P-706

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING
KUMARAGURU COLLEGE OF TECHNOLOGY
COIMBATORE-641 006.

CERTIFICATE

This is to certify that the project entitled

"MOTOR MONITORING SYSTEM USING PIC MICROCONTROLLER"

has been submitted by

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SYNOPSIS

Monitoring the electrical parameters of a motor is essential in college laboratories and industries.For the measurement of electrical parameters.Individual meters are used to measure current, voltage, speed, Temperature and frequency. Individual meters increase the cost and space required .also human error is unavoidable during observation. So we have developed an Instrument which measures all the electrical parameters using single instrument. A PIC microcontroller is used as processor which reads all the electrical parameters from the motor through Analog to Digital Converter and displays all the electrical parameters using seven segments LED Display sequentially. Since we have used embedded technology, the hardware is very compact in size and the cost involved is also very low.

CONTENTS

CHAPTER	PAGE NO.
CERTIFICATE	2
ACKNOWLEDGEMENT	4
SYNOPSIS	5
CONTENTS	6
CHAPTER 1	
1. INTRODUCTION	
1.1. CONCEPTS OF MICROCONTROLLER	11
1.2. GENERAL BLOCK DIAGRAM	12
CHAPTER 2	
2. PIC 16C628 MICROCONTROLLER	
2.1. Architecture of PIC 16C628	15
2.2. Features of PIC 16C628	22
2.3. Special Features of PIC 16C628	22
CHAPTER 3	
3. HARDWARE	
3.1. Measurement of Voltage	24
3.2. Measurement of Current	24
3.3. Measurement of Speed	25
3.4. Measurement of Temperature	26
3.5. Measurement of Frequency	27
3.6. Processor section	27
3.7 Display section	28
3.8. Description of Hardware Design	29
CHAPTER 4	
4. SOFTWARE	
4.1. Flow chart	30
4.2. Coding	32
CHAPTER 5	
5. CONCLUSION	46
BIBLIOGRAPHY	48
APPENDIX:	
(i) Pin Configuration	
(ii)PCB Layout	

CHAPTER-1

INTRODUCTION

P.706

Most men are supposed to devote their time on creative work in order to improve the way and standard of living and comfort for the human society. But in reality many are employed only in doing the same work in a mechanical manner. Doing the same type of work repeatedly for days together cause strain and fatigue. Hence he has limitation in respect of speed and perfection while doing any repeated and routine jobs.

1.1. CONCEPTS OF MICROCONTROLLER

A microcontroller – one of the great inventions in digital electronics comes to rescue of the human being from the above drawbacks. Then the microcontrollers have begun to occupy a prime position in our daily life. Now a days microcontroller are used in computer,robotics,control of missile, satellite and industrial process control, biomedical field etc, to get accuracy, speed of work and easy to handle.

Motor monitoring is one of the essential requirements in college laboratories and industrial testing. For this individual meter are used for measurement of various parameters. Due to this size and cost is more and also human errors are introduced when readings are taken. The errors are avoided by constructing all the individual meters into single one using microcontroller.

1.2. GENERAL BLOCK DIAGRAM

The block diagram representation of Motor Monitoring system is shown in the Fig.1.1

For the measurement of voltage, the voltage input from the motor is stepped down by using suitable potential transformer. The reduced voltage is rectified and filtered and it is given as input to the multiplexer.

For the measurement of Current, the Current input from the motor is stepped down by using suitable potential transformer. The reduced current is rectified and filtered and it is given as input to the multiplexer.

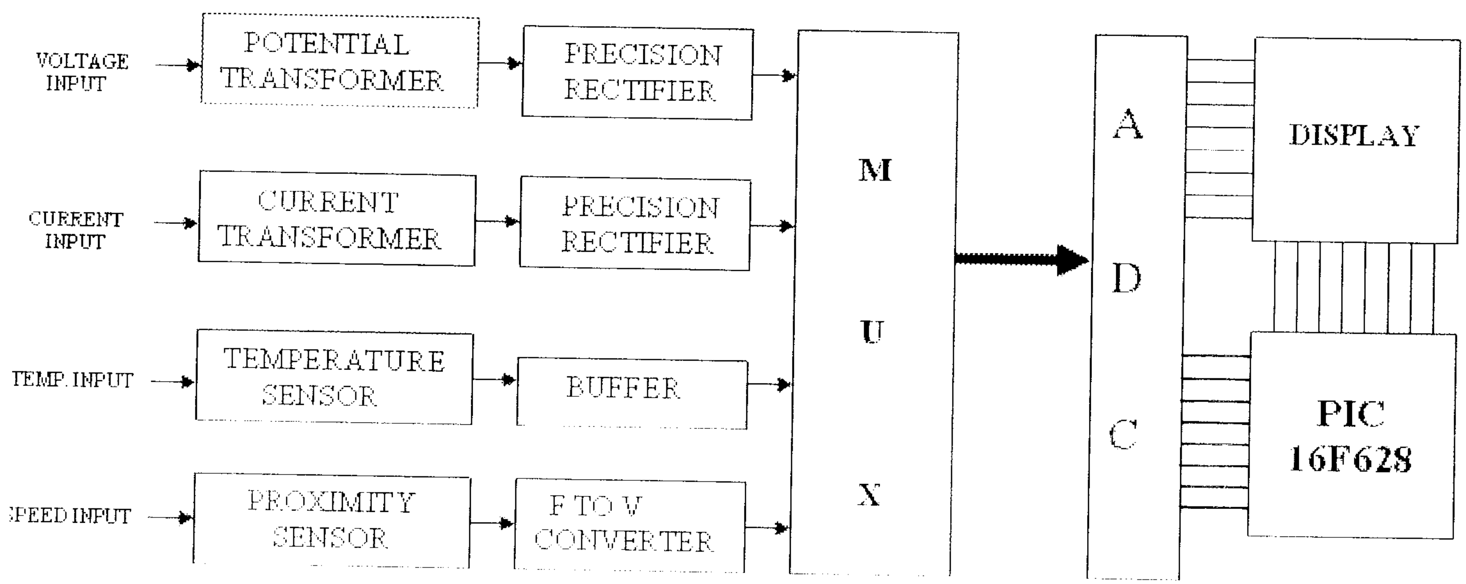
For the measurement of temperature, the sensor which is connected to the motor body senses the temperature and it is converted into electrical signals which is amplified and given as input to the multiplexer.

For the measurement of frequency, the voltage input signal is used. The voltage input signal which crosses the zero levels are measured with the help of PIC microcontroller.

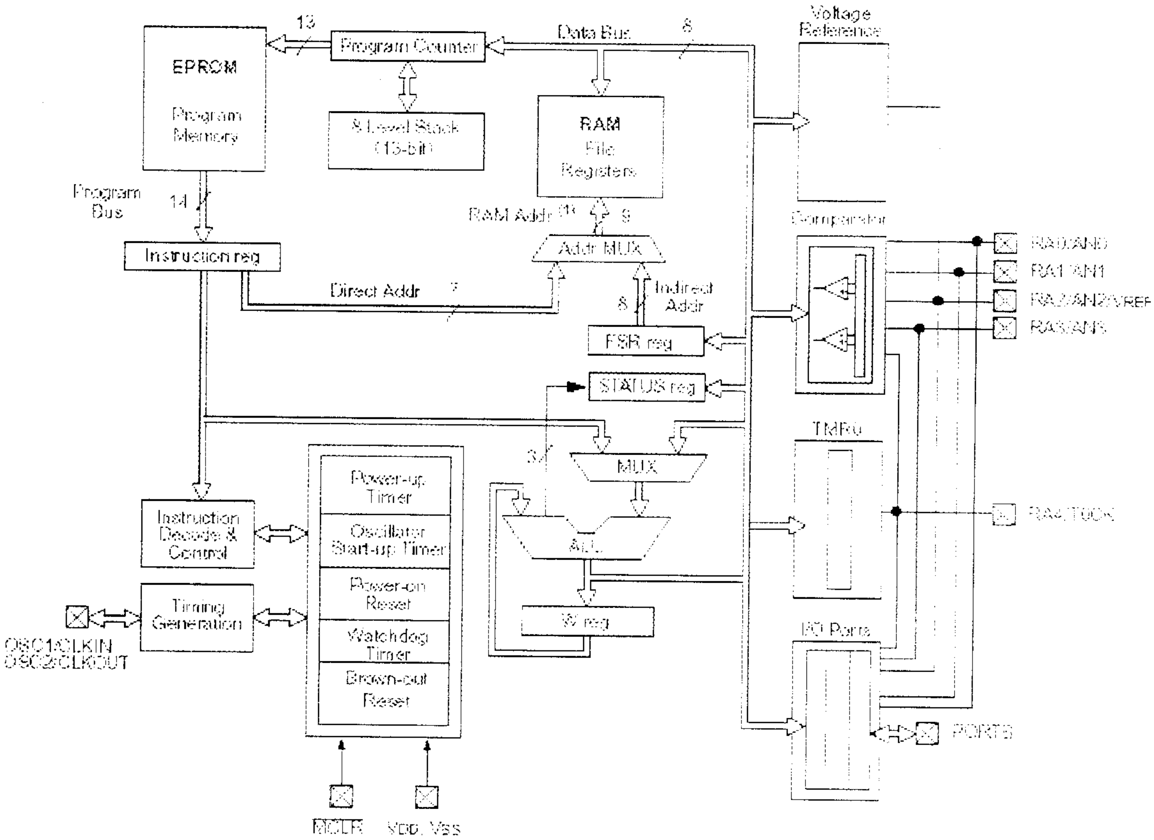
For the measurement of speed, the proximity sensor converts the number of revolutions into pulses. The pulses are again converted into voltage by means of Frequency to Voltage converter and it is given as input to the multiplexer.

All the input parameters are given as input to the multiplexer which allows only one output at a time. The output of the multiplexer is given as input to the Analog to Digital converter which converts the analog input into digital output. The Digital output is given to PIC microcontroller for storage and all the input parameters are displayed by means of seven segment LED display.

BLOCK DIAGRAM



2.1.ARCHITECTRUE OF PIC 16C628



CHAPTER 2

2.1.PIC 16C628 ARCHITECTURE

PIC 16C628 is one of the most popular 8 bit microcontrollers. It is an 18 pin DIP fabricated on a single chip. It clock speed is 10 MHZ. It has 35 single word instructions. The architecture is shown in Fig.2.1. Various blocks are explained below.

2.1.1. ARITHMETIC AND LOGIC UNIT:

The arithmetic and logical unit perform various arithmetic and logical operations such as addition, subtractions, AND, OR, X-OR and rotate an 8 bit number. For ALU operation, one data must be in W register.

2.1.2.W REGISTER:

It is an 8 bit working register used for ALU operations. It is not an addressable register.

2.1.3.STATUS REGISTER:

The status register contains the arithmetic status of ALU, reset status and bank select bit for data memory. There are three flags used to know the status of ALU such as Digit carry flag, Carry flag and zero flag.

2.1.4.PROGRAM COUNTER:

The program counter (pc) is 13 bits wide. The low byte is PCL register which is readable and writable register. The high byte of the pc is neither directly readable nor writable and comes from PCLATH register. It is a register used to store the address of the next instruction to be executed.

2.1.5.STACK:

The PIC 16C628 has an 8 deep x 13 bit wide hardware stack. The stack space is not part of either program or data space. The stack pointer is not readable or writable. The stack operates as circular buffer. (i.e.)After it has been pushed 8 times. the ninth push was stored from first push.

2.1.6.MEMORY ORGANISATION:

There are two memory blocks in PIC 16C628 microcontroller.

1. Program memory.
2. Data memory.

2.1.7.PROGRAM MEMORY ORGANISATION:

The PIC 16C628 has a 13 bit program counter capable of addressing 8kx14 program memory space. For PIC 16C628, the first 1kx14 are physically implemented. Accessing allocation above the physically implemented address will cause a wrap around. For example PIC 16C628 locations 20h. 420h. 820h will be the same instruction.

The reset vector is at 0000h and interrupt vector is at 0004h.

2.1.8.DATA MEMORY ORGANISATION:

The data memory is partitioned into two areas. The first is the Special Function Register (SFR) area, while the second is the General Purpose Register (GPR) area. Data memory is partitioned into two banks which contain GPR & SFR.Bank 0 is selected by clearing the RP0 bit(STATUS).Bank 1 is selected by setting the RP0 bit(STATUS).

2.1.9.GENERAL PURPOSE REGISTER FILE:

All devices have some amount of GPR area. Each GPR is 8 bits wide and is accessed either directly or indirectly through the FSR.

2.1.10SPECIAL FUNCTION REGISTERS:

The Special function Registers are used by CPU and Peripheral function to control the device operation. These registers are static RAM.

2.1.11.I/O PORTS:

The PIC 16C628 has two ports namely Port A & Port B .Some port pins are multiplexed with an alternate function for other features on the device.

2.1.12.PORT A AND TRIS A REGISTERS:

Port A is a 5 bit wide latch.RA4 is a Schmitt Trigger input and open drain output. Setting a TRIS a bit will make the corresponding PORT A pin an input. Clearing a TRIS A bit will make the corresponding PORT A pin an output.

2.1.13.PORT B AND TRIS B REGISTERS:

PORT B is an 8 bit wide bidirectional port .The corresponding data direction register is TRIS B.Clearing a TRIS B bit will make the corresponding PORT B pin an output. Setting a TRIS B bit will make the corresponding PORT B pin an output.

2.1.14.DATA EEPROM MEMORY:

The EEPROM data memory is readable and writable during normal operation. These are four SFRS used to read and write this memory. These registers are

- EECON1
- EECON2
- EEDATA
- EEADDR

EEDATA holds the 8 bit data for read/write and EEADDR holds the address of the EEPROM location being accessed.PIC 16C628 devices have 64 bytes of data EEPROM with and address range form 0h to 3Fh.EECON1 is the control register with five low order bit implemented. Control bits RD and WR initiate read and write respectively.

2.2.FEATURES OF PIC 16C628 MICROCONTROLLER

- Only 35 single word instructions
- All instructions are single cycle except for program branches which are two cycle.
- 14 bit wide instruction
- 8 bit wide data path.
- 15 special function hardware register
- Eight level deep hardware stack
- Direct, Indirect and Relative addressing Modes.
- 13 I/O pins with individual directional control

2.3.SPECIAL FEATURES OF PIC MICROCONTROLLER

- In circuit serial programming
- Power on reset (POR)
- Power up timer (PWRT)
- Selectable Oscillator options
- Watchdog timer (WDT)
- Code protection
- Power saving SLEEP mode

CHAPTER 3

HARDWARE

3.1. MEASUREMENT OF VOLTAGE

In this section, voltage input from the motor is measured. The circuit diagram for voltage measurement is shown in Fig.3.1.It consists of 230/12v step down potential transformer. Bridge rectifier, capacitor filter, protection zener and variable potentiometer. The voltage from motor is given to 230/12v potential transformer where the voltage is reduced to 12v.The bridge rectifier is connected to the secondary of the potential transformer. During the positive half cycle, the diode D1 and D3 conducts and during the negative half cycle, the diode D2 and D4 conducts .So the output voltage is unidirectional. That is the AC voltage is converted into DC voltage. In order to avoid the ripple in the DC output, Capacitor filter is used. The filtered output voltage is available across variable potentiometer which is given as input to the multiplexer.Zener diode is used as a regulating element.

3.2. MEASUREMENT OF CURRENT

In this section, current input from the motor is measured. The circuit diagram for current measurement is shown in Fig.3.2.It consists of 3A/300mA step down current transformer. Bridge rectifier, capacitor filter, protection zener and variable potentiometer. The current from motor is given to 3A/300A current transformer where the current is reduced to 300mA.The bridge rectifier is connected to the secondary of the current transformer. During the positive half cycle, the diode D1 and D3 conducts and during the negative half cycle, the diode D2 and D4 conducts .So the output current is unidirectional. That is the AC current is converted into DC current. In order to avoid the ripple in the DC output, Capacitor filter is used. The filtered output current is available across variable potentiometer which is given as input to the multiplexer.Zener diode is used as a regulating element.

