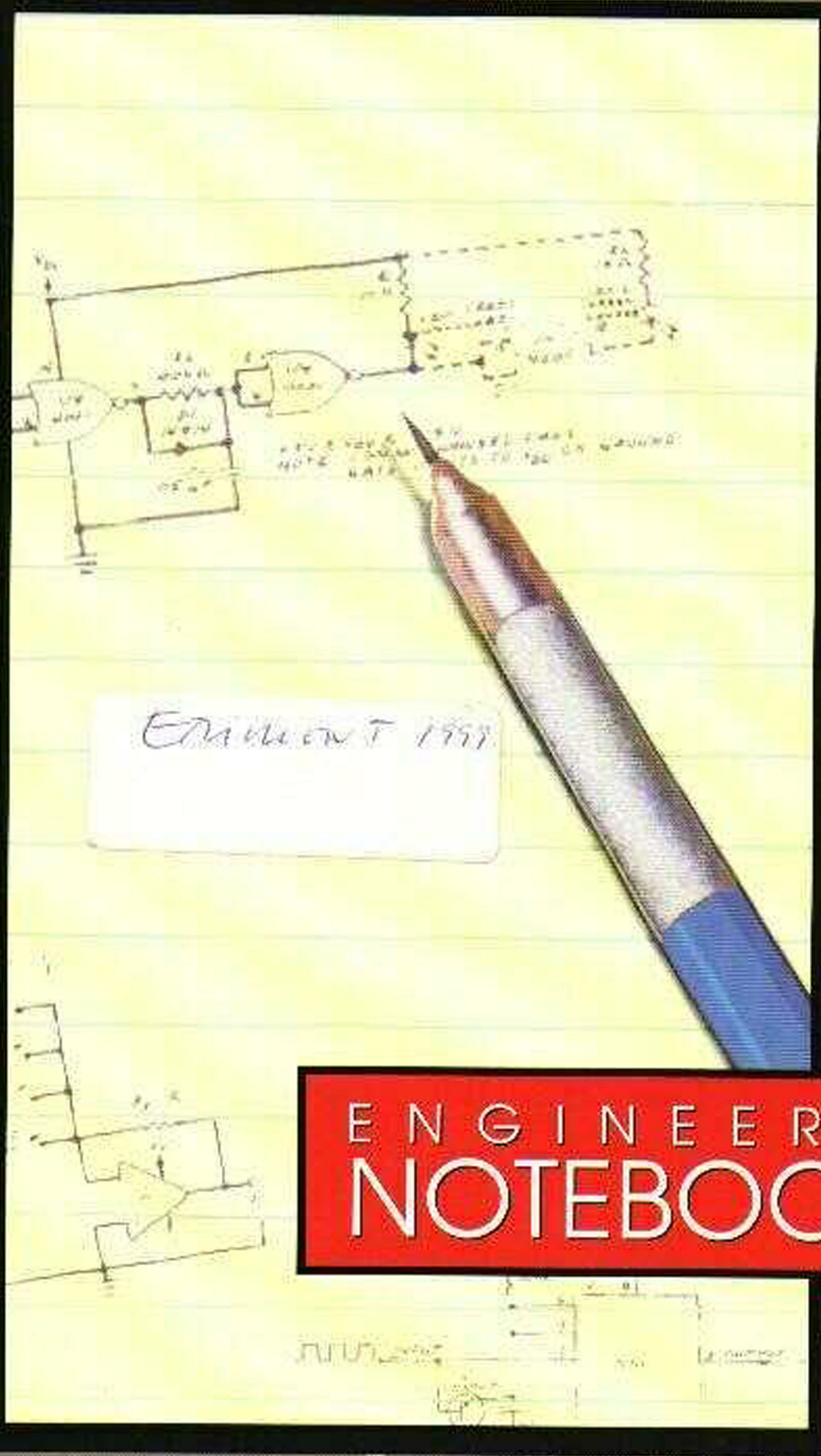


THE
FORREST MIMS



ENGINEER'S
NOTEBOOK

The Forrest Mims Engineer's Notebook

Forrest M. Mims, III

LLH
Technology Publishing
Eagle Rock, Virginia

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FOREWORD

It's a real shame that the millions who have read Forrest's articles, columns, and books over the years have never had the chance to get to know him personally. I've been lucky enough to be able to call him my friend for several years. This book is special to me because the first edition of this book was the reason why I met and got to know Forrest.

