DESIGN AND CONSTRUCTION OF A REMOTE CONTROLLED FAN REGULATOR

BY

ZIBIRI LAWAL

2001/12151EE

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA

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LAWAL ZIBIRI

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DEDICATION

This project work is dedicated to all those, who in their different Careers strive to make this world a better place to live in. kudos and please keep up the good work.

DECLARATION

I, Zibiri Lawal, declare that this work was done by me and has never been presented elsewhere for the award of a degree. I also hereby relinquish the copyright to the Federal University of Technology, Minna.

ZIBIRI LAWAL	Engr M-S-Ahmed
(Name of student)	**(Name of supervisor)**
Zlawal/26/11/2007	26/11/07
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(Name of H.O.D)	**(Name of External Examiner)**
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ABSTRACT

This project work is based on pulse width modulation (PWM). Pulse width modulation is a technique in which the digital input code is used to generate a train of pulse of fixed frequency, with width proportional to the input count.

This was easily implemented using a decade counter, a magnitude comparator and a high frequency clock. The transmitter generates an infrared pulse at a frequency of approximately 38 KHz, which is detected by the sensor on the receiver. The receiver unit then generates a PWM signal that is used to control/regulate the input voltage to the fan.

Hence, the speed of the fan is controlled and the different speed levels are displayed using a 7-segement display. This device enables a user to regulate a fan from approximately 10 meters away.

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CHAPTER ONE

GENERAL INTRODUCTION

1.1 INTRODUCTION

Technology has embraced development in almost all facets of life. Hence, the introduction of fan has brought much comfort and gratification to mankind. Since users have different desire at which the fan should rotate, the fan regulator is there to give free choice of designed speed of the fan blade. The fan is regulated by controlling the input voltage which is proportional to the speed of the blade rotation.

Fan (machine), is a power-driven device that produces a flow of air or gas. Mechanical fans move air and gases through ventilating systems, force air through steam boilers, lower the operating temperature of electronics and machinery, and serve numerous other industrial needs. Fans operate at relatively low pressures. When a high-pressure blast of air or gas is needed, an air compressor is used instead of a fan. [1]

Engineers are always faced with the challenge of economic value and easy maintenance, of the different devices or machines, they design and construct. In other to meet this challenge, this project work technically implements the use of infrared remote controlled fan regulator to control fans.

The cheapest way to remotely control a device within a visible range is through the use of infrared light. Infrared, actually is a normal light with a particular colour. We humans cannot see this colour, because its wavelength of 950nm is below the visible spectrum. This is one of the reasons why infrared is chosen for remote control purposes; we want to use it, but, we are not interested in seeing it. Another reason is because infrared light emitting diodes (IR-LEDs) are quite easy to make, therefore, very cheap. [2]

The use of infrared remote controlled fan regulators to control electrical fans, in turn increases the comfort of the fans. Hence, the user of a remote controlled fan regulator can easily be positioned from a particular range from the fan regulator, and select a desired speed level of the fan, through the use of an infrared remote control.

1.2 AIMS OF THE PROJECT

This project work was designed and constructed to meet the following objectives:

1. To design and construct a system unit that can be controlled by a remote control.
2. To implement a remote control system unit for fans with the use of cheap and readily available electrical components.
3. To provide a system that is simple to understand and also easy to operate.
4. To provide a system that is affordable and easy to maintain.
5. To increase the comfort derived from fans in our homes or offices through the use of an infrared remote control.

1.3 PROJECT PROFILE

This project work is written in five different chapters as explained thus:

Chapter One: This chapter presents a general introduction about what this project work is all about.

It also, highlights the aims of the project, the project profile, the methodology employed and sources of materials used in the design and construction of the project.

Chapter two: This gives the literature review that highlights previous works of the project. It contains the theoretical background, brief historical background and also points out some difficulties that limit the performance of previous works and the advantages of this project work as an improvement.

Chapter Three: This contains the modular steps taken in the design of this project work. It shows the principle of the operation of the circuit diagrams involved, and takes an in-depth look at various component and sub-circuits that makes up the system.

Chapter Four: This covers the construction details, testing and analysis. It brings the bread boarding of the circuit, the soldering of the components on the Vero-board, casing the construction, testing precautions taken, troubleshooting and results obtained. Then finally, it highlights some difficulties encountered in the course of the construction, testing procedures.

Chapter Five: This chapter presents the summary of this project work. It gives the conclusion, recommendations, and possible improvements to further work schedule for the future.

1.4 METHODOLOGY

The method employed on this project is based on pulse width modulation (PWM). Pulse width modulation is a technique, in which the digital input code is used to generate a train of pulse of fixed frequency, with width proportional to the input count. This can be easily done with a counter, magnitude comparator and a high frequency clock [3].

The speed regulation using an infrared remote control consists of a transmitter–receiver circuit. The transmitter circuit is used to produce an infrared signal, which is received by an infrared remote sensor on the receiver circuit. A pulse width modulated signal is generated using a counter, a magnitude comparator, and a high frequency clock.

The pulse width modulated signal generated, is transfered to a solid state switch, which is used to control the fan speed. The speed level is displayed using a 7-segment display connected to a counter.

1.5 SOURCES OF MATERIAL

Considering the availability and cost effectiveness of the materials readily available and affordable, the materials used in this project were carefully selected; they include resistors, IC's (Integrated circuit), step-down transformer, infrared sensor, opto-coupler, etc.

1.6 BENEFITS OF FAN SPEED CONTROL

- **Reduced audible noise.**

One of the most immediately noticeable advantages of fan speed control comes in the form of relief for the human ear. Fans running at full speed when not required can be a significant source of annoyance especially in quiet environment.

- **Reduced Power Consumption**

In situation where minimization of power cost is of paramount importance, fan speed control is quite appreciated. Power consumption can be approximated as the square of the fan's speed.

- **Increased Lifetime**

Reducing fan speed when necessary also decreases the wear on the fan. Fan wear is a rough function of the absolute number of revolutions of the fan. Reduced wear translates into increased lifetime and therefore greater meantime between failures. Because fans are mechanical, they tend to be one of the more common failures in a system [2].

CHAPTER TWO

LITERATURE REVIEW

2.1 BRIEF HISTORY OF INFRARED REMOTE CONTROL

The first remote control, called "lazy bones" was developed in 1950 by Zenith Electronics Corporation (then known as Zenith Radio Corporation). The device was developed quickly, and it was called "Zenith space command", the remote went into production in the fall of 1956, becoming the first practical wireless remote control device [4].

By the early 1980s, the industry moved to infrared, or IR, remote technology. The IR remote works by using a low frequency light beam, so low that the human eye cannot see it, but which can be detected by a receiver in the TV. Zenith's development of cable-compatible tuning and teletext technologies in the 1980s greatly enhanced the capabilities and uses for infrared TV remotes. Today, remote control is a standard feature on other consumer electronics products, including VCRs, cable and satellite boxes, digital video disc players and home audio receivers. And the most sophisticated TV sets have remotes with as many as 50 buttons [5].

In year 2000, more than 99 percent of all TV set and 100 percent of all VCR and DVD players sold are equipped with remote controls. The average individual these days probably picks up a remote control at least once or twice a day. Basically, a remote control works in the following manner. A button is pressed. This completes a specific connection which produces a Morse code line signal specific to that button. The transistor amplifies the signal and sends it to the LED which translates the signal into infrared light. The sensor on the appliance detects the infrared light and reacts appropriately. [4]

2.2 BRIEF HISTORY OF FANS

The earliest known records of fans are from china more than 5000 years ago. An Egyptian sculptor from 3200BC depicts large fans being carried by bearers in a royal procession. Two feathered ceremonial fans were found in the tomb of the king Tutankhamen from 1352BC. Fan history stretches back thousands of years. Fans have two main functions – a status symbol and a useful ornament. In their development, fans are made of a variety of materials some of them are quite decorative and some others are artworks for attraction [6].It is quite evident that any plane material waving through air serves as a fan. Therefore, the simplest and early known fans are fixed leaf types. They were manipulated by hand to cool the body through generated breeze or airflow. In the ancient time, salves were tasked to blow air to their respective masters with large fans. It was recorded in Assyrian and Egyptian histories. Hand fans were in use through time until around the middle 1700s when inventors concentrated their effort in developing mechanical fans [6].

The Industrial Revolution in the late 1800s introduced belt-driven fans powered by factory waterwheels. Attaching wooden or metal blades to shafts overhead that were used to drive the machinery, the first industrial fans were developed. One of the first workable mechanical fans was built by A.A. Sablukov in 1832. He called his invention, a kind of a centrifugal fan, an Air Pump. Centrifugal fans were successfully tested inside coal mines and factories in 1832-1834[6].

In the 1920s, industrial advances allowed steel to be mass-produced in different shapes, bringing fan prices down and allowing more homeowners to afford them. In the 1930s, the first art deco fan was designed. Before this fan, called the Silver Swan, most household fans were fairly plain. In the 1950s, fans were manufactured in colors that were bright and eye catching. Central air conditioning in the 1960s brought an end to the golden age of the electric fan. In the 1970s, Victorian-style ceiling fans became popular [6].

In the 20th century, fans have become utilitarian. During the 2000s, fan aesthetics have become a concern to fan buyers. The fan is part of everyday life in the Far East, Japan, and Spain (among other places). Electric fans have been largely replaced by air conditioners in households and offices, even though electric fans consume much less energy than air conditioners.

Presently, there are two main types of domestic fans – the ceiling and standing table fans [11]. Based on standards, a typical table fan or standing fan include the fan blades, base armature and lead wires, motor, blade guard, motor housing, and oscillator shaft. The modern ceiling fans have taken better shape and efficiency as compare to the inventors' design. Standard ceiling fan controls usually include one for speed (high, medium, low, and off), one for light (on and off), one for directional control of the fan blades (clockwise and counterclockwise).As technology advances, different types of regulators emerged. Some modern design hold computerized control. It usually involves temperature monitoring units that suit fans' speed with the subjected temperature [6].

2.3 METHODS OF SPEED REGULATION

There are many ways to control the speed of a fan. Controlling the speed of a fan, can range from as simple as regulating the input voltage to the fan, to using more complicated digital micro-processor input. Visa vise;

2.3.1 LINEAR REGULATION

The linear regulation option is designed for applications where the input power may fluctuate at different voltage levels. As the term implies, linear regulation adjusts the voltage across the fan by using a linear regulator. Unfortunately, linear regulation has its drawbacks, mainly power dissipation on the pass element (linear regulator) as well as starting up and stalling issues.

Linear regulators work by controlling the voltage across the fan. They do this by dissipating power in the form of heat. During maximum and minimum cooling, power dissipation will be ideally fully on, so the voltage across it is nearly zero. Zero voltage is equal to zero power. During minimum coding, the pass element is (zero current flow), so again, power dissipation is zero. Thus the current drawn by the fan can be approximated as a linear function of the voltage applied, making it look resistive.

Fans require a certain voltage before they will start. This is called "start-up voltage". Once a fan is already spinning, decreasing the voltage below the stall voltage will cause the fan to stop. The start-up voltage is equal to, or usually greater than stall voltage.

Typically, they are 25% to 50% of the rated voltage for the fan. And when linear regulation is used without speed monitoring, there is no way of knowing if the fan has stalled or even started. Selecting the correct voltage to ensure proper start-up for all fans can be difficult. And this could limit the useful range of speed control. [7].

2.3.2 DC - DC REGULATION

DC – DC regulation is similar to linear regulation, in that of controlling the speed of the fan by adjusting the DC voltage across the fan. However, unlike a linear regulator, a DC–DC regulator uses a switch mode power supply. Because both methods control speed by adjusting voltage, both tend to have the same advantage and disadvantage. The one exception, however, is that DC – DCs are ideally 100% efficient and don't generate any heat. Although, in realization, efficiencies tend to be around 75% to 95%. The penalty for efficiency is increased cost of complexity. [7]

2.3.3 THERMAL SPEED CONTROL

Thermal speed control option uses a thermistor or thermostatic switch to monitor the temperature and regulate the speed accordingly. As the name implies, the thermostatic switch turns the fan on and off, depending on the temperature. This switching usually causes a sudden switch from peace to noise and vice versa, which could be rather disturbing. The thermistor metal properties allow it to change its resistance of different temperatures, thus, creating a variable voltage circuit. [7]

2.3.4 PULSE WIDTH MODULATION CONTROL

This is the principle employed in the design of this project work. It has the following advantages over the other above explained methods, i.e. a very simple circuit implementation, good start-up characteristic, minimal heat dissipation in the pass transistor.