3.3. MEASUREMENT OF SPEED

In the section, the speed of the motor is measured. The circuit diagram for the speed measurement is shown in Fig.3.3.It consists of proximity sensor, Frequency to Voltage converter (2917) and Relay driving circuit. The proximity sensor converts the number of revolutions into pulses. The pulses are given as input to the Frequency to Voltage converter through pin 1.The Frequency to Voltage converter converts the pulses into voltage linearly. The output of the Frequency to Voltage converter is available at pin 3 and 4.which is given as input to the multiplexer.

The reference input for Frequency to Voltage converter is given through potentiometer p3 at pin 10.The internal comparator compares the reference input and measured input. If the measured input is above reference input, the pin 8 will give signal to the transistor which operates the relay to indicate that the speed is increased rated speed.

3.4. MEASUREMENT OF TEMPERATURE

In this section, the motor temperature is measured. The circuit diagram for temperature measurement is shown in Fig.3.4. It consists of an IC LM324, Temperature sensor and Relay driving circuit.

The IC LM324 consists of four op-amps such as A1, A2, A3, A4.The op-amp A1 is used for voltage stabilization.

The Temperature sensor (Diode) is connected between inverting input and output of the op-amp A2.if the temperature varies, the junction drop across the diode varies which results in change in input voltage to inverting terminal of op-amp A2.The output of op-amp A2 is given to inverting terminal op-amp A3 which acts as an amplifier. The output of the op-amp A3 is given as input to the analog multiplexer.

The op-amp A4 acts as a comparator .The op-amp A4 compares the measured temp and reference temperature. If the temperature is above reference valued. the op-amp give signal to the driver circuit which switch on the relay to indicate that the temperature is exceeding the limit, by means of LED.

3.5. MEASUREMENT OF FREQUENCY

For the measurement of frequency, the voltage input signal is used. The voltage input signal which crosses the zero levels are measured with the help of PIC microcontroller. By means of programming, it can be displayed using Seven Segment LED Display.

3.6. PROCESSOR SECTION:

The circuit diagram of processor section is shown in Fig3.6.. It consists of multiplexer, Analog to Digital Converter, Tristate buffer and PIC 16C628 microcontroller. All the input parameters are given as input to the multiplexer .The PIC 16C628 microcontroller send the address to the multiplexer which allows only one parameters at a time to Analog to Digital converter.

After the SOC signal is given to the Analog to Digital converter, it converts the analog signal into Digital signal. After the conversion process, the Analog to Digital converter send EOC signal to microcontroller and the digital data available on the data bus is stored in the memory of the microcontroller.

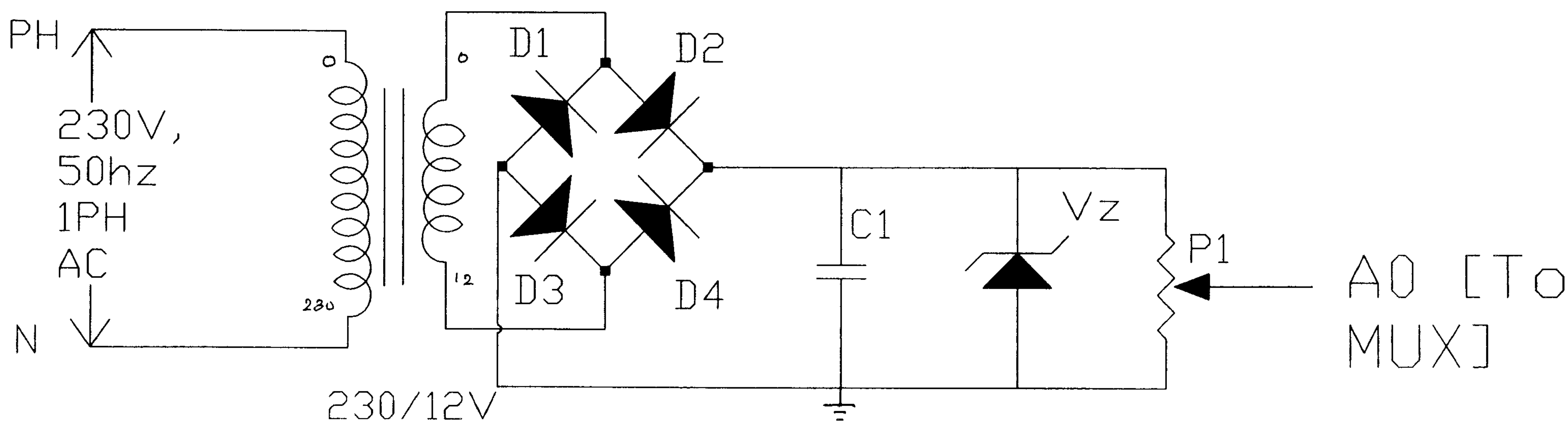
Then the microcontroller sends next address to the multiplexer and the same process continues until all the input parameters are scanned.

There are two tristate buffers used in this section to access the port B pin as input port as well as output port. When Tristate buffer 1 is enabled, port B acts as an input port and when Tristate buffer 2 is enabled, port B acts as an output port.

3.7. DISPLAY SECTION

The circuit diagram of Display section is shown in the Fig.3.6.It consists of four decoders(IC 4094) and four seven segment LED display. Each decoder consists of three important pins called as Data, Strobe, and clock. The Strobe and clock signal is given to all the decoders. The binary data from the microcontroller is given to the data pin of the decoder. After the clock pulse is given, the first data is displayed on the seven segment display and it is shifted to second display and so on. Thus an input parameter is displayed on seven segment LED display.