I first met Forrest in 1979. I can't recall the exact date, but it was a fearsomely hot mid-summer day in Fort Worth, Texas. I was working at Radio Shack's national headquarters in their technical publications department. My boss, Dave Gunzel, had spearheaded an effort for Forrest to generate a book of IC applications circuits that were similar to Forrest's actual working laboratory notebooks. Forrest was carefully preparing each page by hand on transparent Mylar sheets using a fine-tip pen. I monitored his progress eagerly, and one day Dave told me that Forrest Mims would be arriving the following week with the last of his Mylar originals.

Wow! I was going to really meet Forrest Mims! I hadn't seen a photo of Forrest before, nor had Dave told me much about how he looked or acted. (In retrospect, I now realize that was deliberate on Dave's part—he wanted me to "discover" Forrest on my own.) I had my own mental picture of Forrest, though. Obviously, a serious fellow. Anyone who came up with all those electronic circuits couldn't have much time for laughter. Probably sharply focused and not interested in anything other than electronics. An older gentleman, certainly, with a white beard and a fondness for jackets with elbow patches. A pipe and slight Germanic accent were also likely. He would probably think I was really stupid and not have a lot of patience with me.

The Big Day quickly arrived. Forrest was due in that afternoon. I had carefully rehearsed my welcoming speech: "Hello, Mr. Mims. It is certainly good to see you. Would you like an ashtray for your pipe?"

I was alone in the technical publications office that afternoon when someone I didn't recognize stuck his head into the office doorway. He was wearing normal business attire, smiled easily, spoke with a slight Texas accent, and was looking for Dave Gunzel. Oh brother, I thought, another new employee who's lost in Tandy Center. Doesn't this guy know that Forrest Mims is going to show up this afternoon and I don't have any time to waste on him??? I mumbled something about Dave being gone for a few minutes and that we were expecting a visitor later that afternoon.

The stranger seemed apologetic. He didn't want to waste any of my time or Dave's if we were expecting someone important, he said; he just needed to tend to a couple of matters quickly and wouldn't bother us

any further. He approached my desk and extended his hand toward me.

"Hi," he said, "I'm Forrest Mims; you must be Harry."

I don't recall my reply, but I think it was the unmistakable sound of self-mortification.

Forrest had work to do and wondered if I could help. He needed to spray the Mylar sheets with a protective coating before turning them over to us for printing. We commandeered a vacant area of the then-new Tandy Center, spread out the Mylar sheets, and spent the next couple of hours emptying aerosol cans of clear lacquer while discussing the state of the universe.

That afternoon, I discovered what a remarkably unpretentious guy Forrest is. Here was one guy who had earned the right to a massive ego, yet he was straightforward, down to Earth, and almost skeptical of his achievements. Our conversation ranged from electronics to lasers to politics to Texas history to computers to religion to . . . well, you name it. It was incredible how many subjects Forrest was interested in, and how insatiable his curiosity was about everything in the natural world. By the end of that afternoon, I felt as if I had known Forrest for years.

A lot has happened since then. I eventually left Texas to become a book editor in New York and, a few years after that, moved to California where I became a founding partner in HighText Publications. Throughout, Forrest remained a valued friend and trusted confidant. The intelligence and insight that are apparent in his circuits extends to many other areas, and he has a wit and sense of irony that are delicious. While we don't get to spend much time physically in each other's company, it's a rare week when we don't have at least two or three lengthy telephone conversations. As technology has advanced, so have our modes of interaction; we often exchange a couple of faxes per day on various subjects.

We had no idea that the book we worked on back on that hot summer afternoon in 1979 would go on to sell over 750,000 copies in its various editions. Some of the pages we worked on back in 1979 appear in this book, a testimony to the enduring quality and relevance of Forrest's work. For readers such as yourself, this book will be a valuable reference to contemporary, real-world IC applications. For me, it brings back a lot of good memories. And, no, Forrest doesn't smoke a pipe, doesn't wear jackets with elbow patches, and doesn't have a beard.

Harry L. Helms

INTRODUCTION

Since my student days at Texas A&M University I have kept a series of laboratory notebooks. In these notebooks I record details about experiments, measurements, and new ideas. Also included are many electronic circuit diagrams. Dave Gunzel, formerly the director of technical publications at Radio Shack, took an interest in my notebooks in the mid-1970s and suggested that Radio Shack might someday want to publish a book of electronic circuits based on their hand-drawn format. Several years later, Radio Shack assigned me to produce *Engineer's Notebook*, a 128-page book of electronic circuits. The book soon became a Radio Shack bestseller. As new integrated circuits were added to Radio Shack's product line and others were dropped, I revised the book as necessary. Later, Radio Shack authorized me to do an edition of the book for McGraw-Hill.