Pulse-width modulating the fan directly involves turning the fan's power supply on and off at fixed frequency. Duty-cycle adjustments are made to control the speed of the fan. The larger the duty-cycle, the faster the fan spins. The pulse width modulation rise and fall times must be sufficiently slow, to enable long-term reliability of the fan [8].

2.4 THEORETICAL BACKGROUND

Power supply from the basis of any Electrical and Electronic equipment, are detailed with the specification of nominal voltage for its optimum efficiency.

However, this project work "a remote controlled fan regulator" is not an exception of the above fact. The control of the speed level of the fan is based on pulse-width modulation (PWM). The pulse width modulation technique is one in which, the digital input code is used to generate a train of pulses, of fixed frequency with width proportional to the input count. This can be easily done with a counter, magnitude comparator and a high-frequency clock [9].

The remote controlled fan regulator is employed for controlling the speed of the fan, by regulating the input supply voltage to the changes due to each press on the button of the infrared remote control.

The output of the monostable multivibrator circuit is fed/used to clock an input "A" of a decade counter, where it advances the count (from 0 to 9), once every infrared signal is detected. A monostable multivibrator remains in a stable state, unless a positive pulse is momentarily applied to switch it into conduction [10].

A decade counter has a count sequence of zero (0000) through nine (1001), in BCD code (Binary Coded Decimal). This type of counter is useful in display application, in which BCD is required for conversion to a decimal readout [11].

A free running astable multivibrator is used to clock the input "B" of the decade counter. An astable multivibrator is a two-stage capacitor coupled common emitter amplifier with the whole of its output fed back to the input. When the supply V_{cc} is connected, the inevitable asymmetry causes one transistor to conduct quicker than the other, hence, a series of rectangular pulses of amplitude is generated by the oscillator [10].

The astable–clocked counter is connected to the "Ai"4–bit input of the magnitude comparator, while the monostable driven counter is connected to the B_i input. A comparator is used to compare the magnitude of two binary quantities, to determine the relationship of its quantities. [11].

Hence, a pulse width modulated signal is generated by the magnitude comparator; by comparing the two binary signals from the decade counters A & B.

Basically, a remote control works in the following manner. A button is pressed, and this completes a specific connection which produces a Morse code line signal specific to that button. The transistor amplifies the signal and sends it to the LED which translates the signal into infrared light. The sensor on the appliance detects the infrared light and reacts appropriately [4].

CHAPTER THREE

DESIGN AND ANALYSIS

3.1 SYSTEM DESIGN AND ANALYSIS

The remote controlled fan regulator system was designed using the functional modules as shown below, from which the steps in the design and analysis are discussed.

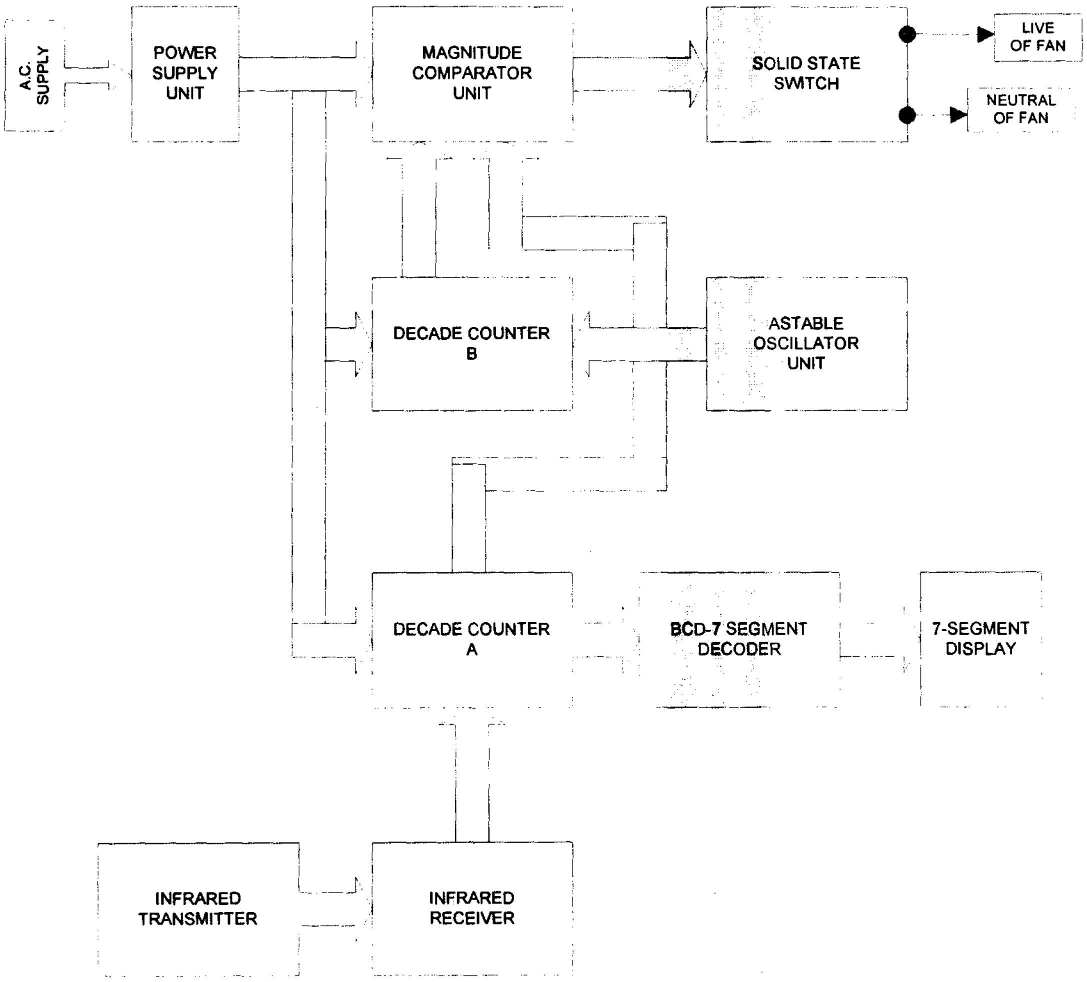


Fig. 3.1.0 simple block diagram illustrating how this project works

The remote controlled fan regulator with digital fan speed read-out was built around the under-listed sub-system:

1. Power supply unit
2. Infrared transmitter unit
3. Infrared sensor unit
4. Pulse Width modulator unit
5. Solid state switch unit
6. BCD-7 segment display and Decoder unit

3.1.1 POWER SUPPLY UNIT

The power supply is shown below: it consists of a live-noise filter network, a 12V, 0.5A step-down transformer, smothering capacitor, a full wave bridge rectifier and a 7805 voltage regulator.

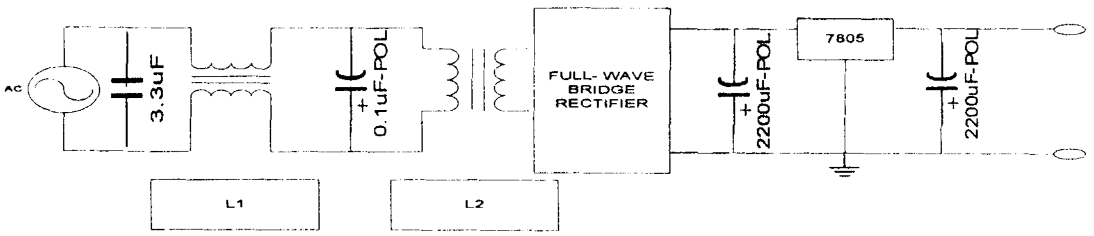


Fig. 3.1.1 Circuit diagram of Power Supply Unit

L1 is a two-coil inter-wound inductor on a ferrite core. It is used to eliminate noise on the AC supply that would otherwise cause system misbehavior, especially noises generated by heavy-duty AC motors, switching power devices, etc.

The capacitor connected across the two windings provides a path to earth, for the noise.

L2 is a 12-volt, 0.5A step-down transformer with a 240-volt primary input. It connects with a full-wave bridge rectifier to convert the A. C. input voltage to pulsating DC that is smoothened by the 2200uF capacitor, and regulated by the 7805, 5 volts regulator, and further buffered by a 2200uF capacitor across the 5 volt supply. This a.c. free constant wave supply is fed into the circuit.

Calculations:

Let V_P = primary voltage

V_s = secondary voltage

$V_P = 240V_{rms}$, $V_s = 12V_{rms}$

The transformer ratio is given by,

$V_p: Vs = 240:12 = 20:1$-- (1)

$V_{peak} = (V_{rms}\sqrt{2}) - 1.4)$ v-- (2)

V_{peak} = peak amplitude of the DC voltage at the output of bridge rectifier.

$\sqrt{2}$ = rms. to peak conversion scaling factor

1.4 = Two diode forward voltage drop.

For the Transformer used,

$V_{peak} = (12\sqrt{2}) - 1.4 = 15.51V.$

The voltage appearing across the capacitor is given by the expression [12]:

$$V_{dc} = \frac{Vpeak}{1+1/4FCR_L} \text{ --- } (3)$$

F = Mains frequency = 50Hz, in Nigeria

C = Value of smoothening capacitor across rectifier

R_L = Lead resistance on the rectifier

$$V_{dc} = \frac{(12\sqrt{2}) - 1.4}{1 + 1/(4x50x2200x10^{-6}xR_L)} \text{ -------------------------------- } (4)$$

Since the capacitor is on open at DC, R_L is effectively the resistance presented to the rectifier by the regulator and was designated as being greater than 10kΩ

Inserting this value into the equation (4), yields:

$$V_{dc} = \frac{(12\sqrt{2}) - 1.4}{1 + 1/(4x50x2200x10^{-6}x10,000)}$$

V_{dc} = 15.57V

This value of voltage is fed into the input terminal of a three-pin fixed-voltage regulator, where it is regulated down to 5V to supply the circuit.

3.1.2 INFRARED (IR) TRANSMITTER UNIT

This features the 555 multivibrator chip configured as an astable. It generates a constant amplitude 38 KHz infrared beam, when activated. This beam is detected at the receiver end to change/control the fan speed. The IR transmitter generates an unmodulated signal, thus, there is no means of directly selecting a particular speed setting. Rather, the transmitter is activated successively until the desired setting is obtained from the receiver unit.