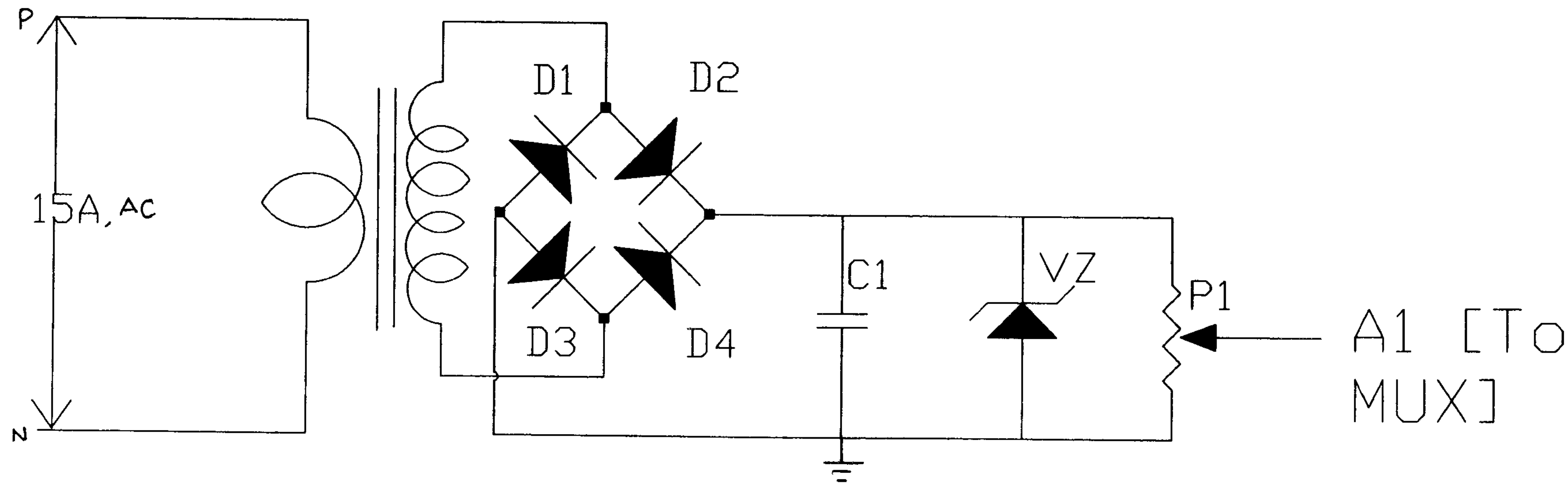
CIRCUIT FOR MEASURING VOLTAGE



D1 = D2 = D3 = D4=1N4001　VZ=5.2v

C1=0.01MF　P1=10k

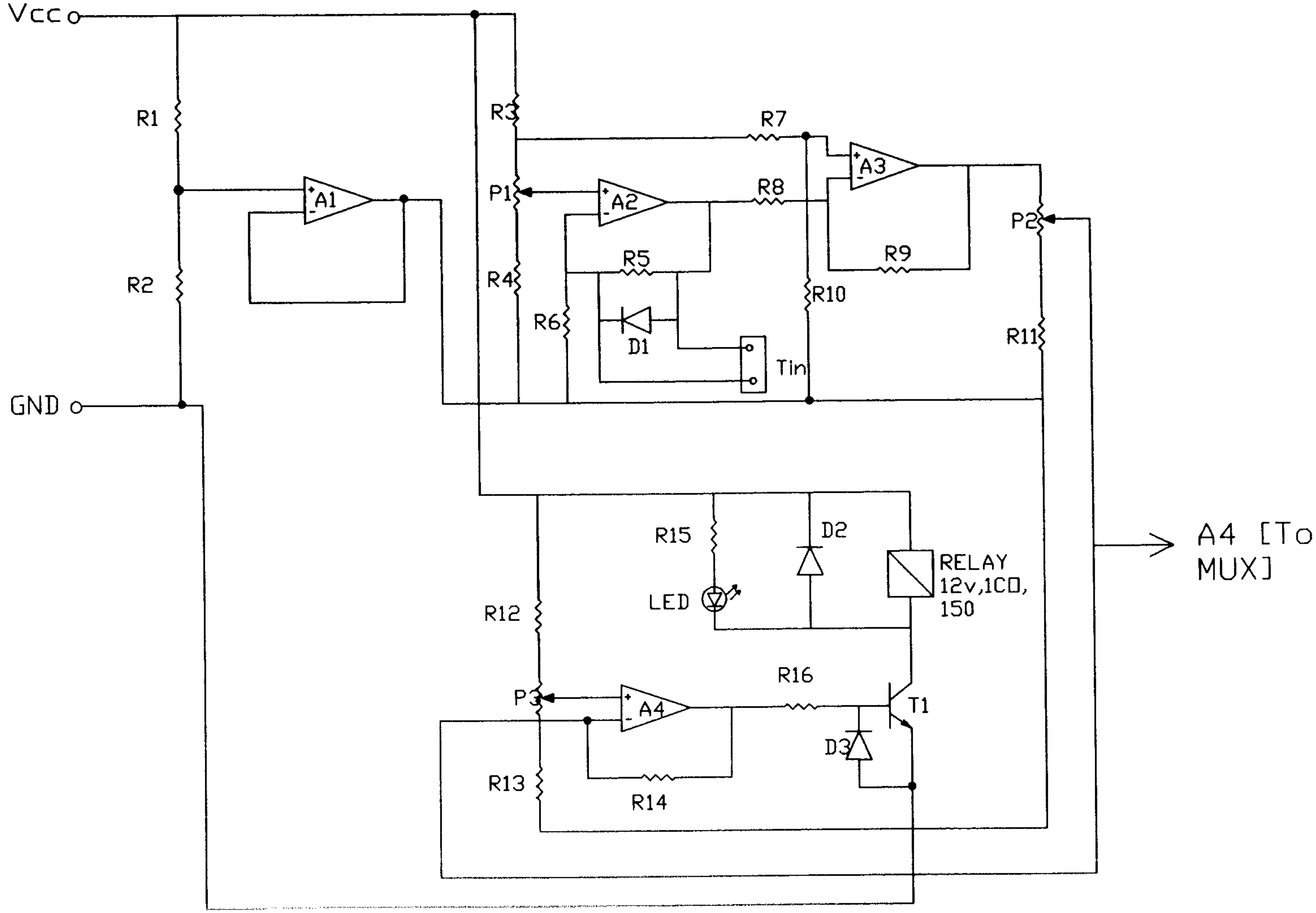
CIRCUIT FOR MEASURING CURRENT



D1 = D2 = D3 = D4=1N4001
C1=0.01MF

VZ=5.2v
P1=10k

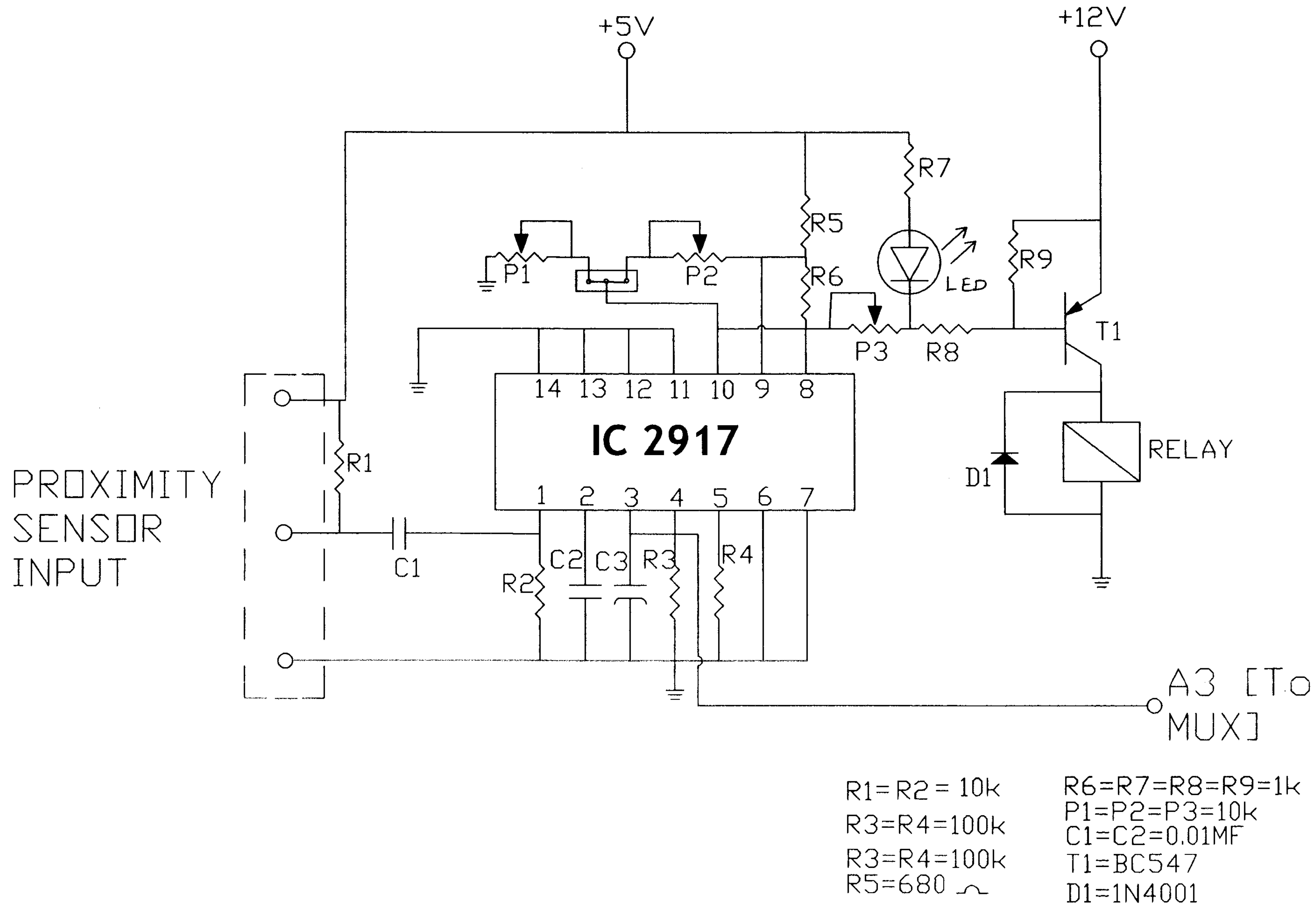
CIRCUIT FOR MEASURING TEMPERATURE



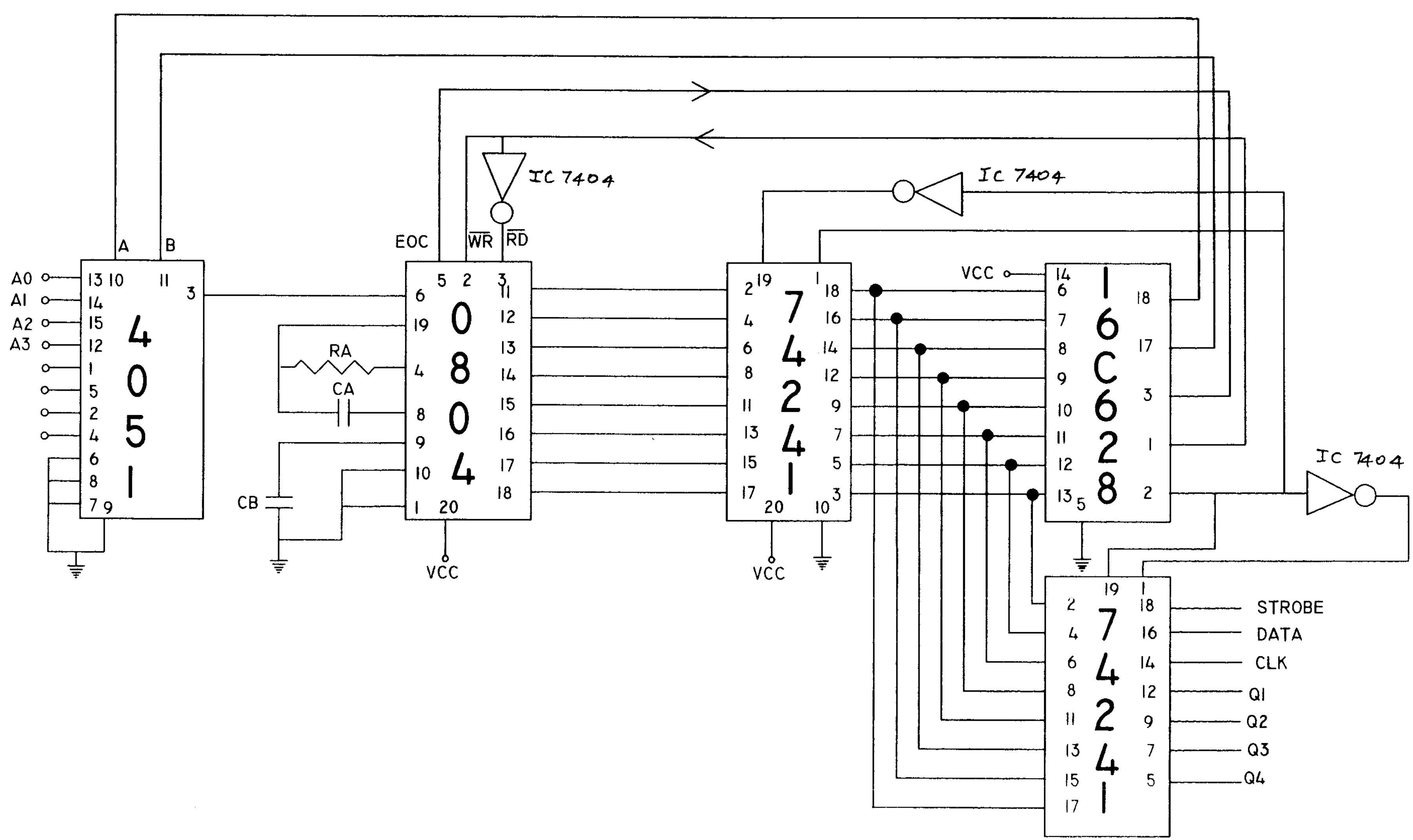
A1=A2=A3=A4=IC LM324
R1=R2=R8=R11=10K
R3=680 Ω
R4=R12=2.2K
R5=R6=R7=R13=R15=1K

R9=R10=R16=6.8K
D1=IN4148
D2=D3=1N4001
T1=BC547
Vcc = 12V

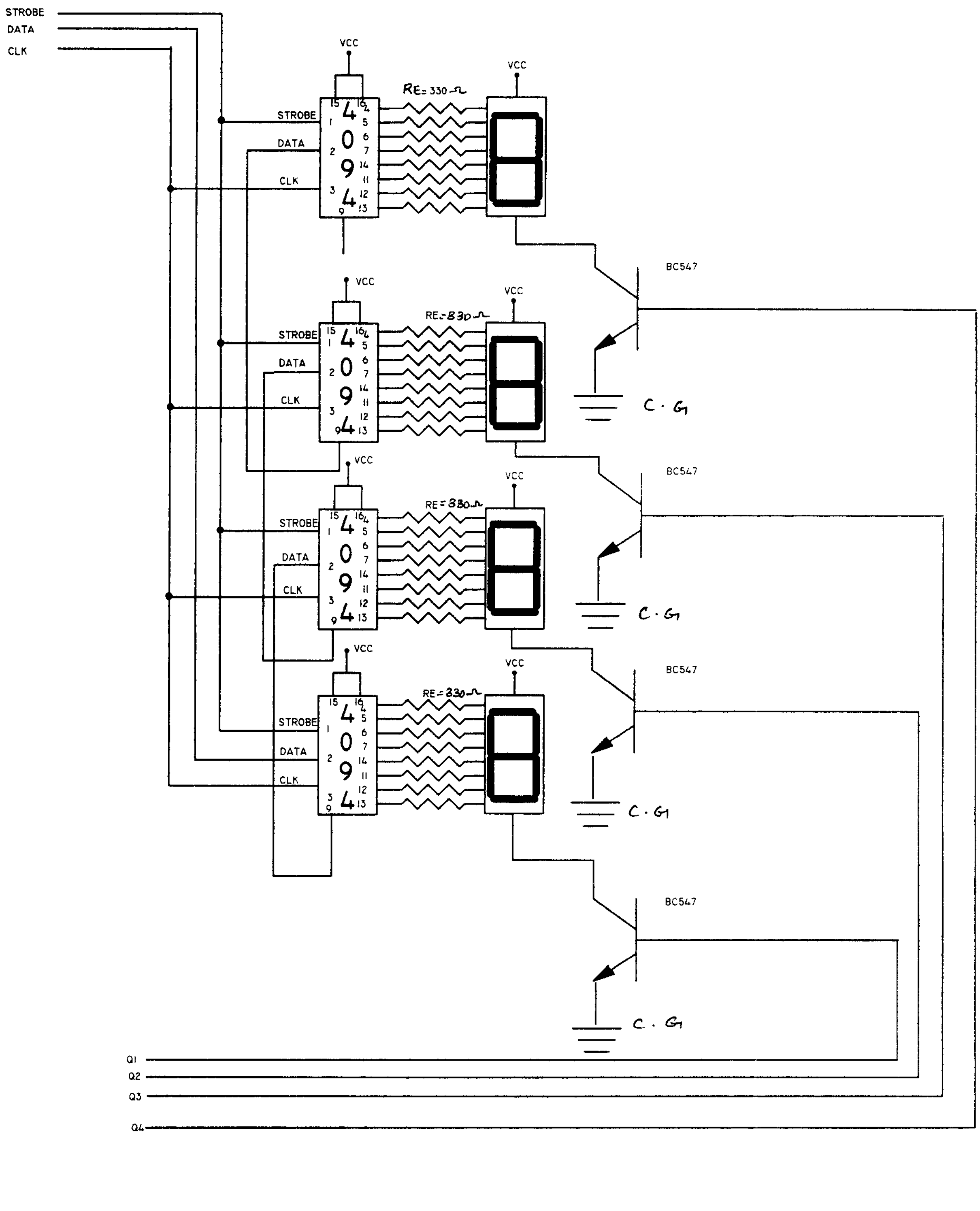
CIRCUIT FOR MEASURING SPEED



PROCESSOR SECTION



DISPLAY SECTION



3.8.DESCRIPTION OF HARDWARE DESIGN

The circuit diagram of the motor monitoring system is shown in the figure. It consists of various sections such as voltage measurement and frequency measurement sections. In the voltage measurement section, the voltage input from the motor is applied to 230/12v step-down potential transformer, where the voltage is reduced to 12v .The Bridge rectifier converts the Ac voltage into Dc voltage.(i.e)During the positive half cycle, the output voltage is positive for full half cycle. During the negative half cycle ,the diodes D2 and D3 are forward biased and the output voltage is also positive for remaining half cycle. The rectified output contains Ac components and the Dc parts. The Ac components called ripples should be removed to get a smooth output.Therefore it is necessary to include filter between rectifier and the output to avoid the ripples. The filtered output voltage which is available across potentiometer is given to A0 of the multiplexer.

In the current measurement section, the current input from the motor is applied to 3A/300mA current transformer, where the current is reduced to 300mA.The Bridge rectifier converts the Ac current into Dc current.(i.e.) During the positive half cycle, Diode D1 and D4 are forward biased and the output current is positive for full half cycle. During the negative half cycle, Diode D2 and D3 are forward biased and the output current is positive for full half cycle. The rectified output contains Ac components as well as Dc components. The Ac components called ripples are removed to get the smooth output.Therefore it is necessary to include the filter between rectifier and output to avoid the ripples. The filtered output voltage which is available across potentiometer is given to A1 of the multiplexer.

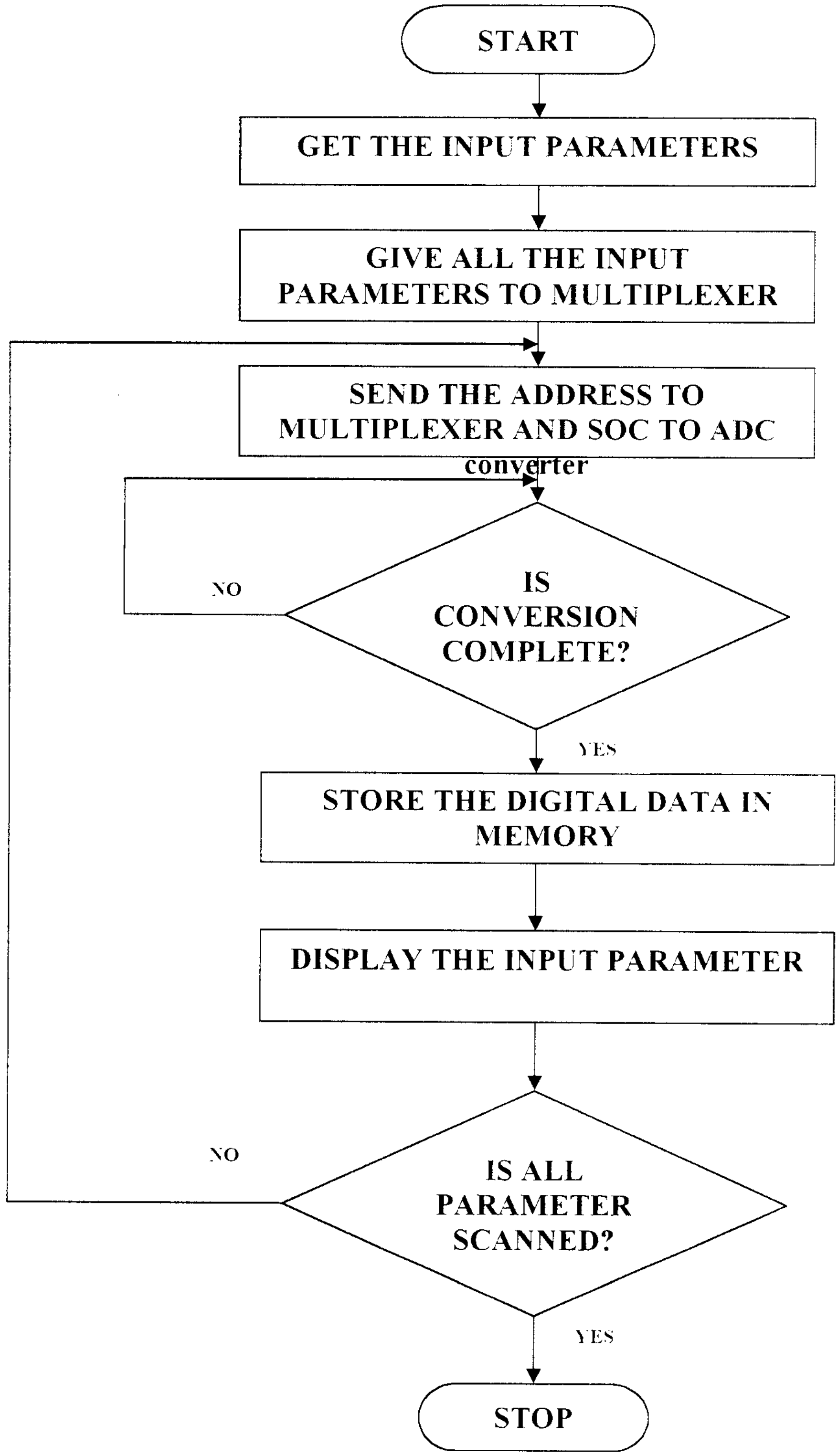
In the speed measurement section, the proximity sensor converts the motor revolution into pulses which is applied to the pin 1 of the frequency to voltage converter. The Frequency to voltage converter converts the pulses into voltage linearly. The output voltage which is available across pin 3 and 4 is given to the A3 of the multiplexer. The reference input is given to pin 10 of the Frequency to voltage converter through potentiometer p1 and p2 .The internal comparator in the Frequency to voltage converter compares the reference input and measured input. If the measured input exceeds reference input the signal is given to transistor T1 to operate the relay and LED to indicate that the speed is above normal.

In the temperature measurement section, the IC LM324 consists of four op-amps such as A1, A2,A3 and A4.The op-amp A1 acts as a voltage follower and it is used for voltage stabilization. The Temperature sensor is connected across inverting terminal of op-amp A2.The reference input is given to non-inverting terminal of A2 through potentiometer p1.If the temperature varies, the junction drop across diode varies which causes the change in output voltage of op-amp A2.The output of op-ampA2 is given to inverting terminal of op-amp A3 which is available across p2 is given to A4 of multiplexer. The op-amp A4 compares the measured input and reference input if the measured input is above reference input, the output of op-ampA4 will give signal to transistor to switch on the relay and LED to indicate that the temperature is exceeding the limit.

In the frequency measurement section, the voltage input signal which crosses the zero levels are measured and displayed by means of programming in PIC microcontroller.

All the input parameters are applied to multiplexer 4051 which allows only one output depends upon the status signals given to the multiplexer. First the microcontroller sends status signals to the multiplexer and SOC to the Analog to Digital Converter. Then the multiplexer sends the voltage input to the Analog to Digital Converter and then Analog to Digital Converter starts converting the analog signal into Digital signal. After converting the analog signal into Digital signal the Analog to Digital Converter send EOC signal to microcontroller to indicate that the conversion is over. The Digital Data which is available in the port B pins is stored in the memory of the microcontroller. There are two tristate buffers used to use port B pins as input port as well as output port. If the tristate Buffer 1 is enabled, Port b is used as input port and vice versa. Then the microcontroller sends next status signals and the process continues until all the parameters are scanned. The data which is available in the microcontroller is sending to data pin of the last IC 74241 decoder and data is transferred to next decoder and so on. The clock and strobe signals are given to all the decoders from the microcontroller. Thus the digital data is displayed using seven segments LED.