This revised edition for HighText Publications represents the best and most interesting circuits from all previous editions.

The integrated circuits described in this book remain among the most popular ever introduced. Most of them are readily available from Radio Shack, electronics parts suppliers, and mail-order dealers. Magazines such as *Radio-Electronics* carry ads from mail-order IC dealers. A few of the chips are specialized and finding sources for them may be more difficult. Four of the devices—the CEX-4000, S50240, PCIM-161, and SAD-1024—may be available only from dealers in surplus and discontinued ICs. However, the overwhelming majority of chips described in this book are readily available from many different sources. In fact, prices for some of the more common devices have fallen substantially since the first edition of this book. Some are available today for pennies!

Most of the part numbers given for the integrated circuits in this book are generic, and various manufacturers may add additional letters or numbers or even use a completely different number. For example, the 4011 is a quad of CMOS NAND gates. An "A" suffix (4011A) means this chip can operate from a 3- to 12-volt supply. A "B" suffix (4011B) means the chip can operate from a 3- to 18-volt supply. The high-voltage version of the chip is by far the most common. National Semiconductor adds a CD prefix to its versions of the 4011B (CD4011B), while Motorola adds an MC1 prefix (MC14011B). Nevertheless, both chips are functionally identical.

For additional information about chip identification and specifications, see the data books published by the various integrated circuit manufacturers. These books are available directly from manufacturers of integrated circuits and from industrial supply companies that represent integrated circuit manufacturers. They are also available from some mail-order electronics parts dealers.

ABOUT THE AUTHOR

Forrest Mims has been an electronics hobbyist since building a one-tube radio kit at the age of 11. Following graduation from Texas A&M University in 1966 and service as a photointelligence officer in Vietnam, he worked for three years with high-powered lasers, solid-state instrumentation, and trained monkeys with the Air Force Weapons Laboratory in New Mexico. Since becoming a full-time writer in 1970, he's written several hundred magazine articles and scholarly papers. His articles and columns have appeared in virtually every significant electronics magazine, including *Popular Electronics*, *Radio-Electronics*, and *Modern Electronics*. His articles on other scientific topics have appeared in a wide range of other publications, including *National Geographic World*, *Science Digest*, *Highlights for Children*, and *Scientific American*. His editorial exploits have included an assignment from the *National Enquirer* to evaluate the feasibility of eavesdropping on Howard Hughes by laser (it was possible, but Forrest declined to take part) and getting dropped by *Scientific American* as their "The Amateur Scientist" columnist because he admitted to the magazine's editors that he was a born-again Christian. His book sales total in the millions, and he is likely the most widely-read electronics writer in the world.

Forrest is currently busy as the founding editor of *Science PROBE!*, a new magazine aimed at amateur scientists. In this role, Forrest is creating the sort of magazine that he wishes had been available in his youth while acquiring a new understanding of the frustrations of being an editor. He still keeps up a hectic pace of electronics and science experimentation and writing.

Forrest and his wife Minnie have three children, and they currently live in the Texas countryside near San Antonio. They are active in church activities, and Forrest is a Baptist deacon. He has his office and electronics lab in an old restored farmhouse adjacent to his home.

PARTS SOURCES

The chips and related components (resistors, capacitors, etc.) used in this book are available from a variety of sources, including electronics stores (such as Dick Smith Electronics in Australia and David Reid stores in New Zealand), advertisers in electronics magazines, and industrial electronics suppliers. Some chips—such as the SN76477N, SN76488N, and SAD-1024A—are a bit "rarer" and you may have to look for them at companies specializing in surplus and discontinued devices.

Manufacturers of integrated circuits publish "data sheets" giving the bare-bones specifications for a chip and "applications notes" that give additional information, including circuit schematics using the chip. These can be obtained by contacting the national headquarters of the chip manufacturer or their nearest sales office.