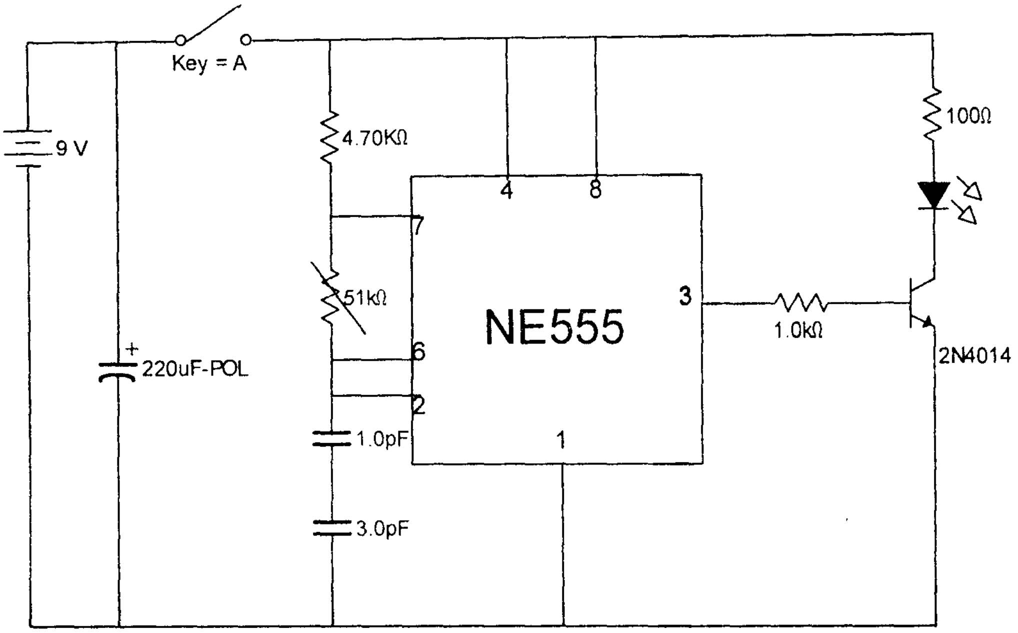


Fig. 3.1.2 circuit diagram of transmitter Unit

The oscillator is enabled by every closure of the switch A, the 9-volt battery supply power to the 555 chip. This chip then oscillates at a frequency determined by [9]:

$$F = \frac{1.44}{(R_A + 2R_B)C} \quad \text{---} \; (5)$$

Where $R_A = 4.7k\Omega$

$R_B = 22.3k\Omega$ ------------------- (adjusted from the $51k\Omega$ variable resistor)

And $C_1 = 0.001\ \mu F$, $C_2 = 0.0033\ \mu F$

Let $\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2}$

$$\rightarrow \quad C = \frac{C_1 \text{ x } C_2}{C_1 + C_2}$$

$$= \frac{(0.001 \text{ x } 0.0033) \text{ x } 10^{-12}}{(0.001 + 0.0033) \text{ x } 10^{-6}}$$

$$= \frac{(3.3\text{x } 10^{-6} \text{ x } 10^{-12})}{4.3 \text{ x } 10^{-9}}$$

$$C = 0.7674 \text{ x } 10^{-9} \text{ F}$$

Using equation (5), we have,

$$\text{Frequency, } F = \frac{1.44}{(4.7\text{x}10^3 + (2 \text{ x } 22.3 \text{ x } 10^3))(0.7674 \text{ x } 10^{-9})}$$

$$= 38062.19 \text{ Hz}$$

$$F \approx 38\text{KHz}$$

The frequency pulse makes the infrared LED in the collector terminal of the transistor to be on, so as to propagate itself across the distance separating it from the infrared sensor.

3.1.3 INFRARED (RECEIVER) SENSOR UNIT

The IR sensor sub-system shown below consists of two components:

- a three-pin infrared detector, and
- a monostable multivibrator designed out of a 555 timer chip

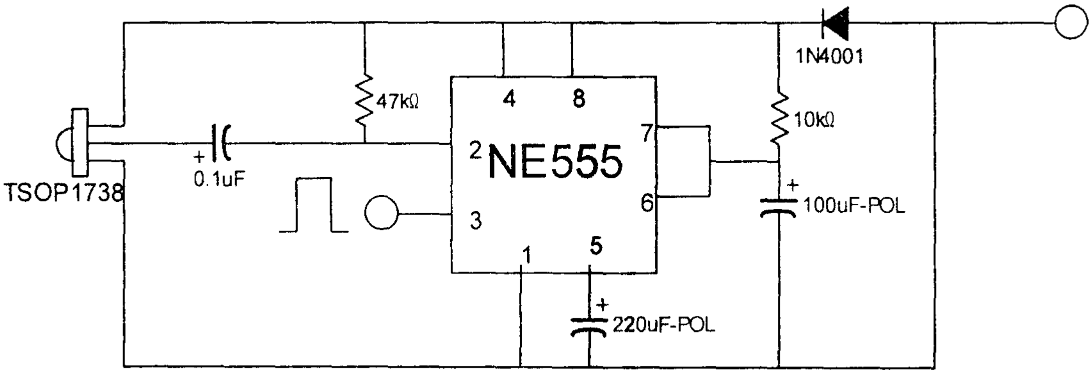


Fig. 3.1.3.0 Circuit diagram of receiver Unit

The sensor is a TSOP1738 three-pin photo-diode which is to pre-amplify the 38KHz infrared incoming signal. It responds to the transmitted IR carrier signal by taking its input low to trigger the 555 monostable as shown below:

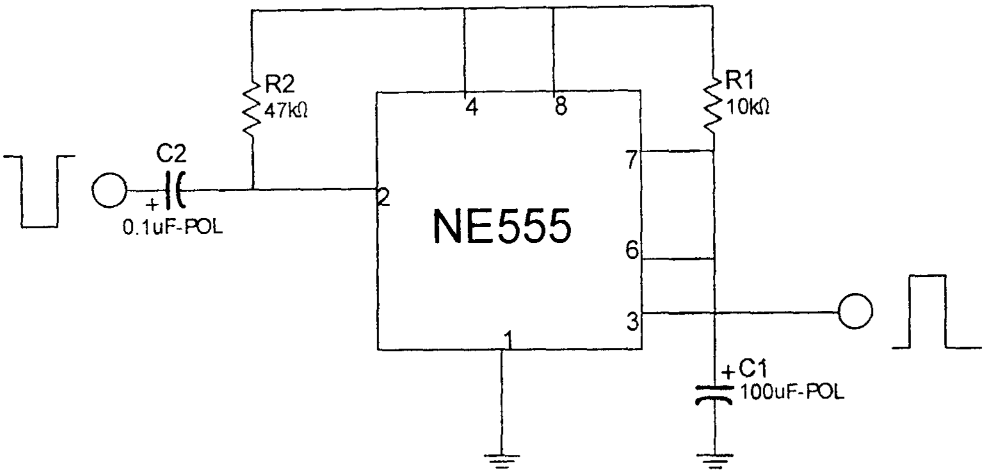


Fig. 3.1.3.1 Sub-Circuit diagram of receiver Unit

The monostable circuit, as shown above is a system that generates an output pulse of width proportional to the time constant of RC timing components for every input trigger pulse.

The 555 monostable is triggered by taking its Pin-2 lesser than $1/3V_{cc}$, switching its output (pin 3) higher for a period of time given by [11]:

T = 1.1RC

Where R = resistance between pin (7, 6) and Vcc, and

C = Capacitance between pin (7, 6) and ground.

Pin 3 returns low after T seconds.

The output at pin-3 is fed into an up-counter (decade counter) chip; CD4518 where it advances the count once every IR signal is detected.

The timing components used are:

$R_1 = 10K\Omega$

$C_1 = 100\mu F$

Yielding, $T = 1.1R_1C_1$

$= 1.1x10^4 \text{ x } 10^2 \text{ x } 10^{-6}$

$= 1.1s$

Thus, for every detected IR signal, pin-3 is high for a time of 1.1 seconds.

3.1.4 PULSE WITH MODULATOR (PWM) UNIT

The PWM sub-system consists of:

a) High-frequency astable oscillator

b) Two dual 4-bit up-counter

c) 74LS85N 4-BIT magnitude comparator.

Realization:

To generate a digital pulse-width modulation wave form (i.e. a rectangular wave form of variable duty cycle), two 4-bit logic inputs are compared using a 4-bit magnitude comparator.

In the digital realization, a continuously changing (increasing or decreasing) binary/BCD count is compared with a reference binary/BCD value using a magnitude comparator.

The comparator's output (A>B, A = B or A<B) switch to reflect the magnitude of the 4-bit inputs relative to each other.

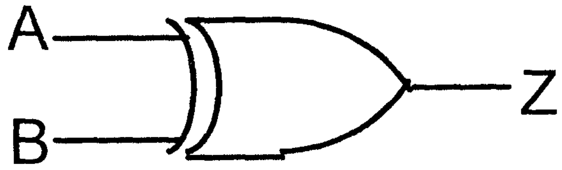


Fig. 3.1.4 Exclusive-OR circuit of Comparator

The logical representation of a 1-bit comparator is shown below:

Table 3.1.4 Truth Table of Exclusive-OR Circuit

A	B	Z
0	0	0
0	1	1
1	0	1
1	1	0

Comparing two digital values, demands the use of n-gates, n being the number of bits.

The magnitude comparator used in the 74LS85N 4-bits magnitude comparator shown below:

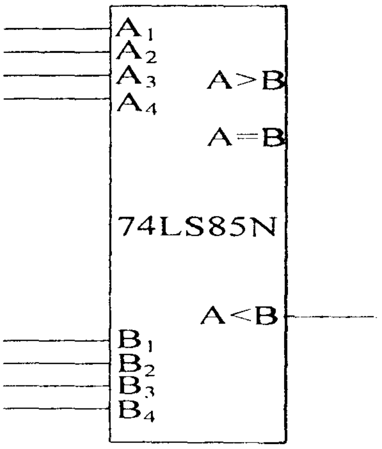


Fig. 3.1.4.0 Comparator Circuit diagram

The logic device has two 4-bit inputs with cascade features.

Three outputs are provided; A> B, A < B, A = B, all with positive output.

The A < B out is used in this project.

The two halves of the decade counters CD4518 (up-counters) are shown below. They are cascaded in one IC.

The up-counters provide the two 4-bit inputs into the comparator. One counter is clocked by the free-running oscillator, and the other counter is clocked by astable the monostable's output.

Fig. 3.1.4.1 Two halves of the decade Counter

The astable-clocked counter is connected to the A_i input of the comparator, while the monostable driven counter connects to the B_i input of the comparator.

The PWM is generated by comparing the 4-bit binary inputs, and the generated pulse width is a direct comparison of the differential values on the two inputs.

The A < B output is used as the output and it switches high or low as when the values of the two 4-bit inputs intersect. Consider the following:

Assuming the B_i input is held constant at 0011 & A_i-input cycles from 0 through 9. The truth table is shown below.

An examination of the A < B output reveals a PWM waveform that has a high period of three clock cycles divided by ten, and a low period of seven clock cycle divided by ten

Table 3.1.4.0 Input and output Variables of Comparator

S/N	A	B	A > B	A <B	A = B
0	0000	0011	0	1	0
1	0001	0011	0	1	0
2	0010	0011	0	1	0
3	0011	0011	0	0	1
4	0100	0011	1	0	0
5	0101	0011	1	0	0
6	0110	0011	1	0	0
7	0111	0011	1	0	0
8	1000	0011	1	0	0
9	1001	0011	1	0	0

If the B input is fixed at five, the output wave form is seen to posses a low time of 5 clock cycles and a high time of 5 clock cycles.

Thus by varying the binary word set on the 3-input, different duty cycles can be affected.

The method of pulse width modulation was easily implemented using digital parts, and provides power delivery in equal steps for a given reference level.

3.1.5 SOLID STATE SWITCH UNIT

This was designed around a high-power 16A triac; BT139. The triac was connected in series with the load, and due to this series connection, the average power developed in the fan winding can be directly modulated by controlling the ON – OFF time of the triac.

This is done by the PWM output via an NPN transistor.

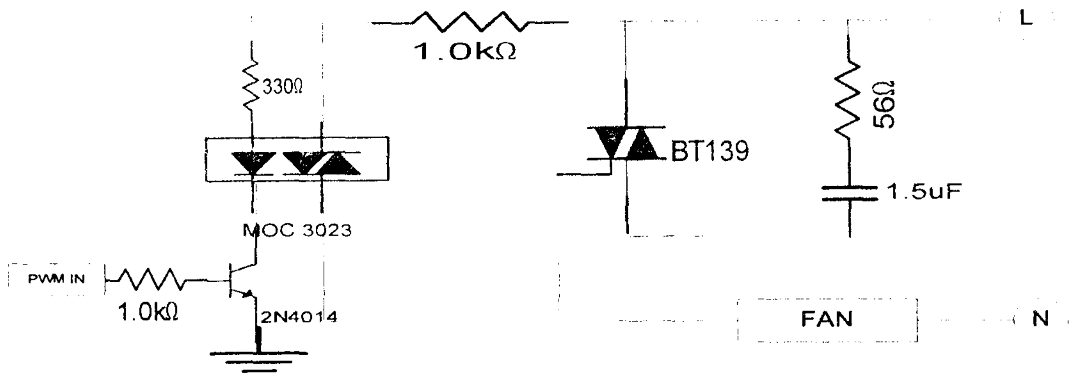


Fig. 3.1.5 Circuit diagram of Solid State Switch Unit

The power triac is controlled by an opto-triac (MOC3023), which is in-turn controlled by an infrared LED internal to the package.