4.1. FLOWCHART:



```
;-----------------------
W        EQU    00
F        EQU    01

;----- Register Files------------------------------------------------------
INDF         EQU    00          ;register file definition
TMR0         EQU    01
PCL          EQU    02
STATUS       EQU    03
FSR          EQU    04
PORTA        EQU    05
PORTB        EQU    06
OPTION_REG   EQU    81
TRISA        EQU    85
TRISB        EQU    86
RB0          EQU    00          ;port 'B' definition
RB1          EQU    01
RB2          EQU    02
RB3          EQU    03
RB4          EQU    04
RB5          EQU    05
RB6          EQU    06
RB7          EQU    07
;----- STATUS Bits ------------------------------------------------------

Z      EQU    02
C      EQU    00
RA4    EQU    04
RA0    EQU    00
```

```
RA1      EQU    01
RA2      EQU    02
RA3      EQU    03
RA4      EQU    04
RB7      EQU    07
F        EQU    01
;-------------------------------
SCRTCH0                 EQU 20
SCRTCH1                 EQU 21
LSD                     EQU 22
MSD                     EQU 23
MMSD                    EQU 24
VOLTAGE                 EQU 25
TMR_COMP                EQU 26
COUNTER_100MS_1         EQU 27
COUNTER_4MS_1           EQU 28
TMR_COMP_1              EQU 29
UNIT                    EQU 2A
TENS                    EQU 2B
HUND                    EQU 2C
CURRENT                 EQU 2D
DSP                     EQU 2E
SPEED                   EQU 2F
AARGB0                  EQU 30
BARGB0                  EQU 31
AARGB1                  EQU 32
LOOPCOUNT               EQU 33
DISP_STROBE             EQU 0
DISP_DATA               EQU 2
```

```
DISP_CLK            EQU 1
RA3                 EQU 3
RA7                 EQU 7
;----------------------
#DEFINE DATA_HI BSF PORTB, DISP_DATA
#DEFINE DATA_LO BCF PORTB, DISP_DATA
#DEFINE CLK_HI BSF  PORTB, DISP_CLK
#DEFINE CLK_LO BCF  PORTB, DISP_CLK
#DEFINE STROBE_HI BSF PORTB, DISP_STROBE
#DEFINE STROBE_LO BCF PORTB, DISP_STROBE
;-----------------------------------
        DIS        NOP                      ;display 7 segment data
                                            serially
MAIN0           RLF SCRTCH1,F
                BTFSC STATUS,C
                GOTO MAIN1
                DATA_LO
                GOTO MAIN2
MAIN1           DATA_HI
MAIN2           NOP
                NOP
                CLK_HI
                NOP
                NOP
                CLK_LO
                NOP
                NOP
                DECFSZ SCRTCH0,F
                GOTO MAIN0
```

```
                STROBE_HI
                NOP
                STROBE_LO
                DATA_LO
                RETURN
;---------------------------------------
LUT   ADDWF PCL,F                      ; 7 segment lookup table
RETLW B'00000011'    ;0
RETLW B'10011111'    ;1
RETLW B'00100101'    ;2
RETLW B'00001101'    ;3
RETLW B'10011001'    ;4
RETLW B'01001001'    ;5
RETLW B'01000001'    ;6
RETLW B'00011111'    ;7
RETLW B'00000001'    ;8
RETLW B'00011001'    ;9
;-----------------------------------------------
DELAY     MOVLW 0XFA    ;4000 MICRO SEC (1:16 * 250)
          MOVWF TMR_COMP_1        ;800 msec delay routine
REPS      MOVF TMR_COMP_1,W
          XORWF TMR0,W
          BTFSS STATUS,Z
          GOTO REPS
          MOVLW 0XFA
          ADDWF TMR_COMP_1,F
          INCF COUNTER_4MS_1,F
          MOVLW 0X19
```

```
XORWF COUNTER_4MS_1,W;IS4MS*25=100MSEC
OVER
BTFSS STATUS,Z
OTO REPS
CLRF COUNTER_4MS_1
INCF COUNTER_100MS_1,F
MOVLW 0X0A            ;100 MSEC DELAY
XORWF COUNTER_100MS_1,W
BTFSS STATUS,Z
GOTO REPS
CLRF COUNTER_100MS_1
RETURN
;-----------------------------------
BINBCD      CLRF MSD;8 bit binary to BCD routine convertion
            MOVWF LSD
            TENTH     MOVLW .10
            SUBWF LSD,W
            BTFSS STATUS,C
            GOTO OVER
            MOVWF LSD
            INCF MSD,F
            GOTO TENTH
OVER        RETLW 0
;-----------------------
MUL         MOVLW 0X08   ;speed data * 4 multiplication routine
MOVWF LOOPCOUNT
            MOVF AARGB0,W
LOOP        RRF BARGB0, F
            BTFSC STATUS,C
```

```
                GOTO LUM
                DECFSZ LOOPCOUNT, F
                GOTO LOOP
                CLRF AARGB0
                RETLW 0X00
LUM             BCF STATUS,C
                GOTO LUM08
LOOPUM          RRF BARGB0, F
                BTFSC STATUS,C
                ADDWF AARGB0, F
LUM08           RRF AARGB0, F
                RRF AARGB1, F
                DECFSZ LOOPCOUNT, F
                GOTO LOOPUM
                RETURN
;----------------------------
START           CLRF PORTA
                CLRF PORTB          ;clear all files
                CLRF INTCON
                CLRF COUNTER_100MS_1
                CLRF COUNTER_4MS_1
                CLRF TMR_COMP_1
                CLRF LSD
                CLRF MSD
                CLRF MMSD
           CLRF UNIT
           CLRF TENS
           CLRF HUND
           CLRF AARGB0
```

```
          CLRF BARGB0
          CLRF AARGB1
          CLRF LOOPCOUNT
          MOVLW 0X07
          MOVWF CMCON
          BSF STATUS,5
          MOVLW B'10010000'
          MOVWF TRISA
          MOVLW B'11111111'
          MOVWF TRISB
          CLRF TMR0
          MOVLW 0XC3 ;TIMER0 PRESCALE 1:16
          OPTION
          BCF STATUS,5

CYCLE     BSF STATUS,5
          MOVLW B'11111111'
          MOVWF TRISB
          BCF STATUS,5
          BCF PORTA,RA3       ;READ MODE
          BCF PORTA,RA0       ;ANALOG MUX SEIECTION
          BCF PORTA,RA1
          BCF PORTA,RA2       ;SOC
          CALL DELAY
          BSF PORTA,RA2
CHECK     BTFSS PORTA,RA4          ;CHECK FOR EOC
          GOTO CHECK
          MOVF PORTB,W
          MOVWF VOLTAGE
```

```
        BSF PORTA,RA3           ;DISPLAY MODE
        BSF STATUS,5
        MOVLW B'00000000'
        MOVWF TRISB
        BCF STATUS,5

        MOVLW 0XC7
        MOVWF DSP


DISPLAY         BSF PORTB,RB7  ;display voltage data
                MOVLW H'08'
                MOVWF SCRTCH0
                MOVF DSP,W
                MOVWF SCRTCH1
                CALL DIS
                MOVLW H'08'
                MOVWF SCRTCH0
                MOVF HUND,W
                MOVWF SCRTCH1
                CALL DIS
                MOVLW H'08'
                MOVWF SCRTCH0
                MOVF TENS,W
                MOVWF SCRTCH1
                CALL DIS
                MOVLW H'08'
                MOVWF SCRTCH0
                MOVF UNIT,W
```

```
        MOVWF SCRTCH1
        CALL DIS
        CLRF LSD
        CLRF MSD
        CLRF MMSD
        CLRF UNIT
        CLRF TENS
        CLRF HUND
        CLRF VOLTAGE
        CALL DELAY
        BCF PORTB,RB4
        BCF PORTB,RB5
        BCF PORTB,RB6
        BCF PORTB,RB3

        BSF STATUS,5
        MOVLW B'11111111'
        MOVWF TRISB
        BCF STATUS,5
        BCF PORTA,RA3        :READ MODE
        BCF PORTA,RA0
        BSF PORTA,RA1        :ANALOG MUX SELECT
        BCF PORTA,RA2        :SOC
        CALL DELAY
        BSF PORTA,RA2
CHEC    BTFSS PORTA,RA4          :CHECK FOR EOC
        GOTO CHEC
        MOVF PORTB,W
        MOVWF CURRENT
```

```
            BSF PORTA,RA3        ;DISPLAY MODE
            BSF STATUS,5
            MOVLW B'00000000'
            MOVWF TRISB
            BCF STATUS,5

            MOVLW 0X63
            MOVWF DSP

            BSF STATUS,5
            MOVLW B'11111111'
            MOVWF TRISB
            BCF STATUS,5
            BCF PORTA,RA3        ;READ MODE
            BSF PORTA,RA0
            BCF PORTA,RA1        ;ANALOG MUX SELECT
            BCF PORTA,RA2        ;SOC
            CALL DELAY
            BSF PORTA,RA2
CHE         BTFSS PORTA,RA4          ;CHECK FOR EOC
            GOTO CHE
            MOVF PORTB,W
            MOVWF AARGB0
            MOVLW 0X04
            MOVWF BARGB0
            CALL MUL
            MOVF AARGB0,W
            MOVWF SPEED
            BSF PORTA,RA3        ;DISPLAY MODE
```

```
            BSF STATUS,5
            MOVLW B'00000000'
            MOVWF TRISB
            BCF STATUS,5
            BSF PORTB,RB3
            MOVLW 0X11
            MOVWF DSP


DISPL       BSF PORTB,RB7        ;display "current"
            MOVLW H'08'
            MOVWF SCRTCH0
            MOVF DSP,W
            MOVWF SCRTCH1
            CALL DIS
            MOVLW H'08'
            MOVWF SCRTCH0
            MOVF HUND,W
            MOVWF SCRTCH1
            CALL DIS
            MOVLW H'08'
            MOVWF SCRTCH0
            MOVF TENS,W
            MOVWF SCRTCH1
            CALL DIS
            MOVLW H'08'
            MOVWF SCRTCH0
            MOVF UNIT,W
            MOVWF SCRTCH1
```

```
CALL DIS
CLRF LSD
CLRF MSD
CLRF MMSD
CLRF UNIT
CLRF TENS
CLRF HUND
CLRF SPEED
CALL DELAY
CLRF AARGB0
CLRF BARGB0
CLRF AARGB1
BCF PORTB,RB4
BCF PORTB,RB5
BCF PORTB,RB6
BCF PORTB,RB3
BCF PORTA,RA1
GOTO CYCLE
END
```

CHAPTER 5
CONCLUSION

Monitoring the electrical parameters of motor has been implemented using PIC microcontroller. This project gives Current, voltage, temperature, frequency, speed without any error. In this project work, we have an exclusive study on the embedded systems. This project finds applications on college laboratories and industrial testings.by the implementation of this project, the motor monitoring is very simplex compared to conventional method of measuring electrical parameters. Since the size and cost of this system is reduced, there is future scope for this project in industries of very large power rating motors.

BIBLIOGRAPHY

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2. Floyd," Digital Fundamentals", 3rd Edition, Universal Book Stall, New Delhi,1995.

3. Franco," Design with Operational amplifier and analog integrated circuits" Tata McGraw Hill,1998.

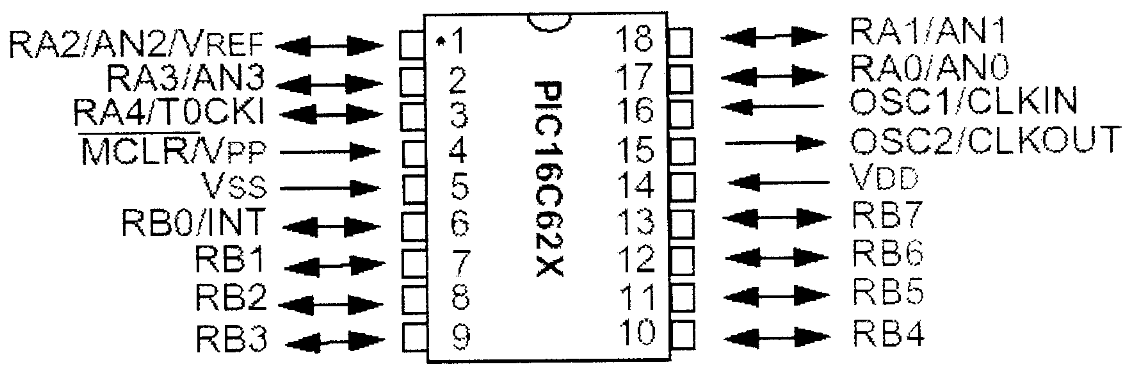
4. "Microchip user manual"

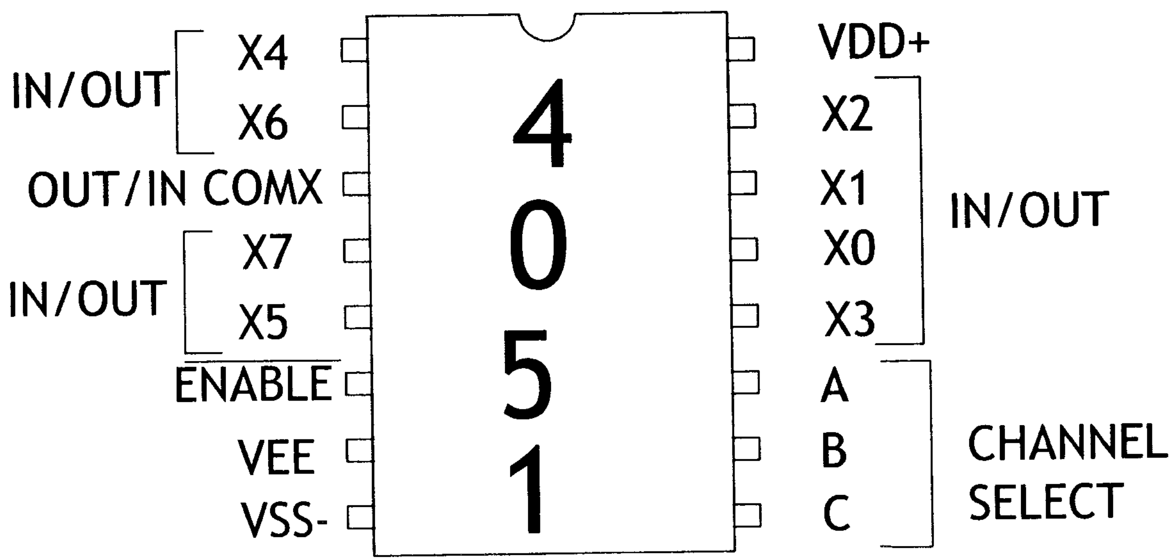
5."Intersil user manual".

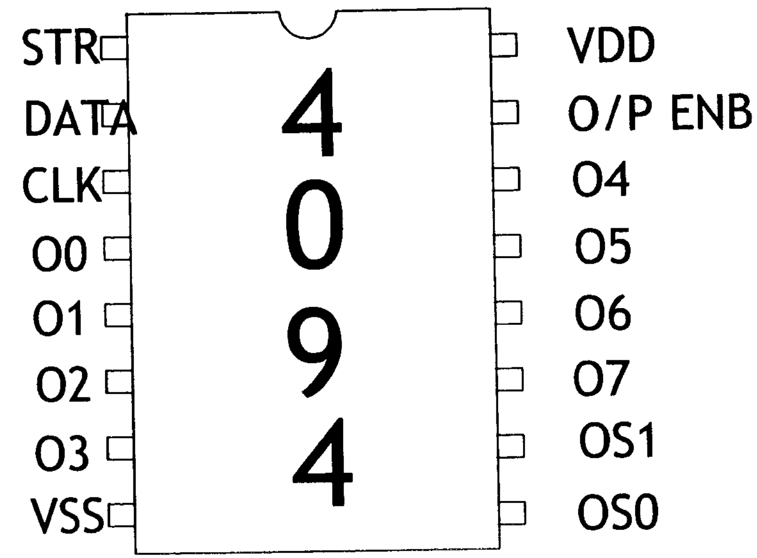
6. "National Instruments user manual"