The manufacturer of an integrated circuit is identified by a prefix in front of the actual part number. For example, "LM741" and "MC741" would both indicate the device was the common 741 operational amplifier found on pages 93 to 96 of this book. However, the "LM" would indicate the device was manufactured by National Semiconductor while the "MC" would denote a device manufactured by Motorola. Here are some common prefixes and manufacturers:

AD	Analog Devices	M	Mitsubishi
Am	Advanced Micro Devices	MB	Fujitsu
Bx	Sony	MC	Motorola
CA	RCA (now Harris)	MM	Motorola
CD	RCA (now Harris)	NE	Signetics
Cx	Sony	PM	Precision Monolithics
DM	National Semiconductor	T	Toshiba
F	Fairchild (now National Semiconductor)	TL	Texas Instruments
FSS	Ferranti	TMS	Texas Instruments
HA	Harris	XR	Exar
HA	Hitachi	μPB	NEC
HD	Hitachi		
HG	Hitachi		
HI	Harris		
IR	Sharp		
KA	Samsung		
LF	National Semiconductor		
LM	National Semiconductor		
LT	Linear Technology		

REVIEWING THE BASICS

INTRODUCTION

"Can I use a 0.22 μ F capacitor instead of a 0.01 μ F unit?"

"Is it okay to substitute a 12,000 ohm resistor for a 10,000 ohm unit?"

This section will tackle these common questions and many others. Master them, and you will be well prepared to tackle the circuits in this book.

RESISTORS

Resistors limit the flow of electrical current. A resistor has a resistance (R) of 1 ohm if a current (I) of 1 ampere flows through it when a potential difference (E) of 1 volt is placed across it. In other words:

$$R = \frac{E}{I} \quad (\text{or}) \quad I = \frac{E}{R} \quad (\text{or}) \quad E = IR$$

These handy formulas form Ohm's law. Memorize them. You will use them often.

Resistors are identified by a color code:



COLOR	1	2	3 (Multiplier)
BLACK	0	0	1
BROWN	1	1	10
RED	2	2	100
ORANGE	3	3	1,000
YELLOW	4	4	10,000
GREEN	5	5	100,000
BLUE	6	6	1,000,000
VIOLET	7	7	10,000,000
GRAY	8	8	100,000,000
WHITE	9	9	(none)

A fourth color band may be present. It specifies the tolerance of the resistor. Gold is $\pm 5\%$ and silver is $\pm 10\%$. No fourth band means $\pm 20\%$.

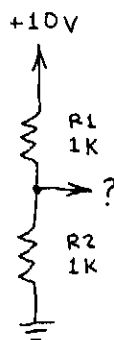
Since no resistor has a perfect tolerance, it's often okay to substitute resistors. For example, it's almost always okay to use a 1.8K resistor in place of a 2K unit. Just try to stay within 10-20% of the specified value.

What does K mean? It's short for 1,000. 20K means 20 x 1,000 or 20,000 ohms. M is short for meg-ohm or 1,000,000 ohms. Therefore a 2.2M resistor has a resistance of 2,200,000 ohms.

Resistors which resist lots of current must be able to dissipate the heat that's produced. Always use resistors with the specified power rating. No power rating specified? Then it's usually okay to use 1/4 or 1/2 watt units.

Almost every electronic circuit uses resistors. Here are three of the most important applications for resistors:

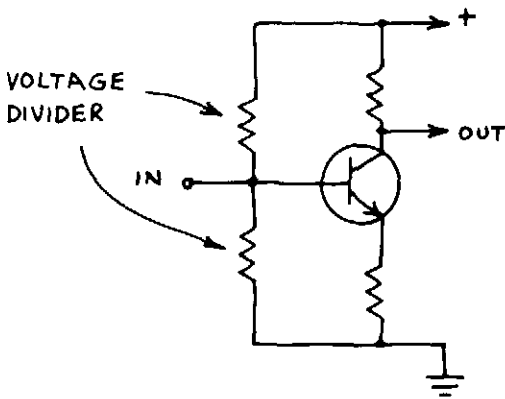
1. Limit current to LEDs, transistors, speakers, etc.
2. Voltage division. For instance:



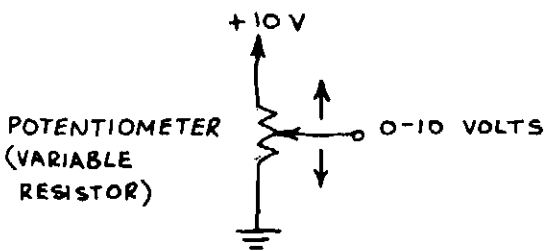
The voltage at ? is $I \times R_2$. I means the current through R1 and R2. So $I = 10 / (R_1 + R_2)$ or 0.005 amperes. Therefore, ? = (0.005) x (1000) or 5 volts.