If the LED is forward-biased, the opto-triac is turned on, and vice-versa.

Thus, by generating different ON-OFF times for the LED, the ON-OFF time of the opto-triac is modulated and so also is the load. Since the load is mechanical in nature, the parcels of electrical energy delivered to it are averaged out in the moving mass.

3.1.6 BCD-7 SEGMENT DISPLAY/ DECODER UNIT

The unit also features a single-digit 7-segment LED display powered via a decade. The decoder, a CD4511 connects to the 4-bit output of the monostable-driven counter, and gives a direct read-out of the fan speed.

A single cathode resistance of 27Ω was used, and the calculations were done using the expression given by [13]:

$$R_S = \frac{V_{CC} - V_{LED}}{I_{LED}}$$

$V_{CC} = 5V$, $V_{LED} = 2V$

$I_{LED} = 10mA = 0.01A$

$$R_S = \frac{5-2}{0.01} = \frac{3}{0.01} = 300\Omega$$

Since the seven LEDs are connected in parallel, the value of the above resistance is divided by 7, yielding 43 Ω. A 27 Ω, 2W resistance was used as it provides a bright enough visual display.

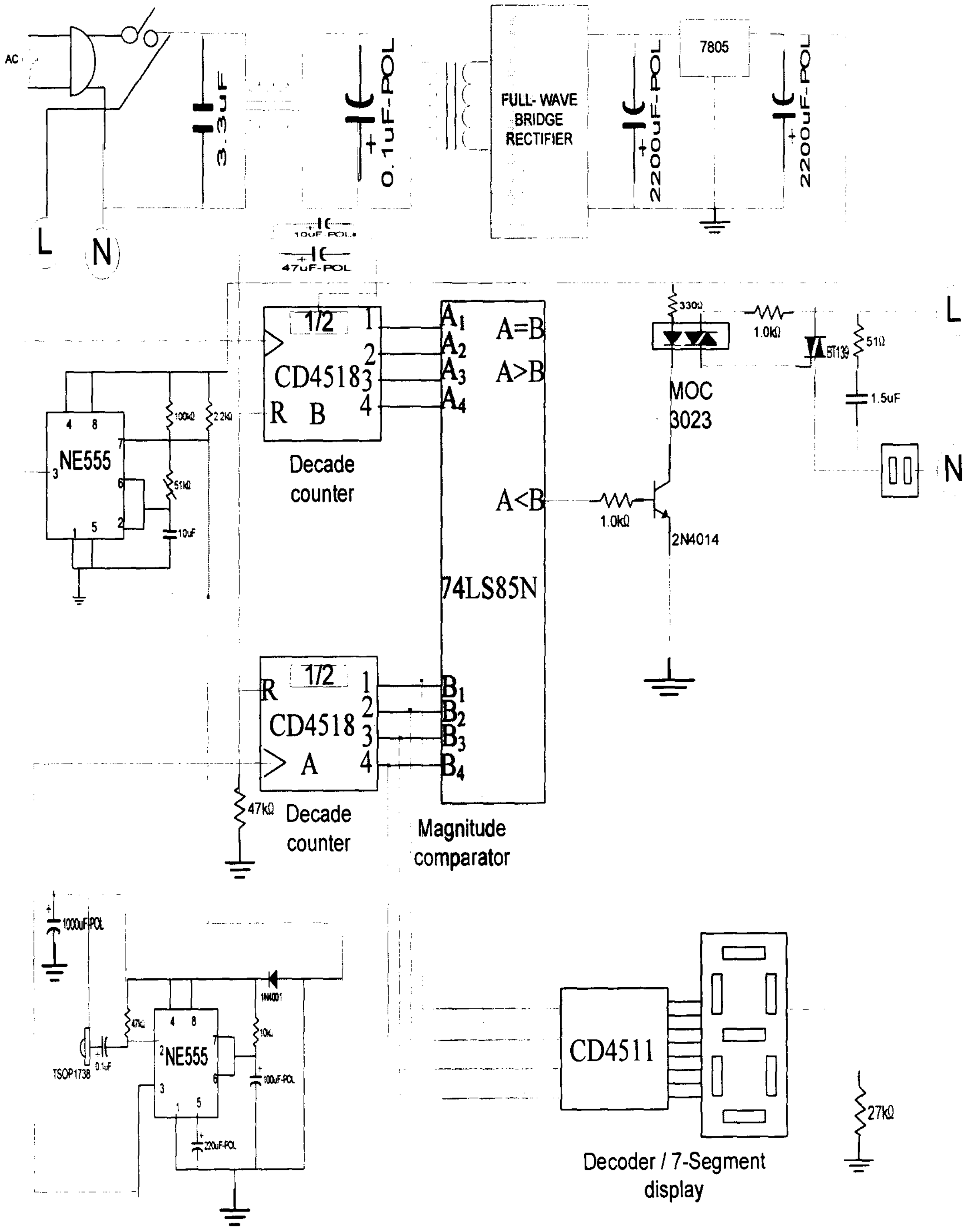


Fig.3.1.6 Complete Circuit diagram

CHAPTER FOUR

CONSTRUCTION AND DISCUSSION

4.1 CONSTRUCTION, TESTING AND RESULTS

The circuit was first laid out on the breadboard to observe its operational response and ensure that it was in line with the required objectives. Then it was dismantled.

The circuit was finally constructed on the Vero board starting with the power supply unit. The components were inserted into the holes on the board properly to ensure they were out on the other side where the copper tracks are. All components and jumpers (connecting wires) were inserted in place before soldering. This was to permit better judgment on connection linkages between the components. The connection between the components on different horizontal lines (potential) was carried out with the use of aluminum wires and a hole was made break the horizontal line continuity where it was necessary.

To obtain a good soldering joint which is very important, it was ensured that the tip of the wire was in contract with the copper track, the wire to be soldered and the soldering lead. This soldering operation was carried out for a period of five seconds or less to prevent the components from getting overheated thereby damaging the components. The integrated circuits are very sensitive to this heat, so they were protected.

This chapter brings focus on the construction procedures and techniques used to produce the system, the testing and the results obtained.

To ease the construction procedures, the circuitry was segmented into functional blocks. A component layout plan was the drawn to ease construction.

The construction included a prototype located on a breadboard followed by the final construction located on a Vero board.

4.2 HARDWARE CONSTRUCTION

i. **Breadboard:** - This is a board with connectivity along its horizontal lines and vertical lines (in some cases) it was used primarily for temporal setting up of the design and to ascertain its working condition and hence further modification.

ii. **Vero Board:-** This is a perforated plastic board where the working circuit was finally mounted and soldered permanently.

iii. **Soldering Lead:** - This is metal with low melting point. It was used to hold components and connecting wires in place in the Vero board.

iv. **Soldering Iron:** - This is a low power heating element typically to watts. It provides the heat needed to melt the lead, so that it can be used for the connection of the components permanently on the Vero board. It is usually connected to the AC mains.

v. **Lead Sucker:** - This was used to suck up excess molten lead from the Vero board to prevent short circuiting (bridging) or undesirable electrical connections.

vi. **Multimeter**: - This is a multi-functional device used for testing of continuity and measurement of voltages currents and resistances in the course of the construction.

vii. **Wires and connections:** - Wires were used during the testing stage of the project on the breadboard to connect the component together as well as during the soldering of the components on the Vero board. Aluminum soldering wires were used.

viii. **Wire cutters/strippers:** - These tools were used to cut the wires to the desired size required before use, as well as to strip off insulation of the wire in other to expose the conductor for proper and neat soldering.

4.3 TESTING AND ANALYSIS

On completion of the construction, a thorough test and assessment of the component connection were carried out. The following steps were followed:

1 The continuity and connectivity of the jumper wires and links were taken using a multimeter while the circuit was not powered.

2 The construction was tested block by block.

3 The system was set up with a working fan, and the range of the use of remote control was found to be about 10meters

To operate the circuit, the switch, is held down while pointing the LED at the receiver.

4.4 DISCUSSION OF RESULT

The aim of this project was to design a remote control that would be portable in size and a receiver that responds only to the infra-red signal transmitted by the use of a remote control. The entire circuit board and the transformer were housed in a casing. The type of casing used was made of floor-flex tiles. The material for the casing was chosen because of its poor conductivity, ready availability and relatively cheaper. The appropriate holes for the 7-segment display, sensors, wires and power cable were drilled at different positions of the casing.

The receiver-transmitter maximum distance should be approximately 10m as such is the range of the transmission of the infra-red diode used. It was noted that the receiver unit was able to receive signal propagated from about 80% of that distance which is still within an acceptable range.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

One of the primary objectives of an engineer is to endeavor to deliver the best product or the most efficient services at the lowest cost to the end user. The system has being tested and found to meet the expected results.

The aim of this project was to design and construct a remote controlled fan regulator, and the system has thus accomplished. The remote control device sends an infra-red beam, which is received by the infra-red sensor on the regulator, and then the display on the regulator indicates a change in fan speed and also increase in speed.

5.2 RECOMMENDATION

In the remote controlled fan regulator system, the transmitter unit was made up of a 555 timer chip which was configured as an astable multivibrator. The input properties of such configuration are sometimes inconvenient, which may result to less delay that can trigger the infrared LED to generate IR signal even when not needed.

Engineers trying to improve on this project should generate a better/longer delay for the frequency generated by the transmitter unit, the ''HC4060'' integrated circuit (IC) is suggested for this purpose.

REFERENCES

[1] Microsoft ® Encarta ® 2007. © 1993-2006 Microsoft Corporation. All rights reserved.

[2] Richard D.H: Infrared System Engineering, Oxford University Press, London, 1976, pp373.

[4] Howstuffworks [Internet]; ©1998-2006 Howstuffworks, Available at: http://www.howstuffworks.com/

[5] http://www.ideafinder.com/history/inventions/remotectl.htm

[6] wikipediaencyclopedia@wikipedia.org/wiki/fan

[7] www.maxim-ic.corn/tarticle/view_article.cfm

[8] www.comairrontron.com/engineering/controlfanspeed.htm

[9] Paul Horowitz, Winfiield Hill, The Art Of Electronics, 2nd Ed., Press Syndicate of the University of Cambridge, Low Price Ed., 1995, pp 287 & 618

[10] Musa D. Abdullahi: Lecture Notes on Physical Electronics, Minna, Nigeria, 2004, pp77-80

[11] Thomas L Floyd: Digital Fundamentals, 8th Ed., Pearson Education Press Ltd., Singapore, 2004, pp 12, 428, 464, & 301.

[12] B.L. Theraja & A.K. Theraja: A Text Book of Electrical Technology, 23rd Ed., S. Chand & Company Ltd., Ram Nagar, New Delhi, India, 2003, pp 1939.

[13] Engr. M.S. Ahmed: Lecture Note on Industrial Electronics & Design (ECE529), Federal University of Technology, Minna, Nigeria, 2007, pp 43.