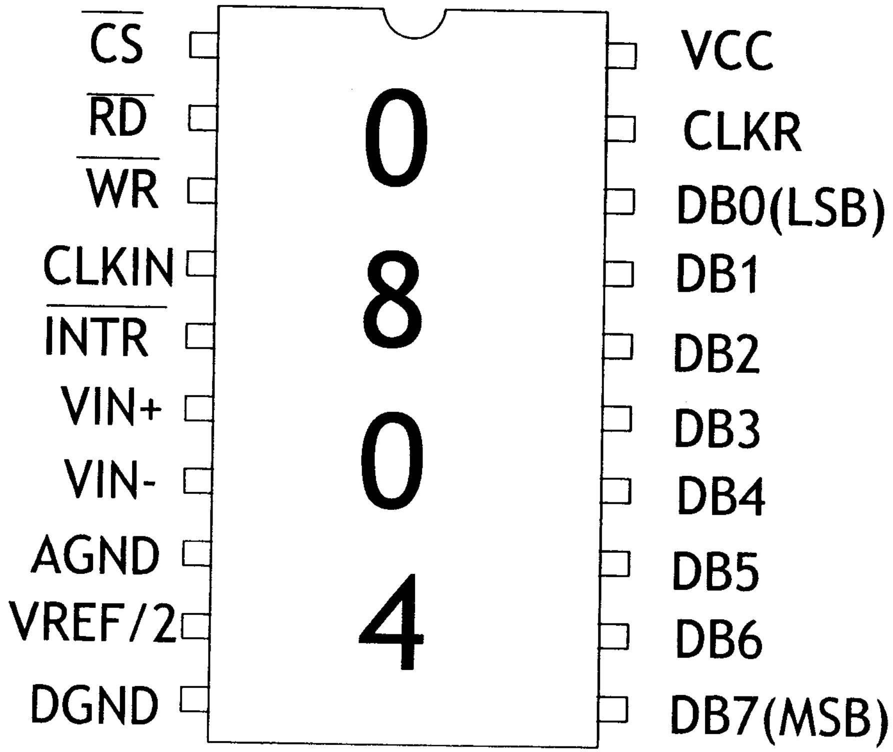
7. www.Keil.Com

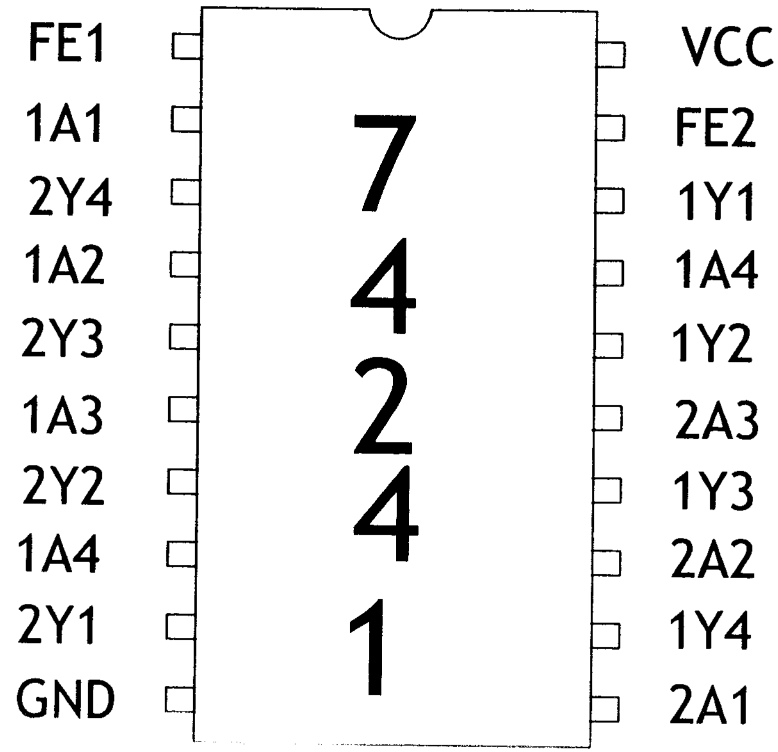
PIN CONFIGURATION OF PIC 16C628:

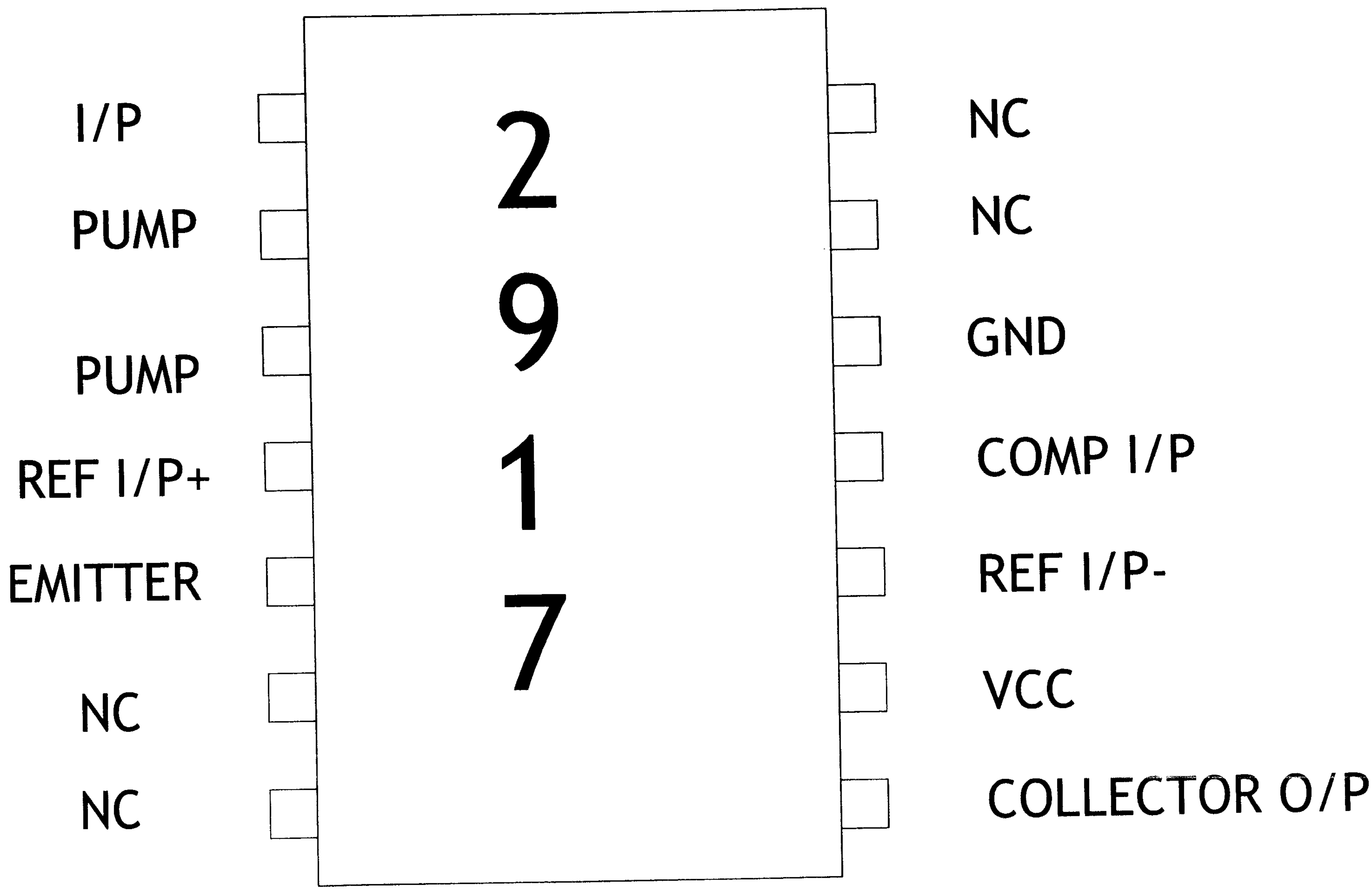


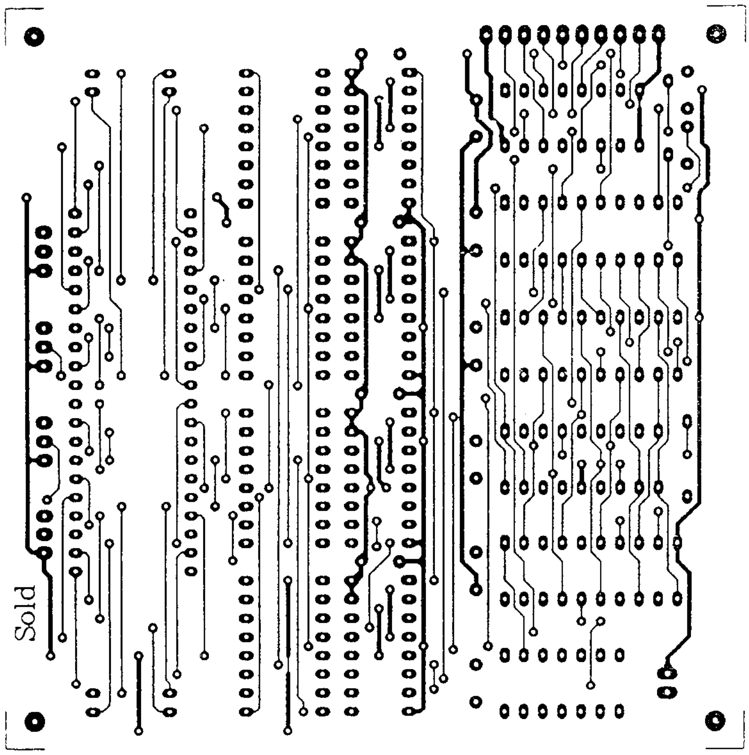

4051
X4
X6
IN/OUT
OUT/IN COMX
X7
X5
IN/OUT
ENABLE
VEE
VSS-
VDD+
X2
X1
X0
X3
IN/OUT
A
B
C
CHANNEL
SELECT

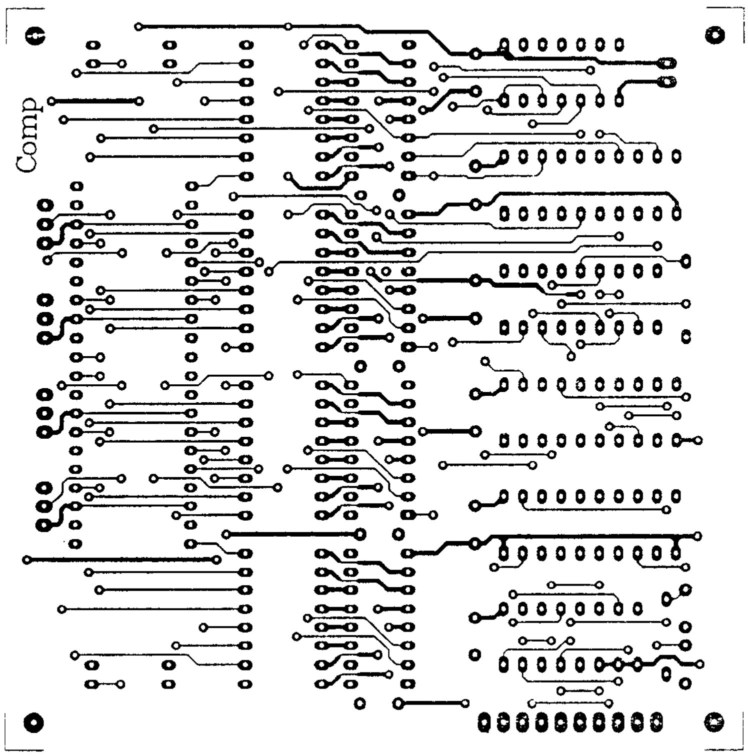

4094
STR
DATA
CLK
O0
O1
O2
O3
VSS
VDD
O/P ENB
O4
O5
O6
O7
OS1
OS0

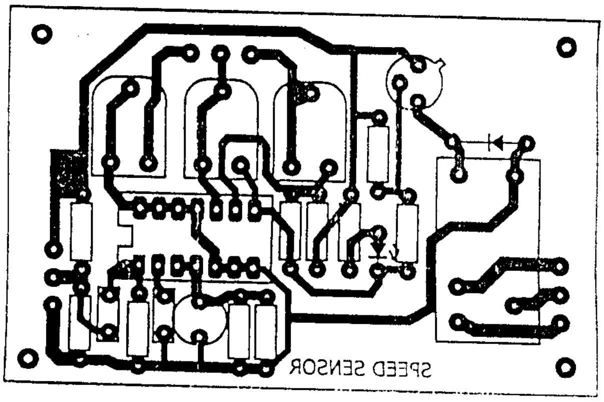

0804
CS
RD
WR
CLKIN
INTR
VIN+
VIN-
AGND
VREF/2
DGND
VCC
CLKR
DB0(LSB)
DB1
DB2
DB3
DB4
DB5
DB6
DB7(MSB)

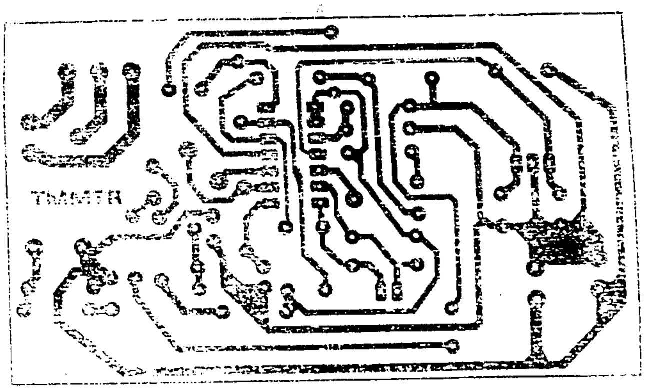

7424 1
FE1
1A1
2Y4
1A2
2Y3
1A3
2Y2
1A4
2Y1
GND
VCC
FE2
1Y1
1A4
1Y2
2A3
1Y3
2A2
1Y4
2A1


2917
I/P
PUMP
PUMP
REF I/P+
EMITTER
NC
NC
NC
NC
GND
COMP I/P
REF I/P-
VCC
COLLECTOR O/P


Sold


Comp


SPEED SENSOR



Specifications and Applications Information

QUAD LOW POWER OPERATIONAL AMPLIFIERS

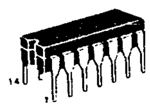
The LM124 Series are low-cost, quad operational amplifiers with true differential inputs. These have several distinct advantages over standard operational amplifier types in single supply applications. The quad amplifier can operate at supply voltages as low as 3.0 Volts or as high as 32 Volts with quiescent currents about one fifth of those associated with the MC1741 (on a per amplifier basis). The common mode input range includes the negative supply, thereby eliminating the necessity for external biasing components in many applications. The output voltage range also includes the negative power supply voltage.

- Short Circuit Protected Outputs
- True Differential Input Stage
- Single Supply Operation: 3.0 to 32 Volts
- Low Input Bias Currents: 250 nA Max
- Four Amplifiers Per Package
- Internally Compensated
- Common Mode Range Extends to Negative Supply
- Industry Standard Pinouts

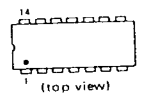
LM124, LM224, LM324, LM2902

QUAD DIFFERENTIAL INPUT OPERATIONAL AMPLIFIERS

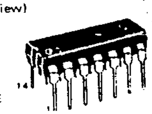
SILICON MONOLITHIC INTEGRATED CIRCUIT



J SUFFIX
CERAMIC PACKAGE
CASE 632
TO-116

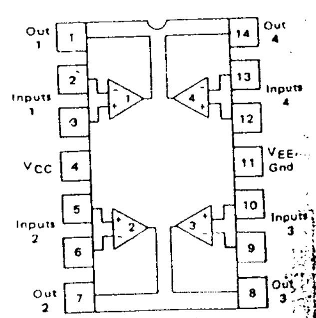


(top view)



N SUFFIX
PLASTIC PACKAGE
CASE 646
(LM224, LM324, LM2902 only)

PIN CONNECTIONS



(top view)

MAXIMUM RATINGS (T_A = +25°C unless otherwise noted)

Rating	Symbol	LM124 LM224 LM324	LM2902	Unit
Power Supply Voltages (1)				Vdc
Single Supply	V_{CC}	32	26	
Split Supplies	V_{CC}, V_{EE}	±16	±13	
Input Differential Voltage Range (1)	V_{IDR}	±32	±26	Vdc
Input Common Mode Voltage Range (2)	V_{ICR}	-0.3 to 32	-0.3 to 26	Vdc
Input Forward Current (3) (V_I < -0.3 V)	I_{IF}	50	–	mA
Output Short Circuit Duration	t_S	Continuous		
Junction Temperature	T_J			°C
Ceramic and Metal Packages		175		
Plastic Package		150		
Storage Temperature Range	T_{stg}			°C
Ceramic and Metal Packages		-65 to +150		
Plastic Package		-55 to +125		
Operating Ambient Temperature Range	T_A			°C
LM124		-55 to +125	–	
LM224		-25 to +85	–	
LM324		0 to +70	–	
LM2902		–	-40 to +85	

(1) Split Power Supplies.
(2) For Supply Voltages less than 32 V for the LM124/224/324 and 26 V for the LM2902, the absolute maximum input voltage is equal to the supply voltage.
(3) This input current will only exist when the voltage is negative at any of the input leads. Normal output states will reestablish when the input voltage returns to a voltage greater than -0.3 V.