Note that the total resistance of R1 and R2 is simply $R_1 + R_2$. This rule provides a handy trick for making custom resistances.

Voltage dividers are used to bias transistors:



They're also a convenient source of variable voltage:



And they're useful in voltage sensing circuits. See the comparator circuits in this notebook.

3. They control the charging time of capacitors. Read on...

CAPACITORS

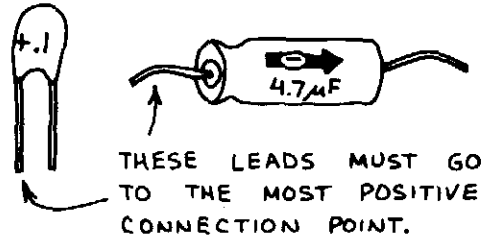
Capacitors store electrical energy and block the flow of direct current while passing alternating current. Capacitance is specified in farads. One farad represents a huge capacitance so most capacitors have values of small fractions of a farad:

1 microfarad (μF) = 10^{-6} farad
 1 picofarad (pF) = 10^{-12} farad
 or
 1 μF = 1,000,000 pF

The value of a capacitor is usually printed on the component. The μF and pF designations may not be present. Small ones marked 1-1000 are rated in pF; larger ones

marked .001-1000 are rated in μF .

Electrolytic capacitors provide high capacity in a small space. Their leads are polarized and must be connected into a circuit in the proper direction.

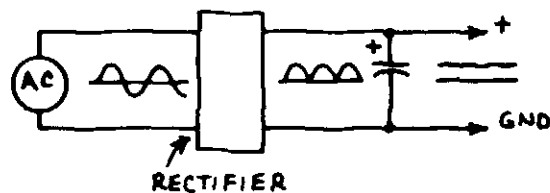


Capacitors have a voltage rating. It's usually printed under the capacity marking. The voltage rating must be higher than the highest expected voltage (usually the power supply voltage).

Caution: A capacitor can store a charge for a considerable time after power is removed. This charge can be dangerous! A large electrolytic capacitor charged to only 5 or 10 volts can melt the tip of a screwdriver placed across its leads! High voltage capacitors can store a lethal charge! Discharge a capacitor by carefully placing a resistor (1K or more; use Ohm's law) across its leads. Use only one hand to prevent touching both leads of the capacitor.

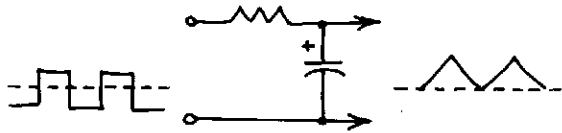
Important capacitor applications:

1. Remove power supply spikes. (Place 0.01-0.1 μF across power supply pins of digital ICs. Stops false triggering.)
2. Smooth rectified AC voltage into steady DC voltage. (Place 100-10,000 μF across rectifier output.)

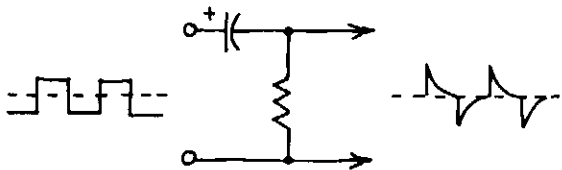


SEMICONDUCTORS

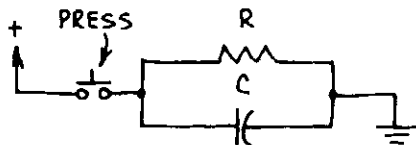
3. Block DC signal while passing AC signal.
4. Bypass AC signal around a circuit or to ground.
5. Filter out unwanted portions of a fluctuating signal.
6. Use with resistor to integrate a fluctuating signal:



7. Or to differentiate a fluctuating signal:



8. Perform a timing function:

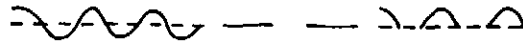


- C will quickly charge...then slowly discharge through R.
9. Store a charge to keep a transistor turned off or on.
 10. Store a charge to be dumped through a flashtube or LED in a fast and powerful pulse.
- Can you substitute capacitors?
 In most cases changing the value of a capacitor 10% or even 100% will not cause a malfunction, but circuit operation may be affected. In a timing circuit, for example, increasing the value of the timing capacitor will increase the timing period. Changing the capacitors in a filter will change the filter's frequency response. Be sure to use the proper voltage rating. And don't worry about the difference between 0.47 and 0.5 μ F.