APPENDIX

LIST OF COMPONENTS

- Magnitude Comparator (74LS85N)
- Dual Decade Counter (CD4518)
- BCD-7 Segment Display
- 7-Segment display Unit
- 555 timer chip (x 3)
- 3.3μF non-electrolytic capacitor
- 0.1μF non-electrolytic capacitor (x2)
- 2200μF electrolytic capacitor (x 3)
- 10μF electrolytic capacitor
- 1.5μF non-electrolytic capacitor
- 220μF electrolytic capacitor
- 240V-12V, 0.5A step-down transformer
- Two coil ferrite core (filter)
- Voltage Regulator (7805)
- 100kΩ resistor (x2)
- 47kΩ resistor (x2)
- 50kΩ Variable resistor
- 2.2kΩ resistor
- 27kΩ resistor
- 330Ω resistor
- Optocoupler (MOC 3023)
- C9014 transistor (x2)
- Power triac (BT139)
- 9V d.c. Source

National Semiconductor

June 1989

54LS85/DM54LS85/DM74LS85
4-Bit Magnitude Comparators

General Description

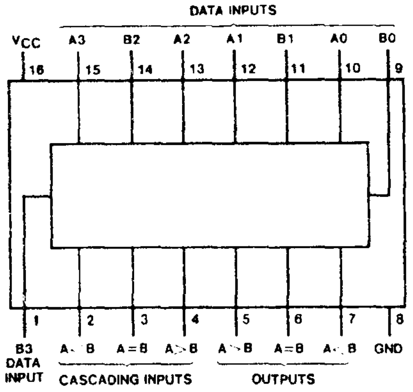
These 4-bit magnitude comparators perform comparison of straight binary or BCD codes. Three fully-decoded decisions about two, 4-bit words (A, B) are made and are externally available at three outputs. These devices are fully expandable to any number of bits without external gates. Words of greater length may be compared by connecting comparators in cascade. The A > B, A < B, and A = B outputs of a stage handling less-significant bits are connected to the corresponding inputs of the next stage handling more-significant bits. The stage handling the least-significant bits must have a high-level voltage applied to the A = B input. The cascading path is implemented with only a two-gate-level delay to reduce overall comparison times for long words.

Features

- Typical power dissipation 52 mW
- Typical delay (4-bit words) 24 ns
- Alternate Military/Aerospace device (54LS85) is available. Contact a National Semiconductor Sales Office/Distributor for specifications.

Connection Diagram

Dual-In-Line Package



TL/F/6379-1

Order Number 54LS85DMQB, 54LS85FMQB, 54LS85LMQB, DM54LS85J, DM54LS85W, DM74LS85M or DM74LS85N
See NS Package Number E20A, J16A, M16A, N16E or W16A

Function Table

Comparing Inputs				Cascading Inputs			Outputs		
A3, B3	A2, B2	A1, B1	A0, B0	A > B	A < B	A = B	A > B	A < B	A = B
A3 > B3	X	X	X	X	X	X	H	L	L
A3 < B3	X	X	X	X	X	X	L	H	L
A3 = B3	A2 > B2	X	X	X	X	X	H	L	L
A3 = B3	A2 < B2	X	X	X	X	X	L	H	L
A3 = B3	A2 = B2	A1 > B1	X	X	X	X	H	L	L
A3 = B3	A2 = B2	A1 < B1	X	X	X	X	L	H	L
A3 = B3	A2 = B2	A1 = B1	A0 > B0	X	X	X	H	L	L
A3 = B3	A2 = B2	A1 = B1	A0 < B0	X	X	X	L	H	L
A3 = B3	A2 = B2	A1 = B1	A0 = B0	H	L	L	H	L	L
A3 = B3	A2 = B2	A1 = B1	A0 = B0	L	H	L	L	H	L
A3 = B3	A2 = B2	A1 = B1	A0 = B0	L	L	H	L	L	H
A3 = B3	A2 = B2	A1 = B1	A0 = B0	X	X	H	L	L	H
A3 = B3	A2 = B2	A1 = B1	A0 = B0	H	H	L	L	L	L
A3 = B3	A2 = B2	A1 = B1	A0 = B0	L	L	L	H	H	L

H = High Level, L = Low Level, X = Don't Care

Absolute Maximum Ratings (Note)

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

Supply Voltage	7V
Input Voltage	7V
Operating Free Air Temperature Range	
DM54LS and 54LS	−55°C to +125°C
DM74LS	0°C to +70°C
Storage Temperature Range	−65°C to +150°C

Note: *The "Absolute Maximum Ratings" are those values beyond which the safety of the device cannot be guaranteed. The device should not be operated at these limits. The parametric values defined in the "Electrical Characteristics" table are not guaranteed at the absolute maximum ratings. The "Recommended Operating Conditions" table will define the conditions for actual device operation.*

Recommended Operating Conditions

Symbol	Parameter	DM54LS85			DM74LS85			Units
		Min	Nom	Max	Min	Nom	Max	
V_{CC}	Supply Voltage	4.5	5	5.5	4.75	5	5.25	V
V_{IH}	High Level Input Voltage	2			2			V
V_{IL}	Low Level Input Voltage			0.7			0.8	V
I_{OH}	High Level Output Current			−0.4			−0.4	mA
I_{OL}	Low Level Output Current			4			8	mA
T_A	Free Air Operating Temperature	−55		125	0		70	°C

Electrical Characteristics over recommended operating free air temperature range (unless otherwise noted)

Symbol	Parameter	Conditions		Min	Typ (Note 1)	Max	Units
V_I	Input Clamp Voltage	V_{CC} = Min, I_I = −18 mA				−1.5	V
V_{OH}	High Level Output Voltage	V_{CC} = Min, I_{OH} = Max V_{IL} = Max, V_{IH} = Min	DM54	2.5	3.4		V
			DM74	2.7	3.4		
V_{OL}	Low Level Output Voltage	V_{CC} = Min, I_{OL} = Max V_{IL} = Max, V_{IH} = Min	DM54		0.25	0.4	V
			DM74		0.35	0.5	
		I_{OL} = 4 mA, V_{CC} = Min	DM74		0.25	0.4	
I_I	Input Current @ Max Input Voltage	V_{CC} = Max V_I = 7V	A < B			0.1	mA
			A > B			0.1	
			Others			0.3	
I_{IH}	High Level Input Current	V_{CC} = Max V_I = 2.7V	A < B			20	μA
			A > B			20	
			Others			60	
I_{IL}	Low Level Input Current	V_{CC} = Max V_I = 0.4V	A < B			−0.4	mA
			A > B			−0.4	
			Others			−1.2	
I_{OS}	Short Circuit Output Current	V_{CC} = Max (Note 2)	DM54	−20		−100	mA
			DM74	−20		−100	
I_{CC}	Supply Current	V_{CC} = Max (Note 3)			10	20	mA

Note 1: All typicals are at V_{CC} = 5V, T_A = 25°C.

Note 2: Not more than one output should be shorted at a time, and the duration should not exceed one second.

Note 3: I_{CC} is measured with all outputs open, A = B grounded and all other inputs at 4.5V.

Switching Characteristics at $V_{CC} = 5V$ and $T_A = 25°C$ (See Section 1 for Test Waveforms and Output Load)

Symbol	Parameter	From Input	To Output	Number of Gate Levels	$R_L = 2\ k\Omega$				Units
					$C_L = 15$ pF		$C_L = 50$ pF		
					Min	Max	Min	Max	
t_{PLH}	Propagation Delay Time Low-to-High Level Output	Any A or B Data Input	A < B, A > B	3		36		42	ns
			A = B	4		40		40	
t_{PHL}	Propagation Delay Time High-to-Low Level Output	Any A or B Data Input	A < B, A > B	3		30		40	ns
			A = B	4		30		40	
t_{PLH}	Propagation Delay Time Low-to-High Level Output	A < B or A = B	A > B	1		22		26	ns
t_{PHL}	Propagation Delay Time High-to-Low Level Output	A < B or A = B	A > B	1		17		26	ns
t_{PLH}	Propagation Delay Time Low-to-High Level Output	A = B	A = B	2		20		25	ns
t_{PHL}	Propagation Delay Time High-to-Low Level Output	A = B	A = B	2		17		26	ns
t_{PLH}	Propagation Delay Time Low-to-High Level Output	A > B or A = B	A < B	1		22		26	ns
t_{PHL}	Propagation Delay Time High-to-Low Level Output	A > B or A = B	A < B	1		17		26	ns

MOC3020X, MOC3021X, MOC3022X, MOC3023X
MOC3020, MOC3021, MOC3022, MOC3023

OPTICALLY COUPLED BILATERAL SWITCH NON-ZERO CROSSING TRIAC

APPROVALS

- UL recognised, File No. E91231 under Package System 'KK'

'X' SPECIFICATION APPROVALS

- VDE 0884 in 3 available lead forms : -
  - STD
  - G form
  - SMD approved to CECC 00802

DESCRIPTION

The MOC302_ series are optically coupled isolators consisting of a Gallium Arsenide infrared emitting diode coupled with a light activated silicon bilateral switch performing the functions of a triac mounted in a standard 6 pin dual-in-line package.

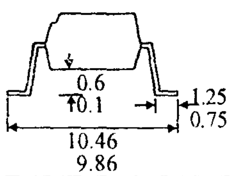
FEATURE

- Options :-
  10mm lead spread - add G after part no.
  Surface mount - add SM after part no.
  Tape&reel - add SMT&R after part no.
- High Isolation Voltage (5.3kV$_{RMS}$,7.5kV$_{PK}$)
- 400V Peak Blocking Voltage
- All electrical parameters 100% tested
- Custom electrical selections available

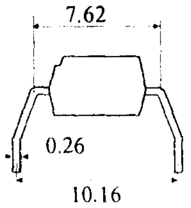
APPLICATIONS

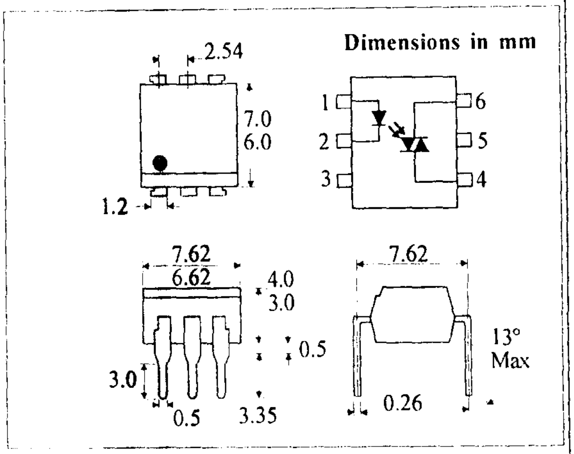
- CRTs
- Power Triac Driver
- Motors
- Consumer appliances
- Printers

OPTION SM
SURFACE MOUNT



OPTION G





ABSOLUTE MAXIMUM RATINGS
(25 °C unless otherwise noted)

Storage Temperature	-55°C - +150°C
Operating Temperature	-40°C - +100°C
Lead Soldering Temperature (1.6mm from case for 10 seconds)	260°C

INPUT DIODE

Forward Current	50mA
Reverse Voltage	6V
Power Dissipation (derate linearly 0.93mW/°C above 25°C)	70mW

OUTPUT PHOTO TRIAC

Off-State Output Terminal Voltage	400V
Forward Current (Peak)	1A
Power Dissipation (derate linearly 4.0mW/°C above 25°C)	300mW

POWER DISSIPATION

Total Power Dissipation (derate linearly 4.4mW/°C above 25°C)	330mW

ISOCOM COMPONENTS LTD
Unit 25B, Park View Road West,
Park View Industrial Estate, Brenda Road
Hartlepool, Cleveland, TS25 1YD
Tel: (01429) 863609 Fax :(01429) 863581

ELECTRICAL CHARACTERISTICS (T_A = 25°C Unless otherwise noted)

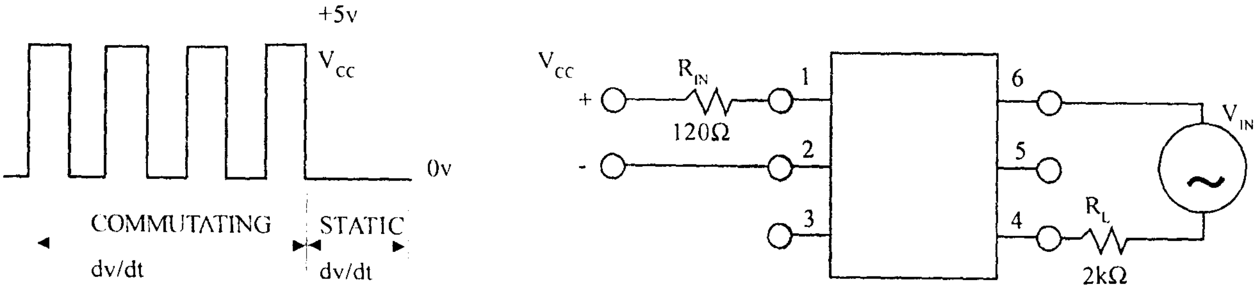
PARAMETER		MIN	TYP	MAX	UNITS	TEST CONDITION
Input	Forward Voltage (V_F)		1.2	1.5	V	I_F = 10mA
	Reverse Current (I_R)			100	µA	V_R=6V
Output	Peak Off-state Current (I_{DRM})			100	nA	V_{DRM}=400V (note 1)
	Peak Blocking Voltage (V_{DRM})	400			V	I_{DRM} = 100nA
	On-state Voltage (V_{TM})		1.5	3.0	V	I_{TM} = 100mA (peak)
	Critical rate of rise of off-state Voltage (dv/dt) (note 1)		10		V/µs	
	Critical rate of rise of commutating Voltage (dv/dt) (note 1)	0.1	0.2		V/µs	I load = 15mA, V_{IN} = 30V (fig 1.)
Coupled	Input Current to Trigger (I_{FT})(note 2)					
	MOC3020			30	mA	V_D = 3V (note 2)
	MOC3021			15	mA	
	MOC3022			10	mA	
	MOC3023			5	mA	
	Holding Current , either direction (I_H)		100		µA	
	Input to Output Isolation Voltage V_{ISO}	5300			V_{RMS}	See note 3
		7500			V_{PK}	See note 3

Note 1. Test voltage must be applied within dv/dt rating.