ORDERING INFORMATION

Device	Temperature Range	Package
LM124J	-55 to +125°C	Ceramic DIP
LM2902J	-40 to +85°C	Ceramic DIP
LM2902N	-40 to +85°C	Plastic DIP
LM224J	-25 to +85°C	Ceramic DIP
LM224N	-25 to +85°C	Plastic DIP
LM324J	0 to +70°C	Ceramic DIP
LM324N	0 to +70°C	Plastic DIP

ELECTRICAL CHARACTERISTICS (V_{CC} = 5.0 V, V_{EE} = Gnd, T_A = 25°C unless otherwise noted)

Characteristic	Symbol	LM124/LM224 Min	Typ	Max	LM324 Min	Typ	Max	LM2902 Min	Typ	Max	Unit
Input Offset Voltage V_{CC} = 5.0 V to 30 V (26 V for LM2902), V_{IC} = 0 V to V_{CC} - 1.7 V, V_O ≃ 1.4 V, R_S = 0 Ω T_A = 25°C T_A = T_{high} to T_{low} (Note 1)	V_{IO}	– –	2.0 –	5.0 7.0	– –	2.0 –	7.0 9.0	– –	2.0 –	7.0 10	mV
Average Temperature Coefficient of Input Offset Voltage T_A = T_{high} to T_{low} (Note 1)	$\Delta V_{IO}/\Delta T$	–	7.0	–	–	7.0	–	–	7.0	–	µV/°C
Input Offset Current T_A = T_{high} to T_{low} (Note 1)	I_{IO}	– –	3.0 –	30 100	– –	5.0 –	50 150	– –	5.0 45	50 200	nA
Average Temperature Coefficient of Input Offset Current T_A = T_{high} to T_{low} (Note 1)	$\Delta I_{IO}/\Delta T$	–	10	–	–	10	–	–	10	–	pA/°C
Input Bias Current T_A = T_{high} to T_{low} (Note 1)	I_{IB}	– –	-45 -50	-150 -300	– –	-45 -50	-250 -500	– –	-45 -50	-250 -500	nA
Input Common-Mode Voltage Range (Note 2) V_{CC} = 30 V (26 V for LM2902) V_{CC} = 30 V (26 V for LM2902), T_A = T_{high} to T_{low}	V_{ICR}	0 0	– –	28.3 28	0 0	– –	28.3 28	0 0	– –	24.3 24	V
Differential Input Voltage Range	V_{IDR}	–	–	V_{CC}	–	–	V_{CC}	–	–	V_{CC}	V
Large Signal Open-Loop Voltage Gain R_L = 2.0 kΩ, V_{CC} = 15 V, For Large V_O Swing, T_A = T_{high} to T_{low} (Note 1)	A_{VOL}	50 25	100 –	– –	25 15	100 –	– –	– –	100 –	– –	V/mV
Channel Separation 1.0 kHz ≤ f ≤ 20 kHz, Input Referenced	–	–	-120	–	–	-120	–	–	-120	–	dB
Common-Mode Rejection Ratio R_S ≤ 10 kΩ	CMRR	70	85	–	65	70	–	50	70	–	dB
Power Supply Rejection Ratio	PSRR	65	100	–	65	100	–	50	100	–	dB
Output Voltage Range R_L = 2 kΩ (R_L ≥ 10 kΩ for LM2902),	V_{OR}	0	–	3.3	0	–	3.3	0	–	3.3	V
Output Voltage–High Limit (T_A = T_{high} to T_{low}) (Note 1) V_{CC} = 30 V (26 V for LM2902), R_L = 2 kΩ V_{CC} = 30 V (26 V for LM2902), R_L = 10 kΩ	V_{OH}	26 27	– 28	– –	26 27	– 28	– –	22 23	– 24	– –	V
Output Voltage–Low Limit V_{CC} = 5.0 V, R_L = 10 kΩ, T_A = T_{high} to T_{low} (Note 1)	V_{OL}	–	5.0	20	–	5.0	20	–	5.0	100	mV
Output Source Current (V_{ID} = +1.0 V, V_{CC} = 15 V) T_A = 25°C T_A = T_{high} to T_{low} (Note 1)	I_{O+}	20 10	40 20	– –	20 10	40 20	 –	20 10	40 20	– –	mA
Output Sink Current V_{ID} = -1.0 V, V_{CC} = 15 V T_A = 25°C T_A = T_{high} to T_{low} (Note 1) V_{ID} = -1.0 V, V_O = 200 mV, T_A = 25°C	I_{O-}	10 5 12	20 8 50	– – –	10 5 12	20 8 50	– – –	10 5 –	20 8 –	– – –	mA µA
Output Short Circuit to Ground (Note 3)	I_{os}	–	40	60	–	40	60	–	40	60	mA
Power Supply Current (T_A = T_{high} to T_{low}) (Note 1) V_{CC} = 30 V (26 V for LM2902), V_O = 0 V, R_L = ∞ V_{CC} = 5 V, V_O = 0 V, R_L = ∞	I_{CC}	– –	1.5 0.7	3.0 1.2	– –	1.5 0.7	3.0 1.2	– –	1.5 0.7	3.0 1.2	mA

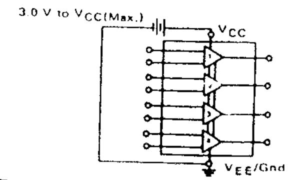
NOTES:

(1) T_{low} = -55°C for LM124, = -40°C for LM2902, = -25°C for LM224, = 0°C for LM324; T_{high} = +125°C for LM124, = +85°C for LM2902 and LM224, = +70°C for LM324

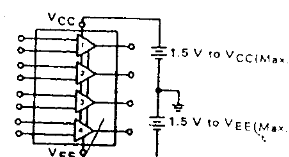
(2) The input common-mode voltage or either input signal voltage should not be allowed to go negative by more than 0.3 V. The upper end of the common mode voltage range is V_{CC} - 1.7 V, but either or both inputs can go to +32 V without damage (+26 V for LM2902).

(3) Short circuits from the output to V_{CC} can cause excessive heating and eventual destruction. Destructive dissipation can result from simultaneous shorts on all amplifiers.

SINGLE SUPPLY

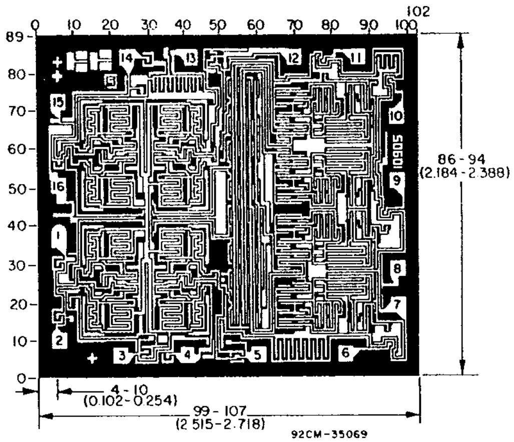


SPLIT SUPPLIES



SPECIAL CONSIDERATIONS

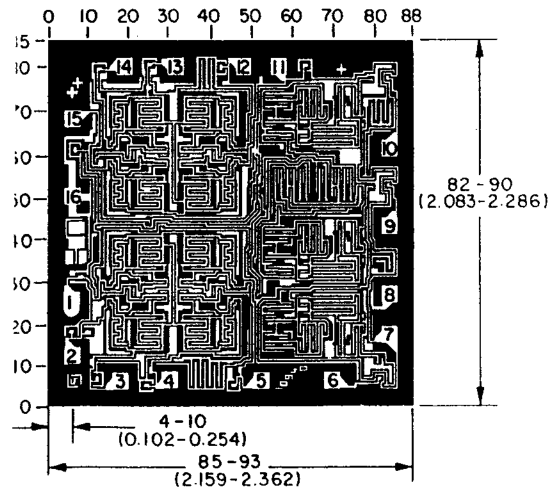
applications where separate power sources used to drive V_{DD} and the signal inputs, V_{DD} current capability should exceed V_{DD}/R_L (R_L = effective external load). This provision avoids permanent current flow or clamp action on the V_{DD} supply when power is applied or removed from the CD4051B, CD4052B, or CD4053B.



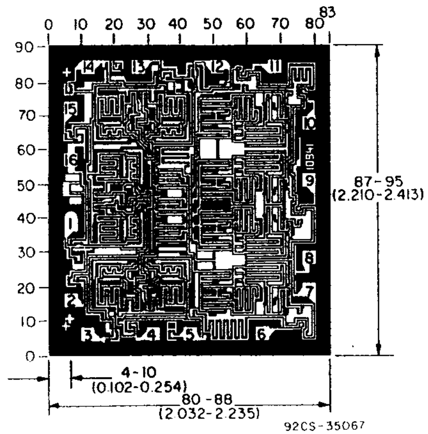
Dimensions and pad layout for CD4051BH.

The photographs and dimensions of each CMOS chip represent a chip when it is part of the wafer. When the wafer is separated into individual chips, the angle of cleavage may vary with respect to the chip face for different chips. The actual dimensions of the isolated chip, therefore, may differ slightly from the nominal dimensions shown. The user should consider a tolerance of −3 mils to +16 mils applicable to the nominal dimensions shown.

Dimensions in parentheses are in millimeters and are derived from the basic inch dimensions as indicated. Grid Graduations are in Mils (10^{-3} inch).



Dimensions and pad layout for CD4052BH.



Dimensions and pad layout for CD4053BH.

CMOS Liquid-Crystal Display Drivers

High-Voltage Types (20-Volt Rating)

CD4054B – 4-Segment Display Driver
CD4055B – BCD to 7-Segment Decoder/Driver with "Display-Frequency" Output
CD4056B – BCD to 7-Segment Decoder/Driver with Strobed-Latch Function

The RCA CD4055B and CD4056B types are single-digit BCD-to-7-segment decoder/driver circuits that provide level-shifting functions on the chip. This feature permits the BCD input-signal swings (V_{DD} to V_{SS}) to be the same as or different from the 7-segment output-signal swings (V_{DD} to V_{EE}). For example, the BCD input-signal swings (V_{DD} to V_{SS}) may be as small as 0 to −3 V, whereas the output-display drive-signal swing (V_{DD} to V_{EE}) may be as large as from 0 to −15V. If V_{DD} to V_{EE} exceeds 15 V, V_{DD} to V_{SS} should be at least 4V (0 to −4V).

The 7-segment outputs are controlled by the DISPLAY-FREQUENCY (DF) input which causes the selected segment outputs to be low, high, or a square-wave output (for liquid-crystal displays). When the DF input is low the output segments will be high when selected by the BCD inputs. When the DF input is high, the output segments will be low when selected by the BCD inputs. When a square-wave is present at the DF input, the selected segments will have a square-wave output that is 180° out of phase with the DF input. Those segments which are not selected will have a square-wave output that is in phase with the input. DF square-wave repetition rates for liquid-crystal displays usually range from 30 Hz (well above flicker rate) to 200 Hz (well below the upper limit of the liquid-crystal frequency response). The CD4055B provides a level-shifted high-amplitude DF output which is required for driving the common electrode in liquid-crystal displays. The CD4056B provides a strobed-latch function at the BCD inputs. Decoding of all input combinations on the CD4055B and CD4056B provides displays of 0 to 9 as well as L, P, H, A, –, and a blank position.

The CD4054B provides level shifting similar to the CD4055B and CD4056B independently strobed latches, and common DF control on 4 signal lines. The CD4054B is intended to provide drive-signal compatibility with the CD4055B and CD4056B 7-segment decoder types for the decimal point, colon, polarity, and similar display lines. A level-shifted high-amplitude DF output can be obtained from any CD4054B output line by connecting the corresponding input and strobe lines to a low and high level, respectively and applying a square wave to DF_{IN}. The CD4054B may also be utilized for logic-level "up conversion" or "down conversion". For example, input-signal swings (V_{DD} to V_{SS}) from +5 to 0 V can be converted to output-signal swings (V_{DD} to V_{EE}) of +5 to −5 V. The level-shifted function on all three types permits the use of different input- and output-signal swings. The input swings from a low level of V_{SS} to a high level of V_{DD} while the output swings from a low level of V_{EE} to the same high level of V_{DD}. Thus, the input and output swings can be selected independently of each other over a 3-to-18 V range. V_{SS} may be connected to V_{EE} when no level shift function is required.

For the CD4054B and CD4056B, data are transferred from input to output by placing a high voltage level at the strobe input. A low voltage level at the strobe input latches the data input and the corresponding output segments remain selected (or non-selected) while the strobe is low.

Whenever the level-shifting function is required, the CD4055B can be used by itself to drive a liquid-crystal display (Fig.16 and Fig.20). The CD4056B, however, must be used together with a CD4054B to provide the common DF output (Fig.19). The capability of extending the voltage swing on the negative end (this voltage cannot be extended on the positive end) can be used to advantage in the setup of Fig.18. Fig.17 is common to all three types.

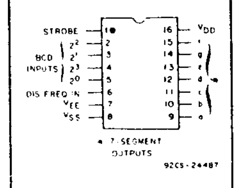
The CD4054B-, CD4055B-, and CD4056B-series types are available in 16-lead ceramic dual-in-line packages (D and F suffixes), 16-lead plastic packages (E suffix), 16-lead ceramic flat packages (K suffix), and in chip form (H suffix).

Features:

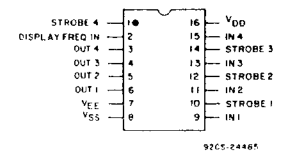
- **Operation of liquid crystals with CMOS circuits provides ultra-low-power displays**
- **Equivalent ac output drive for liquid-crystal displays – no external capacitor required**
- **Voltage doubling across display, e.g. $V_{DD} - V_{EE}$ = 18 V results in effective 36 V p-p drive across selected display segments**
- **Low- or high-output level dc drive for other types of displays**
- **On-chip logic-level conversion for different input- and output-level swings**
- **Full decoding of all input combinations: 0-9, L, H, P, A, –, and blank positions**
- **Strobed-latch function–CD4054B Series and CD4056B Series**
- **DISPLAY-FREQUENCY (DF) output for liquid-crystal common-line drive signal–CD4055B Series (CD4054B Series also: see introductory text)**
- **100% tested for quiescent current at 20 V**
- **Maximum input current of 1 μA at 18 V over full package temperature range; 100 nA at 18 V and 25°C**
- **Noise margin (over full package temperature range):**
  1 V at V_{DD} = 5 V
  2 V at V_{DD} = 10 V
  2.5 V at V_{DD} = 15 V
- **5-V, 10-V, and 15-V parametric ratings**

Applications

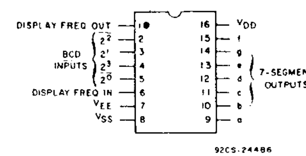
- **General-purpose displays**
- **Calculators and meters**
- **Wall and table clocks**
- **Industrial control panels**
- **Portable lab instruments**
- **Panel meters**
- **Auto dashboard displays**
- **Appliance control panels**



CD4056B
Terminal Assignment



CD4054B Terminal Assignment



CD4055B Terminal Assignment

4051B, CD4052B, CD4053B Types

CTRICAL CHARACTERISTICS (Cont'd)

RACTERISTIC	V_{is} (V)	V_{DD} (V)	R_L (kΩ)	TEST CONDITIONS		LIMITS TYPICAL VALUE	UNITS
ff (−3-dB) quency nnel ON Wave Input)	5•	10	1	V_{OS} at Common OUT/IN	CD4053	30	MHz
	$V_{EE} = V_{SS}$, $20 \log \frac{V_{OS}}{V_{is}} = -3$dB				CD4052	25	
					CD4051	20	
				V_{OS} at Any Channel		60	
Harmonic rtion, HD	2•	5	10			0.3	%
	3•	10				0.2	
	5•	15				0.12	
	$V_{EE} = V_{SS}$, f_{is} = 1 kHz sine wave						
dB through uency Channels OFF)	5•	10	1	V_{OS} at Common OUT/IN	CD4053	8	MHz
	$V_{EE} = V_{SS}$, $20 \log \frac{V_{OS}}{V_{is}} = -40$dB				CD4052	10	
					CD4051	12	
				V_{OS} at Any Channel		8	
dB al Crosstalk uency	5•	10	1	Between Any 2 Channels		3	MHz
	$V_{EE} = V_{SS}$, $20 \log \frac{V_{OS}}{V_{is}} = -40$dB			Between Sections CD4052 Only	Measured on Common	6	
					Measured on Any Channel	10	
				Between Any 2 Sections CD4053 Only	In Pin 2, Out Pin 14	2.5	
					In Pin 15, Out Pin 14	6	
ss-or-Inhibit- gnal Crosstalk	—	10	10#			65	mV (Peak)
	V_{EE}=0, V_{SS}=0, t_r,t_f = 20 ns, $V_C = V_{DD} - V_{SS}$ (Square Wave)						

k-to-peak voltage symmetrical about $\frac{V_{DD} - V_{EE}}{2}$

h ends of channel

TEST CIRCUITS (Cont'd)

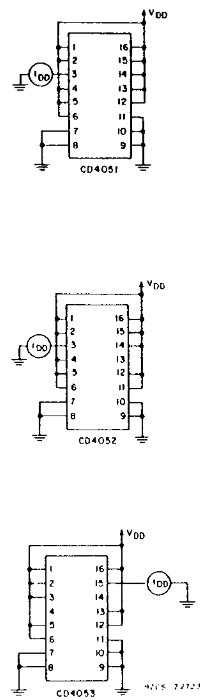


Fig.17 – OFF channel leakage current – all channels OFF.