Usually made from silicon. Be sure to observe all operating restrictions. Brief descriptions of important semiconductor devices:

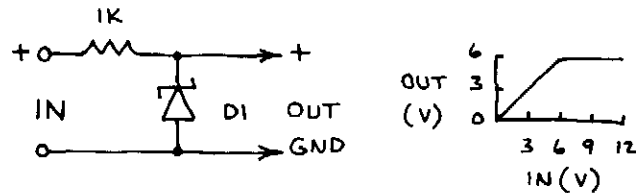
DIODES

Permit current to flow in but one direction (forward bias). Used to rectify AC, allow current to flow into a circuit but block its return, etc.



ZENER DIODES

The zener diode is a voltage regulator. In this typical circuit, voltage exceeding the diode's breakdown voltage is shunted to ground:

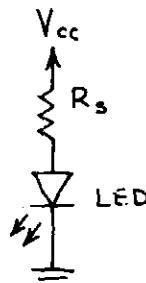


DI = 6 VOLT ZENER DIODE

Zeners can also protect voltage sensitive components and provide a convenient reference voltage.

LIGHT EMITTING DIODES

LEDs emit green, yellow, red or infrared when forward biased. A series resistor should be used to limit current to less than the maximum allowed:



$$R_s = \frac{V_{CC} - V_{LED}}{LED_I}$$

Example: V_{LED} of red LED is 1.7 volts. For a forward current (LED_I) of 20 mA at $V_{CC} = 5$ volts, $R = 165$ ohms. Don't exceed LED_I !!

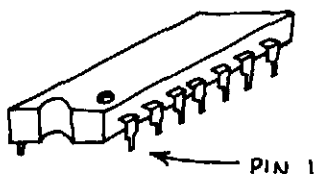
Infrared LEDs are much more powerful than visible LEDs, but their radiation is totally invisible. Use them for object detectors and communicators.

TRANSISTORS

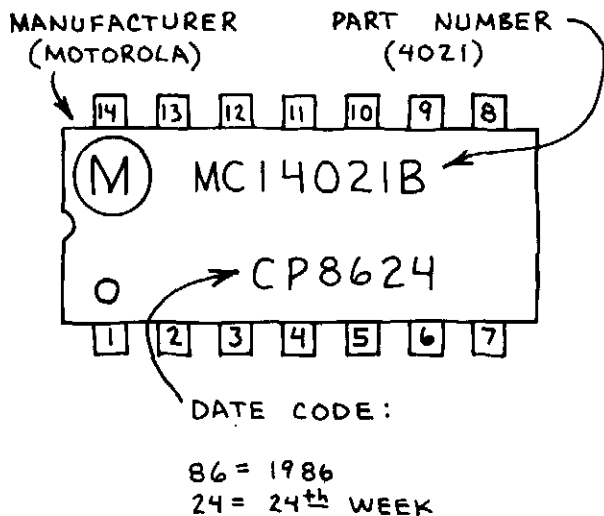
In this notebook, transistors are used as simple amplifiers and switches that turn on LEDs. Any general purpose switching transistors will work.

INTEGRATED CIRCUITS

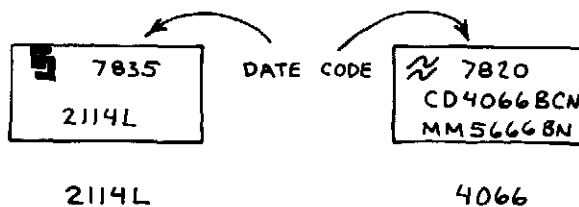
Since an IC is a complete circuit on a silicon chip, you must observe all operating restrictions. Reversed polarity, excessive supply voltage and sourcing or sinking too much current can destroy an IC. Be sure to pay close attention to the location of the power supply pins! Most ICs are packaged in 8, 14 or 16 pin plastic DIPs (Dual In-line Packages). A notch or circle is near pin 1:



When the IC is right side up, pin 1 is at lower left:



Incidentally, a date code may not be present, but other numbers may be...and the date code is not always below the device number:



Store ICs in a plastic cabinet if you can afford one. Or insert them in rows in a styrofoam tray (the kind used for meat in a grocery store). CAUTION: Never store MOS/CMOS ICs in ordinary non-conductive plastic.