Note 2. Guaranteed to trigger at an I_F value less than or equal to max. I_{FT}, recommended I_F lies between Rated I_{FT} and absolute max. I_{FT}.

Note 3. Measured with input leads shorted together and output leads shorted together.

FIGURE 1

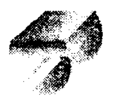


FAIRCHILD
SEMICONDUCTOR®

SS9014

Pre-Amplifier, Low Level & Low Noise

- High total power dissipation. (P_T=450mW)
- High h_{FE} and good linearity
- Complementary to SS9015



1 TO-92

1. Emitter 2. Base 3. Collector

NPN Epitaxial Silicon Transistor

Absolute Maximum Ratings T_a=25°C unless otherwise noted

Symbol	Parameter	Ratings	Units
V_{CBO}	Collector-Base Voltage	50	V
V_{CEO}	Collector-Emitter Voltage	45	V
V_{EBO}	Emitter-Base Voltage	5	V
I_C	Collector Current	100	mA
P_C	Collector Power Dissipation	450	mW
T_J	Junction Temperature	150	°C
T_{STG}	Storage Temperature	-55 ~ 150	°C

Electrical Characteristics T_a=25°C unless otherwise noted

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Units
BV_{CBO}	Collector-Base Breakdown Voltage	I_C =100μA, I_E =0	50			V
BV_{CEO}	Collector-Emitter Breakdown Voltage	I_C =1mA, I_B =0	45			V
BV_{EBO}	Emitter-Base Breakdown Voltage	I_E =100μA, I_C =0	5			V
I_{CBO}	Collector Cut-off Current	V_{CB} =50V, I_E =0			50	nA
I_{EBO}	Emitter Cut-off Current	V_{EB} =5V, I_C =0			50	nA
h_{FE}	DC Current Gain	V_{CE} =5V, I_C =1mA	60	280	1000	
V_{CE} (sat)	Collector-Base Saturation Voltage	I_C =100mA, I_B =5mA		0.14	0.3	
V_{BE} (sat)	Base-Emitter Saturation Voltage	I_C =100mA, I_B =5mA		0.84	1.0	V
V_{BE} (on)	Base-Emitter On Voltage	V_{CE} =5V, I_C =2mA	0.58	0.63	0.7	V
C_{ob}	Output Capacitance	V_{CB} =10V, I_E =0 f=1MHz		2.2	3.5	pF
f_T	Current Gain Bandwidth Product	V_{CE} =5V, I_C =10mA	150	270		MHz
NF	Noise Figure	V_{CE} =5V, I_C =0.2mA f=1KHz, R_S=2KΩ		0.9	10	dB

h_{FE} Classification

Classification	A	B	C	D
h_{FE}	60 ~ 150	100 ~ 300	200 ~ 600	400 ~ 1000

Typical Characteristics

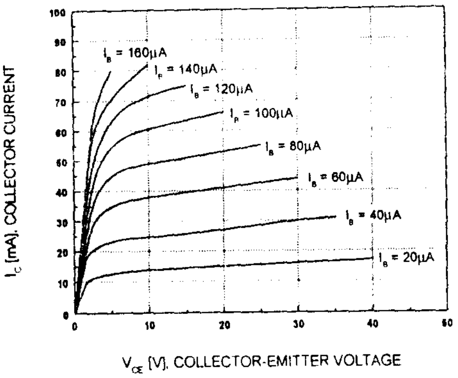


Figure 1. Static Characteristic

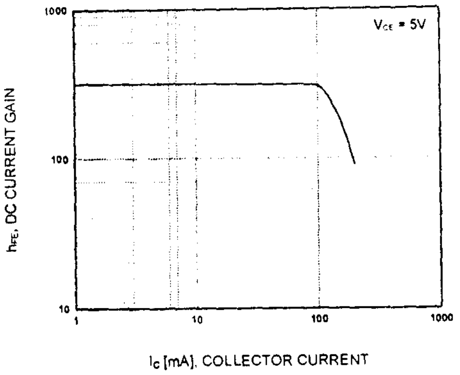


Figure 2. DC current Gain

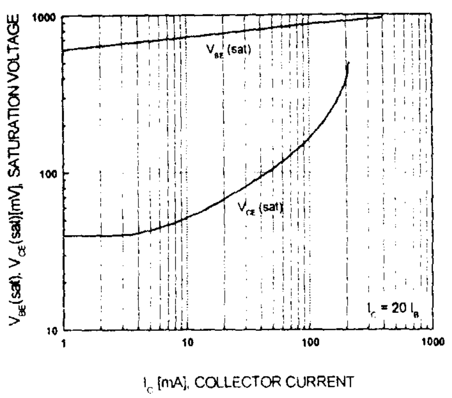


Figure 3. Base-Emitter Saturation Voltage
Collector-Emitter Saturation Voltage

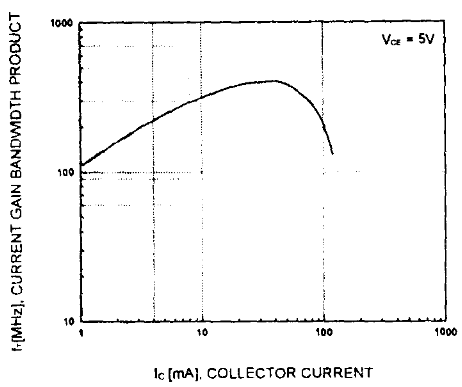


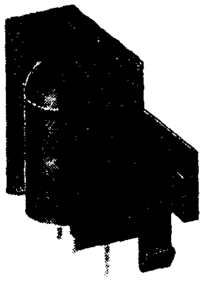
Figure 4. Current Gain Bandwidth Product

IR Receiver Modules for Remote Control Systems

Description

The TSOP17..KA1 - series are miniaturized receivers for infrared remote control systems. PIN diode and preamplifier are assembled on lead frame, the epoxy package is designed as IR filter.

The demodulated output signal can directly be decoded by a microprocessor. TSOP17..KA1 is the standard IR remote control receiver series, supporting all major transmission codes.



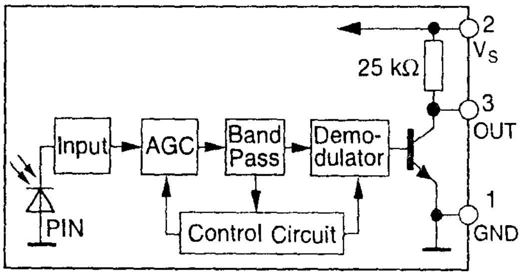
Features

- Photo detector and preamplifier in one package
- Internal filter for PCM frequency
- Improved shielding against electrical field disturbance
- TTL and CMOS compatibility
- Output active low
- Low power consumption

Special Features

- Continuous data transmission possible (up to 2400 bps)
- Suitable burst length ≥ 10 cycles/burst

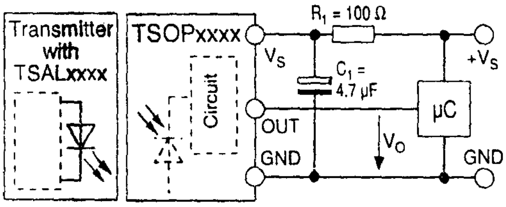
Block Diagram



Parts Table

Part	Carrier Frequency
TSOP1730KA1	30 kHz
TSOP1733KA1	33 kHz
TSOP1736KA1	36 kHz
TSOP1737KA1	36.7 kHz
TSOP1738KA1	38 kHz
TSOP1740KA1	40 kHz
TSOP1756KA1	56 kHz

Application Circuit



$R_1 + C_1$ recommended to suppress power supply disturbances.

The output voltage should not be hold continuously at a voltage below V_O = 3.3 V by the external circuit.

Absolute Maximum Ratings

T_{amb} = 25 °C, unless otherwise specified

Parameter	Test condition	Symbol	Value	Unit
Supply Voltage	(Pin 2)	V_S	- 0.3 to + 6.0	V
Supply Current	(Pin 2)	I_S	5	mA
Output Voltage	(Pin 3)	V_O	- 0.3 to + 6.0	V
Output Current	(Pin 3)	I_O	5	mA
Junction Temperature		T_j	100	°C
Storage Temperature Range		T_{stg}	- 25 to + 85	°C
Operating Temperature Range		T_{amb}	- 25 to + 85	°C
Power Consumption	($T_{amb} \leq 85$ °C)	P_{tot}	50	mW
Soldering Temperature	$t \leq 5$ s	T_{sd}	260	°C

Electrical and Optical Characteristics

T_{amb} = 25 °C, unless otherwise specified

Parameter	Test condition	Symbol	Min	Typ.	Max	Unit
Supply Current (Pin 2)	V_S = 5 V, E_v = 0	I_{SD}	0.8	1.2	1.5	mA
	V_S = 5 V, E_v = 40 klx, sunlight	I_{SH}		1.5		mA
Supply Voltage (Pin 2)		V_S	4.5		5.5	V
Transmission Distance	E_v = 0, test signal see fig.1, IR diode TSAL6200, I_F = 400 mA	d		35		m
Output Voltage Low (Pin 3)	I_{OSL} = 0.5 mA, E_e = 0.7 mW/m², $f = f_o$, test signal see fig. 1	V_{OSL}			250	mV
Irradiance (30 - 40 kHz)	Pulse width tolerance: $t_{pi} - 5/f_o < t_{po} < t_{pi} + 6/f_o$, test signal see fig.1	$E_{e\ min}$		0.35	0.5	mW/m²
Irradiance (56 kHz)	Pulse width tolerance: $t_{pi} - 5/f_o < t_{po} < t_{pi} + 6/f_o$, test signal see fig.1	$E_{e\ min}$		0.4	0.6	mW/m²
Irradiance	$t_{pi} - 5/f_o < t_{po} < t_{pi} + 6/f_o$, test signal see fig. 1	$E_{e\ max}$	30			W/m²
Directivity	Angle of half transmission distance	$\varphi_{1/2}$		± 45		deg

Typical Characteristics (T_{amb} = 25°C unless otherwise specified)

