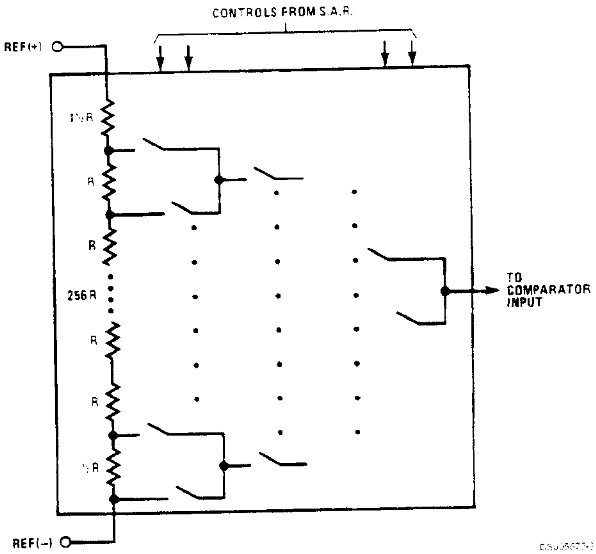


FIGURE 1. Resistor Ladder and Switch Tree

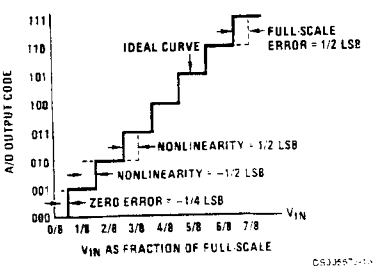


FIGURE 2. 3-Bit A/D Transfer Curve

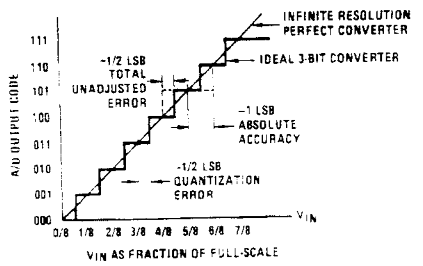


FIGURE 3. 3-Bit A/D Absolute Accuracy Curve

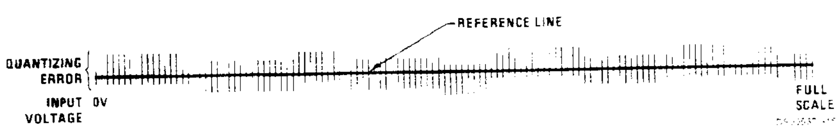
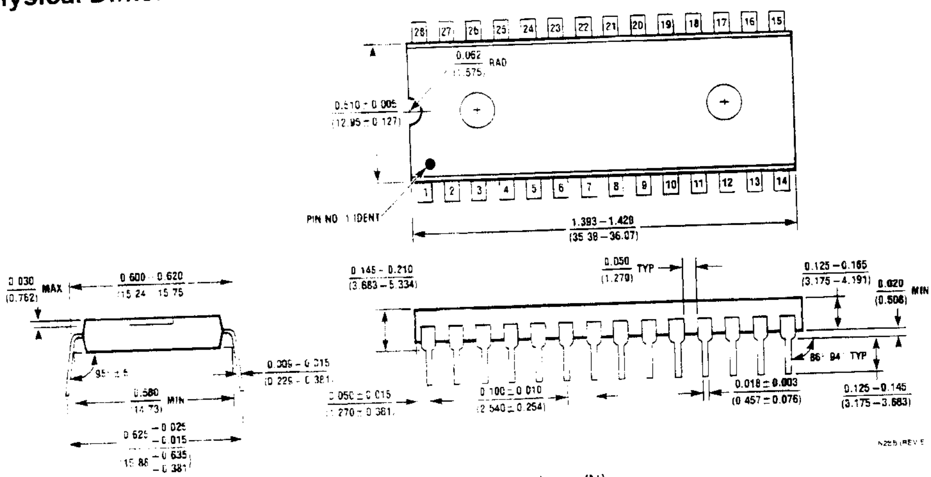
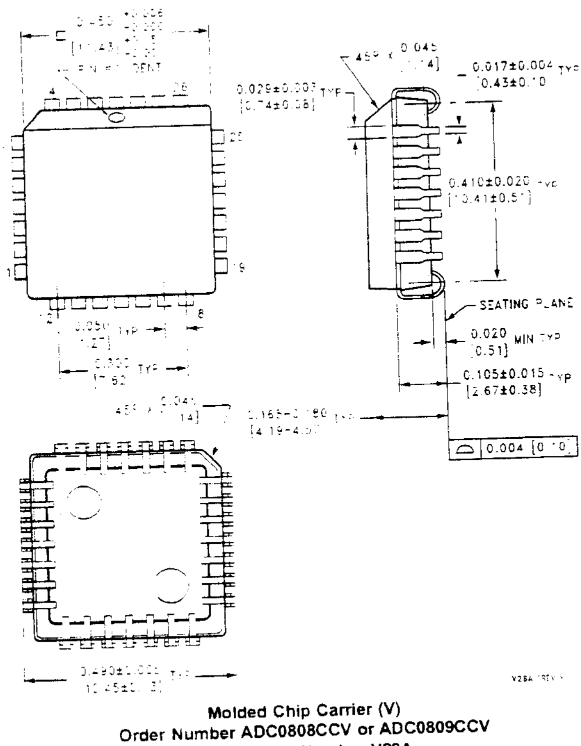


FIGURE 4. Typical Error Curve

Physical Dimensions inches (millimeters) unless otherwise noted



Molded Dual-In-Line Package (N)
Order Number ADC0808CCN or ADC0809CCN
NS Package Number N28B



Molded Chip Carrier (V)
Order Number ADC0808CCV or ADC0809CCV
NS Package Number V28A