DIGITAL INTEGRATED CIRCUITS

INTRODUCTION

DIGITAL ICs ARE 2-STATE DEVICES. ONE STATE IS NEAR 0 VOLTS OR GROUND (LOW OR L) AND THE OTHER IS NEAR THE IC'S SUPPLY VOLTAGE (HIGH OR H). SUBSTITUTE 0 FOR L AND 1 FOR H AND DIGITAL ICs CAN PROCESS INDIVIDUAL BINARY DIGITS (BITS) OR MULTIPLE BIT WORDS. A 4-BIT WORD IS A NIBBLE AND AN 8-BIT WORD IS A BYTE.

THE BINARY SYSTEM

IT'S VERY HELPFUL TO KNOW THE FIRST 16 BINARY NUMBERS. IF 0=L AND 1=H, THEY ARE:

- | | |
|-------------|--------------|
| 0 - L L L L | 8 - H L L L |
| 1 - L L L H | 9 - H L L H |
| 2 - L L H L | 10 - H L H L |
| 3 - L L H H | 11 - H L H H |
| 4 - L H L L | 12 - H H L L |
| 5 - L H L H | 13 - H H L H |
| 6 - L H H L | 14 - H H H L |
| 7 - L H H H | 15 - H H H H |

NOTE THAT L L L L (0) IS AS MUCH A NUMBER AS ANY OTHER NUMBER.

LOGIC GATES

LOGIC CIRCUITS ARE MADE BY INTERCONNECTING TWO OR MORE OF THESE BASIC LOGIC GATES:



AND

A	B	OUT
L	L	L
L	H	L
H	L	L
H	H	H



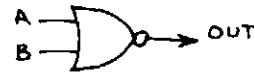
NAND

A	B	OUT
L	L	H
L	H	H
H	L	H
H	H	L



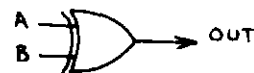
OR

A	B	OUT
L	L	L
L	H	H
H	L	H
H	H	H



NOR

A	B	OUT
L	L	H
L	H	L
H	L	L
H	H	L



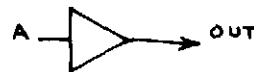
EXCLUSIVE-OR

A	B	OUT
L	L	L
L	H	H
H	L	H
H	H	L



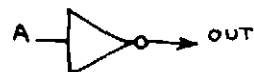
EXCLUSIVE-NOR

A	B	OUT
L	L	H
L	H	L
H	L	L
H	H	H



YES (BUFFER)

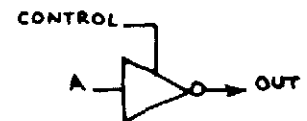
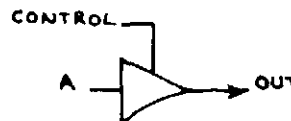
A	OUT
L	L
H	H



NOT (INVERTER)

A	OUT
L	H
H	L

3-STATE LOGIC



CONTROL	A	OUT
L	L	L
L	H	H
H	X	HI-Z

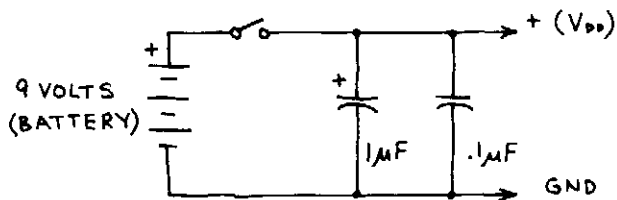
CONTROL	A	OUT
L	L	H
L	H	L
H	X	HI-Z

HI-Z: OUTPUT IN HIGH IMPEDANCE STATE.

MOS/CMOS INTEGRATED CIRCUITS

INTRODUCTION

MOS ICs CAN CONTAIN MORE FUNCTIONS PER CHIP THAN TTL/LS AND ARE VERY EASY TO USE. MOST CHIPS IN THIS SECTION ARE CMOS (COMPLEMENTARY MOS). THEY CONSUME VERY LITTLE POWER AND OPERATE OVER A +3-15 VOLT RANGE. CMOS CAN BE POWERED BY THIS:



OR YOU CAN USE A LINE POWERED SUPPLY MADE FROM A 7805/7812/7815. SEE THE LINEAR SECTION.