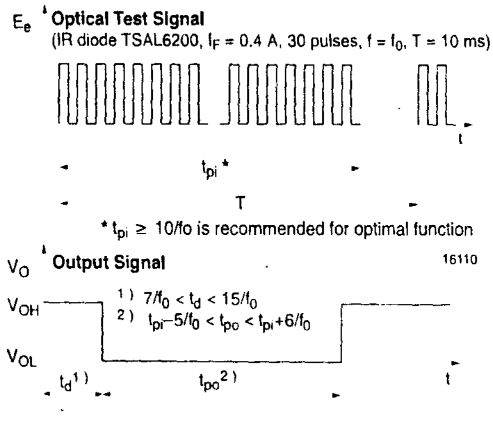


Figure 1. Output Function

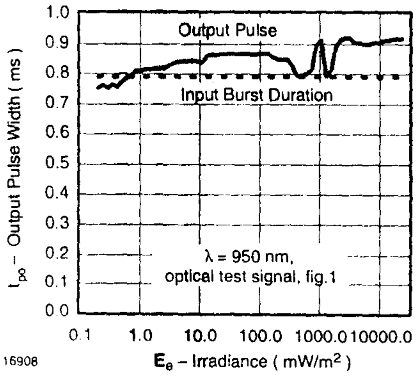


Figure 2. Pulse Length and Sensitivity in Dark Ambient

Absolute Maximum Ratings

Parameter	Symbol	Value	Unit
Input Voltage (for V_O = 5V to 18V) (for V_O = 24V)	V_I V_I	35 40	V V
Thermal Resistance Junction-Cases (TO-220)	$R_{\theta JC}$	5	°C/W
Thermal Resistance Junction-Air (TO-220)	$R_{\theta JA}$	65	°C/W
Operating Temperature Range	T_{OPR}	0 ~ +125	°C
Storage Temperature Range	T_{STG}	-65 ~ +150	°C

Electrical Characteristics (MC7805/LM7805)

(Refer to test circuit ,0°C < T_J < 125°C, I_O = 500mA, V_I = 10V, C_I= 0.33µF, C_O= 0.1µF, unless otherwise specified)

Parameter	Symbol	Conditions		MC7805/LM7805			Unit
				Min.	Typ.	Max.	
Output Voltage	V_O	T_J =+25 °C		4.8	5.0	5.2	V
		5.0mA ≤ Io ≤ 1.0A, P_O ≤ 15W V_I = 7V to 20V		4.75	5.0	5.25	
Line Regulation (Note1)	Regline	T_J=+25 °C	V_O = 7V to 25V	-	4.0	100	mV
			V_I = 8V to 12V	-	1.6	50	
Load Regulation (Note1)	Regload	T_J=+25 °C	I_O = 5.0mA to1.5A	-	9	100	mV
			I_O =250mA to 750mA	-	4	50	
Quiescent Current	I_Q	T_J =+25 °C		-	5.0	8.0	mA
Quiescent Current Change	ΔI_Q	I_O = 5mA to 1.0A		-	0.03	0.5	mA
		V_I= 7V to 25V		-	0.3	1.3	
Output Voltage Drift	$\Delta V_O/\Delta T$	I_O= 5mA		-	-0.8	-	mV/ °C
Output Noise Voltage	V_N	f = 10Hz to 100KHz, T_A=+25 °C		-	42	-	µV/Vo
Ripple Rejection	RR	f = 120Hz V_O = 8V to 18V		62	73	-	dB
Dropout Voltage	V_{Drop}	I_O = 1A, T_J =+25 °C		-	2	-	V
Output Resistance	r_O	f = 1KHz		-	15	-	mΩ
Short Circuit Current	I_{SC}	V_I = 35V, T_A =+25 °C		-	230	-	mA
Peak Current	I_{PK}	T_J =+25 °C		-	2.2	-	A

Note:

1. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.

TEXAS INSTRUMENTS

Data sheet acquired from Harris Semiconductor
SCHS072

CD4511B Types

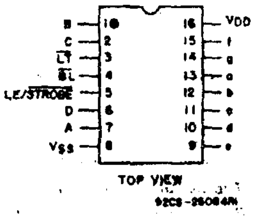
CMOS BCD-to-7-Segment Latch Decoder Drivers

High-Voltage Types (20-Volt Rating)

CD4511B types are BCD-to-7-segment latch decoder drivers constructed with CMOS logic and n-p-n bipolar transistor output devices on a single monolithic structure. These devices combine the low quiescent power dissipation and high noise immunity features of RCA CMOS with n-p-n bipolar output transistors capable of sourcing up to 25 mA. This capability allows the CD4511B types to drive LED's and other displays directly.

Lamp Test ($\overline{LT}$), Blanking ($\overline{BL}$), and Latch Enable or Strobe inputs are provided to test the display, shut off or intensity-modulate it, and store or strobe a BCD code, respectively. Several different signals may be multiplexed and displayed when external multiplexing circuitry is used. The CD4511B is supplied in 16-lead hermetic dual-in-line ceramic packages (D and F suffixes), 16-lead dual-in-line plastic packages (E suffix), and in chip form (H suffix).

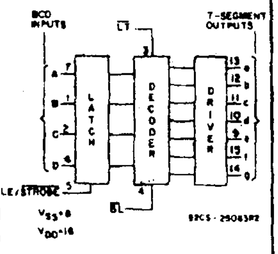
These devices are similar to the type MC14511.



CD4511B
TERMINAL ASSIGNMENT

Features:

- High-output-sourcing capability .... up to 25 mA
- Input latches for BCD Code storage
- Lamp Test and Blanking capability
- 7-segment outputs blanked for BCD input codes > 1001
- 100% tested for quiescent current at 20 V
- Max. input current of 1 µA at 18 V, over full package-temperature range, 100 nA at 18 V and 25°C
- 5-V, 10-V, and 15-V parametric ratings



FUNCTIONAL DIAGRAM

Applications:

- Driving common-cathode LED displays
- Multiplexing with common-cathode LED displays
- Driving incandescent displays
- Driving low-voltage fluorescent displays

MAXIMUM RATINGS, *Absolute-Maximum Values:*

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

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

Characteristic	V_{DD}	Min.	Max.	Units
Supply-Voltage Range (T_A): (Full Package-Temperature Range)	–	3	18	V
Set-Up Time (t_S)	5	150	–	ns
	10	70	–	ns
	15	40	–	ns
Hold Time (t_H)	5	0	–	ns
	10	0	–	ns
	15	0	–	ns
Strobe Pulse Width (t_W)	5	400	–	ns
	10	160	–	ns
	15	100	–	ns

STATIC ELECTRICAL CHARACTERISTICS

CHARACTERISTIC	TEST CONDITIONS				LIMITS AT INDICATED TEMPERATURES (°C)							Units
	I_{OH} (mA)	V_o (V)	V_{IN} (V)	V_{DD} (V)	−55	−40	+85	+125	+25 Min.	+25 Typ.	+25 Max.	
Quiescent Device Current: I_{DD} Max.	–	–	–	5	5	5	150	150	–	0.04	5	μA
	–	–	–	10	10	10	300	300	–	0.04	10	
	–	–	–	15	20	20	600	600	–	0.04	20	
	–	–	–	20	100	100	3000	3000	–	0.08	100	
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	
High Level V_{OH} Min.		–	0.5	5	4	4	4.2	4.2	4.1	4.55	–	V
		–	0,10	10	9	9	9.2	9.2	9.1	9.55	–	
		–	0.15	15	14	14	14.2	14.2	14.1	14.55	–	
Input Low Voltage, V_{IL} Max.	–	0.5,3.8		5	1.5				–	–	1.5	V
	–	1,8.8	-	10	3				–	–	3	
		1.6,13.8		15	4				–	–	4	
Input High Voltage, V_{IH} Min.	-	0.5,3.8		5	3.5				3.5	–	–	V
	–	1,8.8		10	7				7	–	–	
		1.5,13.8		15	11				11	–	–	
Output Drive Voltage: High Level V_{OH} Min.	0			5	4.0	4.0	4.20	4.20	4.10	4.55	–	V
	5	-					–	–	–	4.25	–	
	10				3.80	3.80	3.90	3.90	3.90	4.10	–	
	15					-	3.50	3.50	–	3.95	–	
	20				3.55	3.55	3.30	–	3.40	3.75	–	
	25				3.40	3.40	–	–	3.10	3.55	–	
	0		-	10	9.0	9.0	9.20	9.20	9.10	9.55	–	V
	5					-	-	-	–	9.25	–	
	10	–	–		8.85	8.85	9.00	9.00	9.00	9.15	–	
	15	–	–		–	–	–	–	–	9.05	–	
	20	–	-		8.70	8.70	8.40	8.40	8.60	8.90	–	
	25	–	–		8.60	8.60	–	–	8.30	8.75	–	
	0	–	–	15	14.0	14.0	14.20	14.20	14,10	14.55	–	V
	5	–	–		–	–	–	–	–	14.30	–	
	10	–	–		13.90	13.90	14.0	14.0	14.0	14.20	–	
	15	–	–		–	–	–	–	–	14.10	–	
	20	–	–		13.75	13.75	13.50	13.50	13.70	13.95	–	
	25	–	–		13.65	13.65	–	–	13.50	13.80	–	
Output Low (Sink) Current, I_{OL} Min.	–	0.4	0,5	5	0.84	0.61	0.42	0.38	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	–	
Input Current, I_{IN} Max.	–	0,18	0,18	18	±0 1	±0.1	±1	±1	–	$\pm10^{-5}$	±0.1	μA

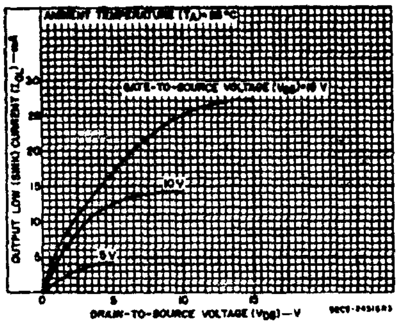


Fig. 1 – Typical output low (sink) current characteristics.

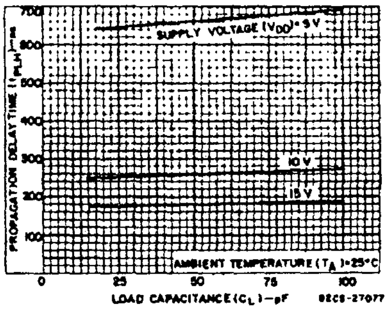


Fig. 2 – Typical data-to-output, low-to-high-level propagation delay time as a function of load capacitance.

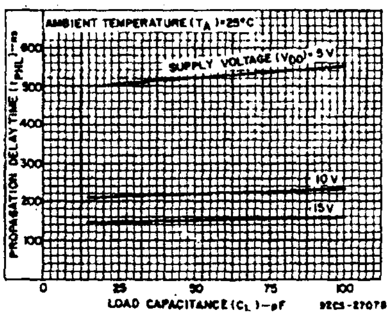


Fig. 3 – Typical data-to-output, high-to-low-level propagation delay time as a function of load capacitance.

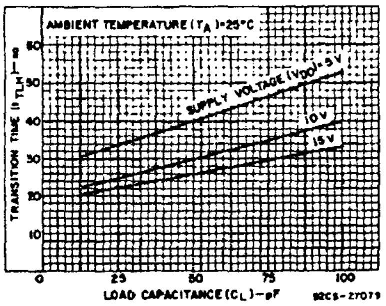


Fig. 4 – Typical low-to-high-level transition time as a function of load capacitance.

CD4511B 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	Test Conditions V_{DD} Volts	LIMITS All Packages Min.	 Typ.	 Max.	UNITS
Propagation Delay Time:	5	–	520	1040	ns
(Data)	10	–	210	420	
High-to-Low Level, t_{PHL}	15	–	150	300	
	5	–	660	1320	ns
Low-to-High Level, t_{PLH}	10	–	260	520	
	15	–	180	360	
Propagation Delay Time:	5	–	350	700	ns
($\overline{BL}$)	10	–	175	350	
High-to-Low Level, t_{PHL}	15	–	125	250	
	5	–	400	800	ns
Low-to-High Level, t_{PLH}	10	–	175	350	
	15	–	150	300	
Propagation Delay Time:	5	–	250	500	ns
($\overline{LT}$)	10	–	125	250	
High-to-Low Level, t_{PHL}	15	–	85	170	
	5	–	150	300	ns
Low-to-High Level, t_{PLH}	10	–	75	150	
	15	–	50	100	
Transition Time:	5	–	40	80	ns
	10	–	30	60	
Low-to-High Level, t_{TLH}	15	–	25	50	
	5	–	125	310	ns
	10	–	75	185	
High-to-Low Level, t_{THL}	15	–	65	160	
Minimum Set-Up Time, t_S	5	150	75	–	ns
	10	70	35	–	
	15	40	20	–	
Minimum Hold Time, t_H	5	0	−75	–	ns
	10	0	−35	–	
	15	0	−20	–	
Strobe Pulse Width, t_W	5	400	200	–	ns
	10	160	80	–	
	15	100	50		
Input Capacitance, C_{IN}		–	5	7.5	pF

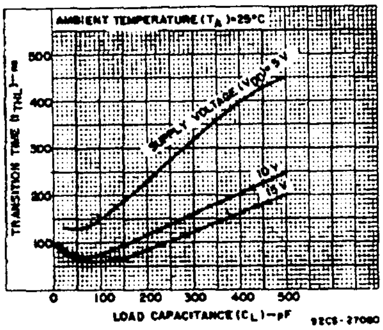


Fig. 5 – Typical high-to-low transition time as a function of load capacitance.