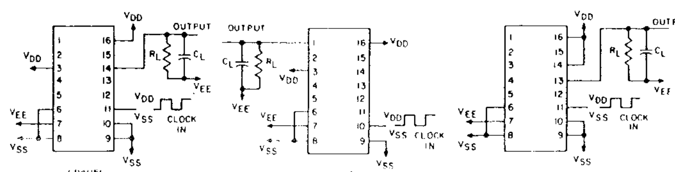


Fig.18 – Propagation delay address input to signal output.

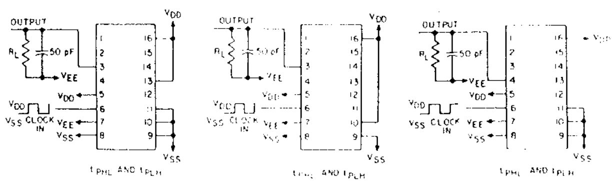


Fig.19 Propagation delay inhibit input to signal output.

CD4051B, CD4052B, CD4053B Types

TEST CIRCUITS (Cont'd)

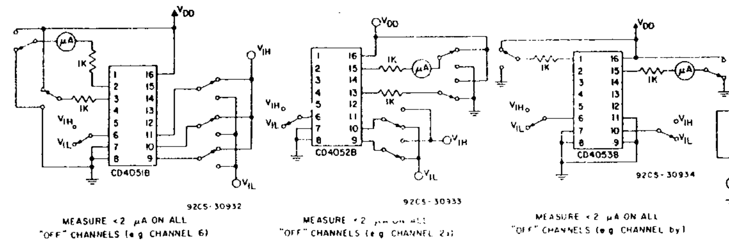


Fig. 20 – Input voltage test circuits (noise immunity).

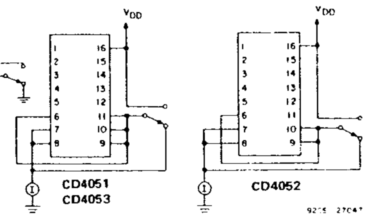


Fig.21 – Quiescent device current.

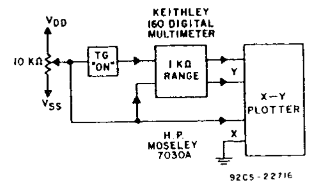


Fig.22 – Channel ON resistance measurement circuit.

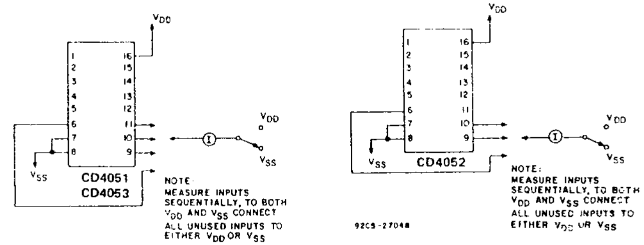


Fig. 23 – Input current.

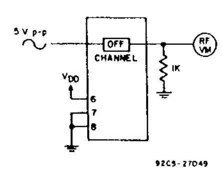


Fig.24 – Feedthrough (all types).

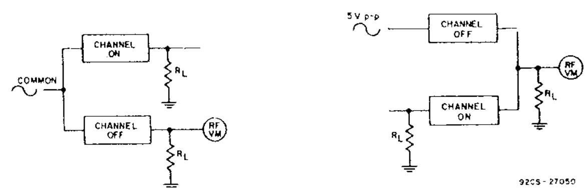


Fig.25 – Crosstalk between any two channels (all types).

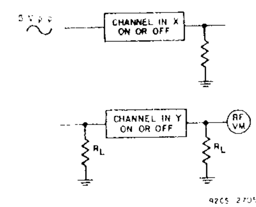


Fig.26 – Crosstalk between duals or triplets (CD4052B, CD4053B).

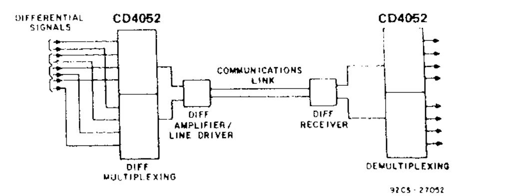


Fig.27 – Typical time-division application of the CD4052B.

CMOS 8-Stage Shift-and-Store Bus Register

High-Voltage Types (20-Volt Rating)

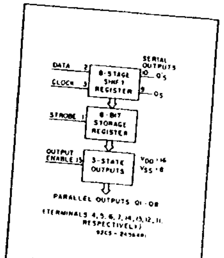
The RCA-CD4094B is an 8-stage serial shift register having a storage latch associated with each stage for strobing data from the serial input to parallel buffered 3-state outputs. The parallel outputs may be connected directly to common bus lines. Data is shifted on positive clock transitions. The data in each shift register stage is transferred to the storage register when the STROBE input is high. Data in the storage register appears at the outputs whenever the OUTPUT-ENABLE signal is high.

Two serial outputs are available for cascading a number of CD4094B devices. Data is available at the Q_S serial output terminal on positive clock edges to allow for high-speed operation in cascaded systems in which the clock rise time is fast. The same serial information, available at the Q'_S terminal on the next negative clock edge, provides a means for cascading CD4094B devices when the clock rise time is slow.

The CD4094B types are supplied in 16-lead hermetic dual-in-line ceramic packages (D and F suffixes), 16-lead dual-in-line plastic package (E suffix), 16-lead ceramic flat package (K suffix), and in chip form (H suffix).

Features:
- 3-state parallel outputs for connection to common bus
- Separate serial outputs synchronous to both positive and negative clock edges for cascading
- Medium speed operation – 5 MHz at 10 V (typ.)
- Standardized, symmetrical output characteristics
- 100% tested for quiescent current at 20 V
- Maximum input current of 1 μA at 18 V over full package-temperature range; 100 nA at 18 V and 25°C
- Noise margin (full package temperature range): 1 V at V_{DD} = 5 V 2 V at V_{DD} = 10 V 2.5 V at V_{DD} = 15 V
- 5-V, 10-V, and 15-V parametric ratings
- Meets all requirements of JEDEC Tentative Standard No. 13A, "Standard Specifications for Description of 'B' Series CMOS Devices"

Applications:
- Serial-to-parallel data conversion
- Remote control holding register
- Dual-rank shift, hold, and bus applications



FUNCTIONAL DIAGRAM

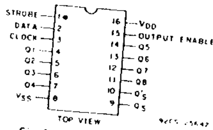


Fig. 1 – Terminal assignment.

MAXIMUM RATINGS, *Absolute-Maximum Values:*

DC SUPPLY-VOLTAGE RANGE, (V_{DD})
(Voltages referenced to V_{SS} Terminal) .... -0.5 to +20 V
INPUT VOLTAGE RANGE, ALL INPUTS .... -0.5 to V_{DD} +0.5 V
DC INPUT CURRENT, ANY ONE INPUT .... ±10 mA
POWER DISSIPATION PER PACKAGE (P_D):
For T_A = -40 to +60°C (PACKAGE TYPE E) .... 500 mW
For T_A = +60 to +85°C (PACKAGE TYPE E) .... Derate Linearly at 12 mW/°C to 200 mW
For T_A = -55 to +100°C (PACKAGE TYPES D, F, K) .... 500 mW
For T_A = +100 to +125°C (PACKAGE TYPES D, F, K) .... Derate Linearly at 12 mW/°C to 200 mW
DEVICE DISSIPATION PER OUTPUT TRANSISTOR:
For T_A = FULL PACKAGE-TEMPERATURE RANGE (All Package Types) .... 100 mW
OPERATING-TEMPERATURE RANGE (T_A):
PACKAGE TYPES D, F, K, H .... -55 to +125°C
PACKAGE TYPE E .... -40 to +85°C
STORAGE TEMPERATURE RANGE (T_{stg}) .... -65 to +150°C
LEAD TEMPERATURE (DURING SOLDERING):
At distance 1/16 ± 1/32 inch (1.59 ± 0.79 mm) from case for 10 s max. .... +265°C

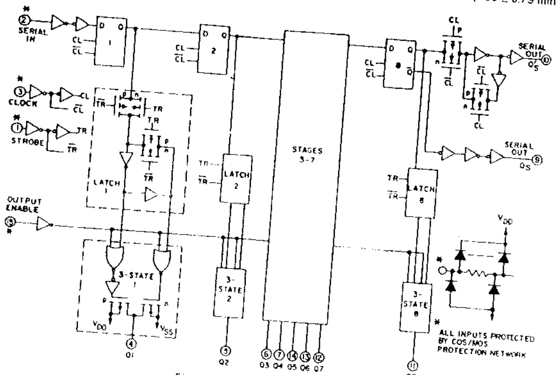


Fig. 2 – CD4094B Logic diagram.

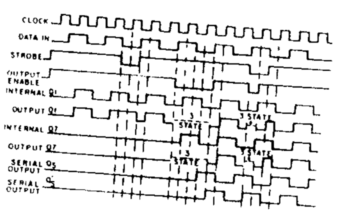


Fig. 3 – Timing diagram.

RECOMMENDED OPERATING CONDITIONS *at T_A = 25°C, Except as Noted. For maximum reliability, nominal operating conditions should be selected so that operation is always within the following ranges:*

CHARACTERISTIC	VDD (V)	LIMITS MIN.	LIMITS MAX.	UNITS
Supply-Voltage Range (For T_A=Full Package-Temperature Range)		3	18	V
Data Setup Time, t_S	5 10 15	125 55 35	– – –	ns
Clock Pulse Width, t_W	5 10 15	200 100 83	– – –	ns
Clock Input Frequency, f_{CL}	5 10 15	dc	1.25 2.5 3	MHz
Clock Input Rise or Fall time, t_rCL, t_fCL:*	5 10 15	–	15 5 5	μs
Strobe Pulse Width, t_W	5 10 15	200 80 70	– – –	ns

*If more than one unit is cascaded t_rCL (for Q_S only) should be made less than or equal to the sum of the fixed propagation delay at 50 pF and the transition time of the output driving stage for the estimated capacitive load.

TRUTH TABLE

CL▲	Output Enable	Strobe	Data	Parallel Outputs Q1	Parallel Outputs QN	Serial Outputs QS*	Serial Outputs Q'S
↑	0	X	X	OC	OC	Q7	NC
↓	0	X	X	OC	OC	NC	Q7
↑	1	0	X	NC	NC	Q7	NC
↑	1	1	0	0	QN-1	Q7	NC
↑	1	1	1	1	QN-1	Q7	NC
↓	1	1	1	NC	NC	NC	Q7

▲ = Level Change
X = Don't Care
NC = No Change
OC = Open Circuit.

Logic 1 = High
Logic 0 = Low

* At the positive clock edge information in the 7th shift register stage is transferred to the 8th register stage and the QS output

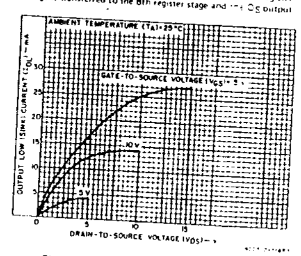


Fig. 4 – Typical output low (sink) current characteristics.

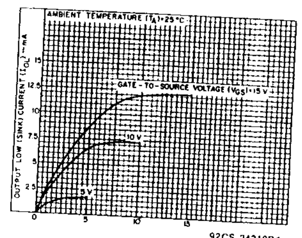


Fig. 5 – Minimum output low (sink) current characteristics.

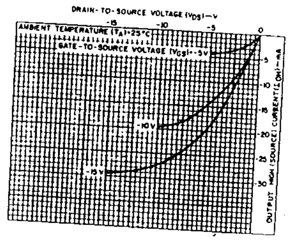


Fig. 6 – Typical output high (source) current characteristics.

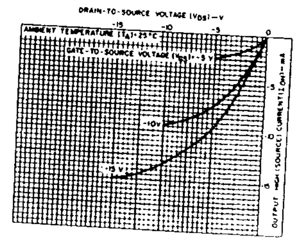


Fig. 7 – Minimum output high (source) current characteristics.

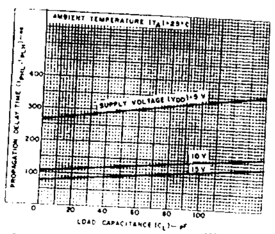


Fig. 8 – Clock-to-serial output Q_S propagation delay vs C_L.

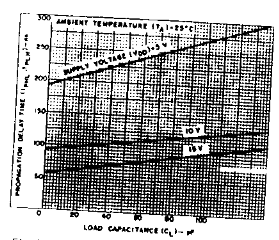


Fig. 9 – Clock-to-serial output Q'_S propagation delay vs C_L.

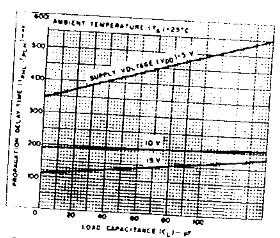


Fig. 10 – Clock-to-parallel output propagation delay vs C_L.

OS Analog ltiplexers/Demultiplexers*

Logic-Level Conversion

Voltages Types (20-Volt Rating)

ı51B – Single 8-Channel
ı52B – Differential 4-Channel
ı53B – Triple 2-Channel

CD4051B, CD4052B, and CD4053B ı multiplexers/demultiplexers are digi-controlled analog switches having low npedance and very low OFF leakage ıt. Control of analog signals up to peak-to-peak can be achieved by digi-gnal amplitudes of 4.5 to 20 V (if V_{SS} = 3 V, a V_{DD}-V_{EE} of up to 13 n be controlled; for V_{DD}-V_{EE} level ences above 13 V, a V_{DD}-V_{SS} of at 4.5 V is required). For example, if = +4.5V, V_{SS} = 0, and V_{EE} = −13.5 V, g signals from −13.5 V to +4.5 V can ntrolled by digital inputs of 0 to 5 V. multiplexer circuits dissipate extremely uiescent power over the full V_{DD}-V_{SS} V_{DD}-V_{EE} supply-voltage ranges, inde-nt of the logic state of the control ls. When a logic "1" is present at the it input terminal all channels are off.

CD4051B is a single 8-channel multi-r having three binary control inputs, A, ıd C, and an inhibit input. The three y signals select 1 of 8 channels to be ıd on, and connect one of the 8 inputs e output.

CD4052B is a differential 4-channel multi-r having two binary control inputs, A 3, and an inhibit input. The two binary t signals select 1 of 4 pairs of channels e turned on and connect the analog in-to the outputs.

CD4053B is a triple 2-channel multi-r having three separate digital control s, A, B, and C, and an inhibit input. control input selects one of a pair of ıels which are connected in a single-double-throw configuration.

CD4051B, CD4052B, and CD4053B are ılied in 16-lead ceramic dual-in-line ages (D and F suffixes), 16-lead plastic -in-line packages (E suffix), 16-lead mic flat packages (K suffix), and in chip (H suffix).

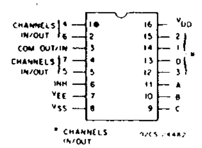
en these devices are used as demultiplexers, "CHANNEL IN/OUT" terminals are the puts and the "COMMON OUT/IN" terminals the inputs.