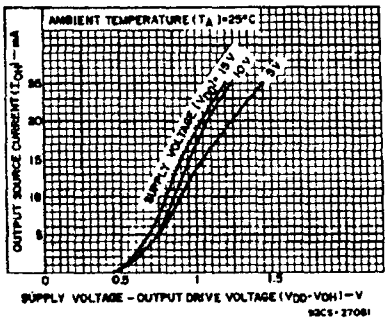


Fig. 6 – Typical voltage drop (V_{DD} to output) vs. output source current as a function of supply.

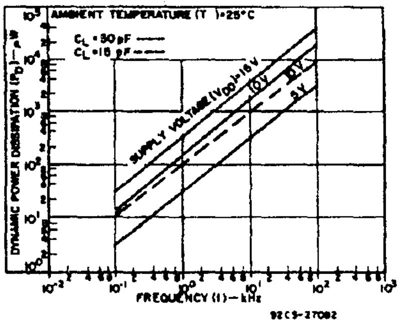


Fig. 7 – Typical dynamic power dissipation characteristics.

AC CHARACTERISTICS

V_{SS} = 0 V; T_{amb} = 25 °C; C_L = 50 pF; input transition times ≤ 20 ns

	V_{DD} V	SYMBOL	MIN.	TYP.	MAX.		TYPICAL EXTRAPOLATION FORMULA
Propagation delays							
CP_0 , $\overline{CP}_1 \rightarrow O_n$	5			120	**240**	ns	93 ns + (0,55 ns/pF) C_L
HIGH to LOW	10	t_{PHL}		55	**110**	ns	44 ns + (0,23 ns/pF) C_L
	15			40	**80**	ns	32 ns + (0,16 ns/pF) C_L
	5			120	**240**	ns	93 ns + (0,55 ns/pF) C_L
LOW to HIGH	10	t_{PLH}		55	**110**	ns	44 ns + (0,23 ns/pF) C_L
	15			40	**80**	ns	32 ns + (0,16 ns/pF) C_L
$MR \rightarrow O_n$	5			75	**150**	ns	48 ns + (0,55 ns/pF) C_L
HIGH to LOW	10	t_{PHL}		35	**70**	ns	24 ns + (0,23 ns/pF) C_L
	15			25	**50**	ns	17 ns + (0,16 ns/pF) C_L
Output transition							
times	5			60	**120**	ns	10 ns + (1,0 ns/pF) C_L
HIGH to LOW	10	t_{THL}		30	**60**	ns	9 ns + (0,42 ns/pF) C_L
	15			20	**40**	ns	6 ns + (0,28 ns/pF) C_L
	5			60	**120**	ns	10 ns + (1,0 ns/pF) C_L
LOW to HIGH	10	t_{TLH}		30	**60**	ns	9 ns + (0,42 ns/pF) C_L
	15			20	**40**	ns	6 ns + (0,28 ns/pF) C_L
Minimum CP_0	5		60	30		ns	see also waveforms Figs 4 and 5
pulse width; LOW	10	t_{WCPL}	30	15		ns	
	15		20	10		ns	
Minimum $\overline{CP}_1$	5		60	30		ns	
pulse width; HIGH	10	t_{WCPH}	30	15		ns	
	15		20	10		ns	
Minimum MR	5		30	15		ns	
pulse width; HIGH	10	t_{WMRH}	20	10		ns	
	15		16	8		ns	
Recovery time	5		50	25		ns	
for MR	10	t_{RMR}	30	15		ns	
	15		20	10		ns	
Set-up times	5		50	25		ns	
$CP_0 \rightarrow \overline{CP}_1$	10	t_{su}	30	15		ns	
	15		20	10		ns	
	5		50	25		ns	
$\overline{CP}_1 \rightarrow CP_0$	10	t_{su}	30	15		ns	
	15		20	10		ns	
Maximum clock	5		8	16		MHz	
pulse frequency	10	f_{max}	15	30		MHz	
	15		20	40		MHz	

Applications Information

MONOSTABLE OPERATION

In this mode of operation, the timer functions as a one-shot (*Figure 1*). The external capacitor is initially held discharged by a transistor inside the timer. Upon application of a negative trigger pulse of less than 1/3 V_{CC} to pin 2, the flip-flop is set which both releases the short circuit across the capacitor and drives the output high.

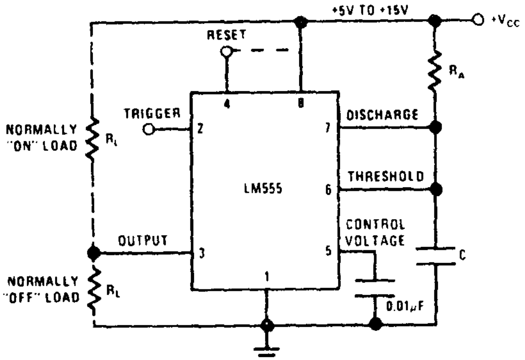
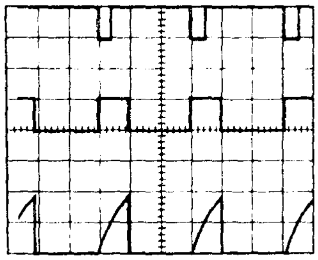


FIGURE 1. Monostable

The voltage across the capacitor then increases exponentially for a period of t = 1.1 R_A C, at the end of which time the voltage equals 2/3 V_{CC}. The comparator then resets the flip-flop which in turn discharges the capacitor and drives the output to its low state. *Figure 2* shows the waveforms generated in this mode of operation. Since the charge and the threshold level of the comparator are both directly proportional to supply voltage, the timing internal is independent of supply.



V_{CC} = 5V	Top Trace: Input 5V/Div.
TIME = 0.1 ms/DIV.	Middle Trace: Output 5V/Div.
R_A = 9.1kΩ	Bottom Trace: Capacitor Voltage 2V/Div.
C = 0.01µF	

FIGURE 2. Monostable Waveforms

During the timing cycle when the output is high, the further application of a trigger pulse will not effect the circuit so long as the trigger input is returned high at least 10µs before the end of the timing interval. However the circuit can be reset during this time by the application of a negative pulse to the reset terminal (pin 4). The output will then remain in the low state until a trigger pulse is again applied.

When the reset function is not in use, it is recommended that it be connected to V_{CC} to avoid any possibility of false triggering.

Figure 3 is a nomograph for easy determination of R, C values for various time delays.

NOTE: In monostable operation, the trigger should be driven high before the end of timing cycle.

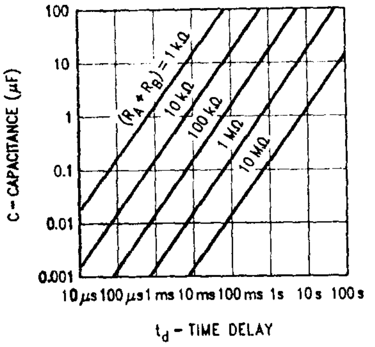


FIGURE 3. Time Delay

ASTABLE OPERATION

If the circuit is connected as shown in *Figure 4* (pins 2 and 6 connected) it will trigger itself and free run as a multivibrator. The external capacitor charges through R_A + R_B and discharges through R_B. Thus the duty cycle may be precisely set by the ratio of these two resistors.

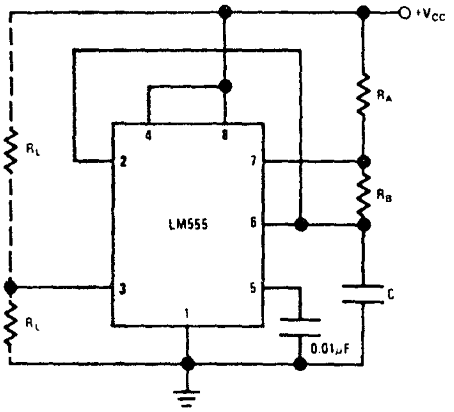


FIGURE 4. Astable

In this mode of operation, the capacitor charges and discharges between 1/3 V_{CC} and 2/3 V_{CC}. As in the triggered mode, the charge and discharge times, and therefore the frequency are independent of the supply voltage.

(T_A = 25°C, V_{CC} = +5V to +15V, unless othewise specified)

Parameter	Conditions	Limits			Units
		Min	**Typ**	**Max**	
Supply Voltage		4.5		16	V
Supply Current	V_{CC} = 5V, $R_L = \infty$		3	6	
	V_{CC} = 15V, $R_L = \infty$		10	15	mA
Timing Error, Monostable					
Initial Accuracy			1		%
Drift with Temperature	R_A = 1k to 100kΩ, C = 0.1μF, (Note 5)		50		ppm/°C
Accuracy over Temperature			1.5		%
Drift with Supply			0.1		%/V
Timing Error, Astable					
Initial Accuracy			2.25		%
Drift with Temperature	R_A, R_B = 1k to 100kΩ, C = 0.1μF, (Note 5)		150		ppm/°C
Accuracy over Temperature			3.0		%
Drift with Supply			0.30		%/V
Threshold Voltage			0.667		x V_{CC}
Trigger Voltage	V_{CC} = 15V		5		V
	V_{CC} = 5V		1.67		V
Trigger Current					
Reset Voltage					
Reset Current			0.1	0.4	mA
Threshold Current	(Note 6)				
Control Voltage Level	V_{CC} = 15V	9	10	11	V
	V_{CC} = 5V	2.6	3.33	4	
Pin 7 Leakage Output High			1	100	nA
Pin 7 Sat (Note 7)					
Output Low	V_{CC} = 15V, I_7 = 15mA		180		mV
Output Low	V_{CC} = 4.5V, I_7 = 4.5mA		80	200	mV

Electrical Characteristics (Notes 1, 2) (Continued)

(T_A = 25˚C, V_{CC} = +5V to +15V, unless othewise specified)

Parameter	Conditions	Limits			Units
		Min	Typ	Max	
Output Voltage Drop (Low)	V_{CC} = 15V				
	I_{SINK} = 10mA		0.1	0.25	V
	I_{SINK} = 50mA		0.4	0.75	V
	I_{SINK} = 100mA		2	2.5	V
	I_{SINK} = 200mA		2.5		
	V_{CC} = 5V				
	I_{SINK} = 8mA				
	I_{SINK} = 5mA		0.25	0.35	
Output Voltage Drop (High)	I_{SOURCE} = 200mA, V_{CC} = 15V		12.5		
	I_{SOURCE} = 100mA, V_{CC} = 15V	12.75	13.3		
	V_{CC} = 5V	2.75	3.3		
Rise Time of Output			100		
Fall Time of Output			100		

Note 1: All voltages are measured with respect to the ground pin, unless otherwise specified.

Note 2: Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which t tional, but do not guarantee specific performance limits. Electrical Characteristics state DC and AC electrical specifications under particular test condi antee specific performance limits. This assumes that the device is within the Operating Ratings. Specifications are not guaranteed for parameters given, however, the typical value is a good indication of device performance.

Note 3: For operating at elevated temperatures the device must be derated above 25˚C based on a +150˚C maximum junction temperature and a the 170˚C/W (S0-8), junction to ambient.

Note 4: Supply current when output high typically

Note 5: Tested at V_{CC} = 5V and V_{CC} = 15V.

Note 6: This will determine the maximum value of $R_A + R_B$ for 15V operation. The maximum total ($R_A + R_B$) is 20MΩ.

Note 7: No protection against excessive pin 7 current is necessary providing the package dissipation rating will not be exceeded.