Applications:

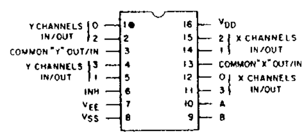
- Analog and digital multiplexing and demultiplexing
- A/D and D/A conversion
- Signal gating

Features:

- Wide range of digital and analog signal levels: digital 3 to 20 V, analog to 20 $V_{p\text{-}p}$
- Low ON resistance: 125 Ω (typ.) over 15 $V_{p\text{-}p}$ signal-input range for V_{DD}-V_{EE} = 15 V
- High OFF resistance: channel leakage of ±100 pA (typ.) @ V_{DD}-V_{EE} = 18 V
- Logic-level conversion for digital addressing signals of 3 to 20 V (V_{DD}-V_{SS} = 3 to 20 V) to switch analog signals to 20 V p-p (V_{DD}-V_{EE} = 20 V); see introductory text
- Matched switch characteristics: R_{ON} = 5 Ω (typ.) for V_{DD}-V_{EE} = 15 V
- Very low quiescent power dissipation under under all digital-control input and supply conditions: 0.2 μW (typ.) @ V_{DD}-V_{SS} = V_{DD}-V_{EE} = 10 V
- Binary address decoding on chip
- 5-, 10-, and 15-V parametric ratings
- 100% tested for quiescent current at 20 V
- Maximum input current of 1 μA at 18 V over full package temperature range; 100 nA at 18 V and 25°C
- Break-before-make switching eliminates channel overlap



CD4051B
Terminal Assignment



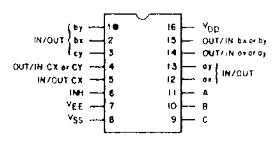
CD4052B
Terminal Assignment

RECOMMENDED OPERATING CONDITIONS AT T_A = 25°C (Unless Otherwise Specified)

For maximum reliability, nominal operating conditions should be selected so that operation is always within the following ranges. Values shown apply to all types except as noted.

CHARACTERISTIC	V_{DD}	Min.	Max.	Units
Supply-Voltage Range (T_A = Full Package-Temp. Range)	–	3	18	V
Multiplexer Switch Input Current Capability*	–	–	25	mA
Output Load Resistance	–	100	–	Ω

* In certain applications, the external load-resistor current may include both V_{DD} and signal-line components. To avoid drawing V_{DD} current when switch current flows into the transmission gate inputs, the voltage drop across the bidirectional switch must not exceed 0.8 volt (calculated from R_{ON} values shown in ELECTRICAL CHARACTERISTICS CHART). No V_{DD} current will flow through R_L if the switch current flows into terminal 3 on the CD4051; terminals 3 and 13 on the CD4052; terminals 4, 14, and 15 on the CD4053.



CD4053B
Terminal Assignment

MAXIMUM RATINGS, *Absolute-Maximum Values:*

DC SUPPLY-VOLTAGE RANGE, (V_{DD})
(Voltages referenced to V_{SS} or V_{EE}, whichever is more negative) . . . −0.5 to +20 V
INPUT VOLTAGE RANGE, ALL INPUTS . . . −0.5 to V_{DD} +0.5 V
DC INPUT CURRENT, ANY ONE INPUT . . . ±10 mA
POWER DISSIPATION PER PACKAGE (P_D):
For T_A = −40 to +60°C (PACKAGE TYPE E) . . . 500 mW
For T_A = +60 to +85°C (PACKAGE TYPE E) . . . Derate Linearly at 12 mW/°C to 200 mW
For T_A = −55 to +100°C (PACKAGE TYPES D, F, K) . . . 500 mW
For T_A = +100 to +125°C (PACKAGE TYPES D, F, K) . . . Derate Linearly at 12 mW/°C to 200 mW
DEVICE DISSIPATION PER OUTPUT TRANSISTOR
FOR T_A = FULL PACKAGE-TEMPERATURE RANGE (All Package Types) . . . 100 mW
OPERATING-TEMPERATURE RANGE (T_A):
PACKAGE TYPES D, F, K, H . . . −55 to +125°C
PACKAGE TYPE E . . . −40 to +85°C
STORAGE TEMPERATURE RANGE (T_{stg}) . . . −65 to +150°C
LEAD TEMPERATURE (DURING SOLDERING):
At distance 1/16 ± 1/32 inch (1.59 ± 0.79 mm) from case for 10 s max. . . . +265°C

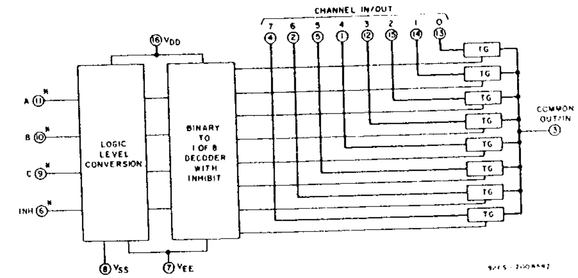


Fig. 1 – Functional diagram of CD4051B.

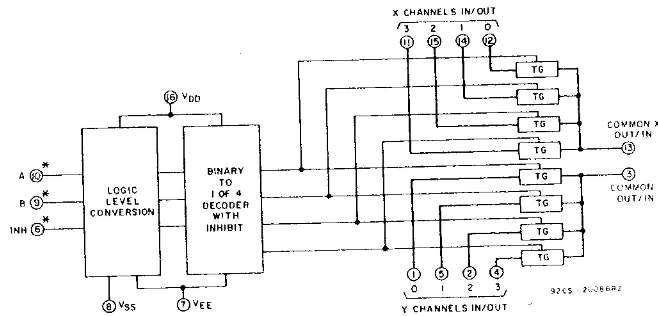


Fig. 2 – Functional diagram of CD4052B.

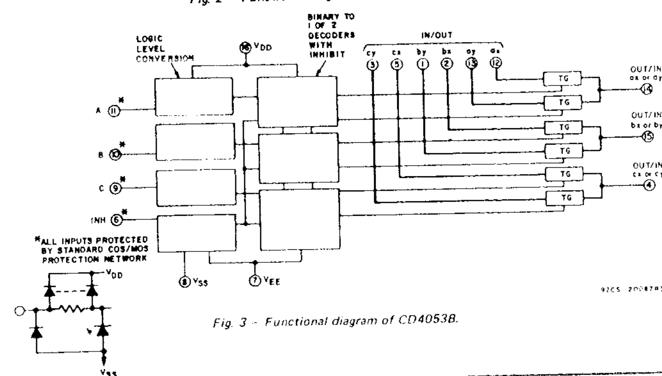


Fig. 3 – Functional diagram of CD4053B.

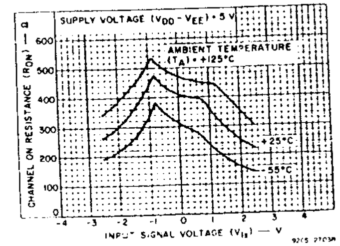


Fig. 4 – Typical channel ON resistance vs input signal voltage (all types).

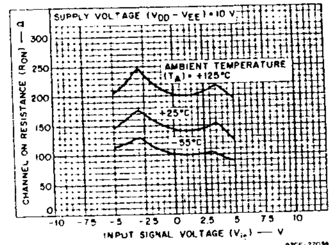


Fig. 5 – Typical channel ON resistance vs. input signal voltage (all types).

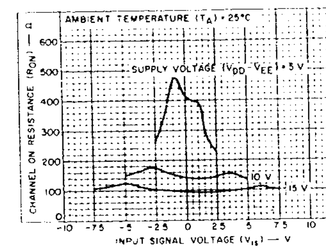


Fig. 6 – Typical channel ON resistance vs. input signal voltage (all types).

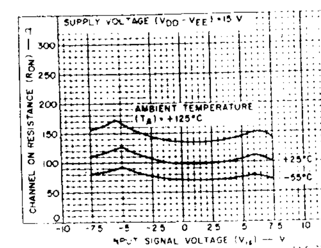


Fig. 7 – Typical channel ON resistance vs. input signal voltage (all types).

CD4094B Types

STATIC ELECTRICAL CHARACTERISTICS

CHARACTERISTIC	CONDITIONS V_O (V)	V_{IN} (V)	V_{DD} (V)	LIMITS AT INDICATED TEMPERATURES (°C) Values at -55, +25, +125 Apply to D, F, K, H Packages; Values at -40, +25, +85 Apply to E Package: -55	-40	+85	+125	+25 Min.	+25 Typ.	+25 Max.	UNITS
Quiescent Device Current, I_{DD} Max.	–	0,5	5	5	5	150	150	–	0.04	5	μA
	–	0,10	10	10	10	300	300	–	0.04	10	
	–	0,15	15	20	20	600	600	–	0.04	20	
	–	0,20	20	100	100	3000	3000	–	0.08	100	
Output Low (Sink) Current I_{OL} Min.	0.4	0,5	5	0.64	0.61	0.42	0.36	0.51	1	–	mA
	0.5	0,10	10	1.6	1.5	1.1	0.9	1.3	2.6	–	
	1.5	0,15	15	4.2	4	2.8	2.4	3.4	6.8	–	
Output High (Source) Current, I_{OH} Min.	4.6	0,5	5	-0.64	-0.61	-0.42	-0.36	-0.51	-1	–	
	2.5	0,5	5	-2	-1.8	-1.3	-1.15	-1.6	-3.2	–	
	9.5	0,10	10	-1.6	-1.5	-1.1	-0.9	-1.3	-2.6	–	
	13.5	0,15	15	-4.2	-4	-2.8	-2.4	-3.4	-6.8	–	
Output Voltage: Low-Level, V_{OL} Max.	–	0,5	5	0.05				–	0	0.05	V
	–	0,10	10	0.05				–	0	0.05	
	–	0,15	15	0.05				–	0	0.05	
Output Voltage: High-Level, V_{OH} Min.	–	0,5	5	4.95				4.95	5	–	
	–	0,10	10	9.95				9.95	10	–	
	–	0,15	15	14.95				14.95	15	–	
Input Low Voltage, V_{IL} Max.	0.5, 4.5	–	5	1.5				–	–	1.5	V
	1, 9	–	10	3				–	–	3	
	1.5,13.5	–	15	4				–	–	4	
Input High Voltage, V_{IH} Min.	0.5, 4.5	–	5	3.5				3.5	–	–	
	1, 9	–	10	7				7	–	–	
	1.5,13.5	–	15	11				11	–	–	
Input Current I_{IN} Max.	–	0,18	18	±0.1	±0.1	±1	±1	–	$\pm10^{-5}$	±0.1	μA
3-State Output Leakage Current I_{OUT} Max.	0,18	0,18	18	±0.4	±0.4	±12	±12		10^{-4}	±0.4	μA

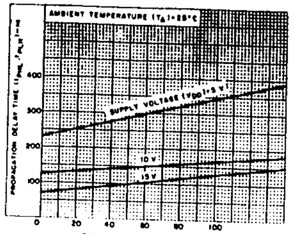


Fig. 11 – Strobe-to-parallel output propagation delay vs C_L.

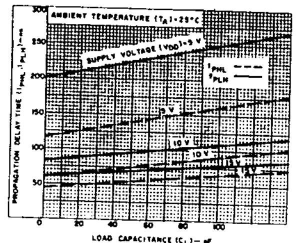


Fig. 12 – Output enable-to-parallel output propagation delay vs C_L.

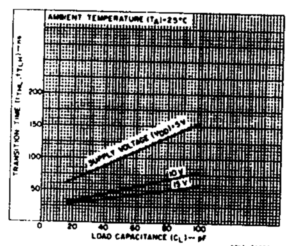


Fig. 13 – Typical transition time vs. load capacitance.

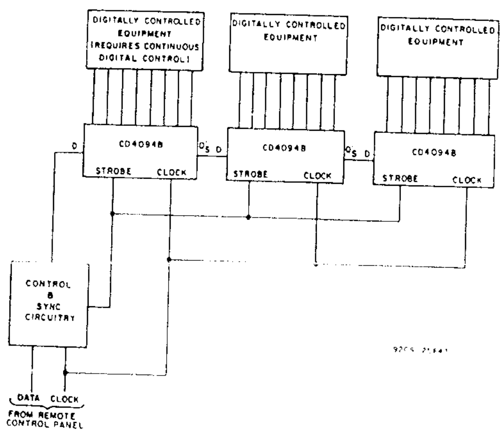


Fig. 14 - Remote control holding register.

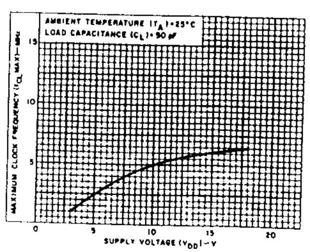


Fig. 15 – Typical maximum-clock-frequency vs. supply voltage.

CD4094B Types

DYNAMIC ELECTRICAL CHARACTERISTICS

At T_A=25°C; Input t_r, t_f = 20 ns, C_L = 50 pF, R_L = 200 kΩ

CHARACTERISTIC	V_{DD} (V)	LIMITS MIN.	TYP.	MAX.	UNITS
Propagation Delay Time, t_{PHL}, t_{PLH} Clock to Serial Output Q_S	5 10 15	– – –	300 125 95	600 250 190	ns
Clock to Serial Output Q'_S	5 10 15	– – –	230 110 75	460 220 150	ns
Clock to Parallel Output	5 10 15	– – –	420 195 135	840 390 270	ns
Strobe to Parallel Output	5 10 15	– – –	290 145 100	580 290 200	ns
Output Enable to Parallel Output: t_{PHZ}, t_{PZH}	5 10 15	– – –	140 60 45	280 120 90	ns
t_{PLZ}, t_{PZL}	5 10 15	– – –	100 50 40	200 100 80	ns
Minimum Strobe Pulse Width, t_W	5 10 15	– – –	100 40 35	200 80 70	ns
Minimum Clock Pulse Width, t_W	5 10 15	– – –	100 50 40	200 100 83	ns
Minimum Data Setup Time, t_S	5 10 15	– – –	60 30 20	125 55 35	ns
Transition Time; t_{THL}, t_{TLH}	5 10 15	– – –	100 50 40	200 100 80	ns
Maximum Clock Input Rise or Fall Time, t_rCL, t_fCL	5 10 15	15 5 5	– – –	– – –	μs
Maximum Clock Input Frequency, f_{CL}	5 10 15	1.25 2.5 3	2.5 5 6	– – –	MHz
Input Capacitance C_{IN} (Any Input)	–	–	5	7.5	pF

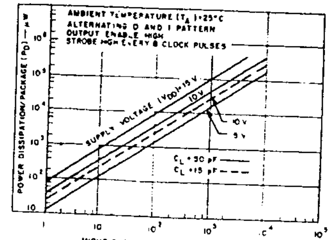


Fig. 16 – Dynamic power dissipation vs input clock frequency.

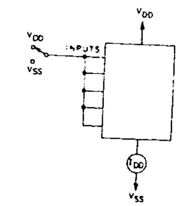


Fig. 17 – Quiescent device current test circuit.

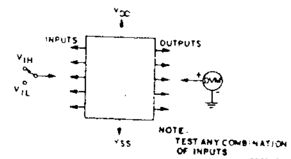


Fig. 18 – Input voltage test circuit.

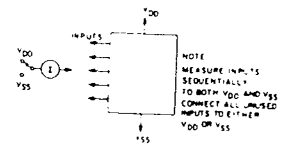
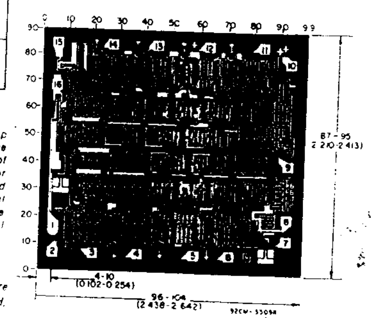


Fig. 19 – Input current test circuit.



Dimensions and Pad Layout for CD4094B Chip

The photographs and dimensions of each CMOS chip represent a chip when it is part of the wafer. When the wafer is separated into individual chips, the angle of cleavage may vary with respect to the chip face for different chips. The actual dimensions of the isolated chip, therefore, may differ slightly from the nominal dimensions shown. The user should consider a tolerance of −3 mils to +16 mils applicable to the nominal dimensions shown.

Dimensions in parentheses are in millimeters and are derived from the basic inch dimensions as indicated. Grid graduations are in mils (10^{-3} inch).