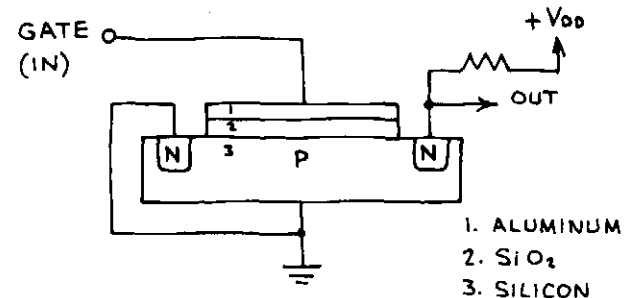
INCIDENTALLY, YOU CAN POWER A CMOS CIRCUIT FROM TWO SERIES CONNECTED PENLIGHT CELLS, BUT A 9-12 VOLT SUPPLY WILL GIVE BETTER PERFORMANCE.

OPERATING REQUIREMENTS

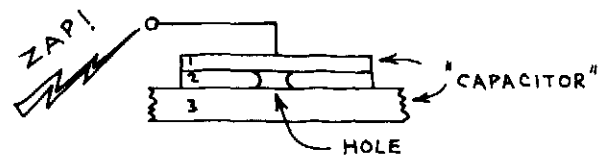
1. THE INPUT VOLTAGE SHOULD NOT EXCEED V_{DD} ! (TWO EXCEPTIONS: THE 4049 AND 4050.)
2. AVOID, IF POSSIBLE, SLOWLY RISING AND FALLING INPUT SIGNALS SINCE THEY CAN CAUSE EXCESSIVE POWER CONSUMPTION. RISETIMES FASTER THAN 15 MICROSECONDS ARE BEST.
3. ALL UNUSED INPUTS MUST BE CONNECTED TO V_{DD} (+) OR V_{SS} (GND). OTHERWISE ERRATIC CHIP BEHAVIOR AND EXCESSIVE CURRENT CONSUMPTION WILL OCCUR.
4. NEVER CONNECT AN INPUT SIGNAL TO A CMOS CIRCUIT WHEN THE POWER IS OFF.
5. OBSERVE HANDLING PRECAUTIONS.

HANDLING PRECAUTIONS

A CMOS CHIP IS MADE FROM PMOS AND NMOS TRANSISTORS. MOS MEANS METAL-OXIDE-SILICON (OR SEMICONDUCTOR). P AND N REFER TO POSITIVE AND NEGATIVE CHANNEL MOS TRANSISTORS. AN NMOS TRANSISTOR LOOKS LIKE THIS:



A PMOS TRANSISTOR IS IDENTICAL EXCEPT THE P AND N REGIONS ARE EXCHANGED. THE SiO_2 (SILICON DIOXIDE) LAYER IS A GLASSY FILM THAT SEPARATES AND INSULATES THE METAL GATE FROM THE SILICON SUBSTRATE. THIS FILM IS WHY A MOS TRANSISTOR OR IC PLACES PRACTICALLY NO LOAD ON THE SOURCE OF AN INPUT SIGNAL. THE FILM IS VERY THIN AND IS THEREFORE EASILY PUNCTURED BY STATIC ELECTRICITY:

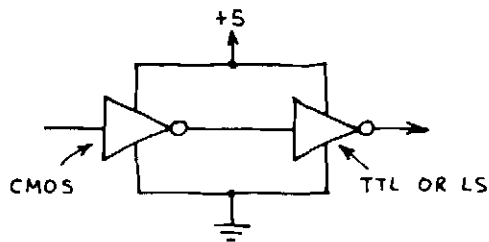
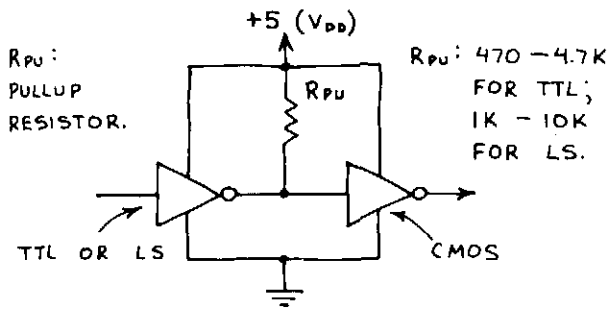


PREVENT STATIC DISCHARGE!

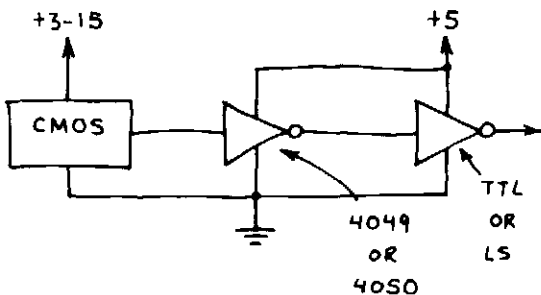
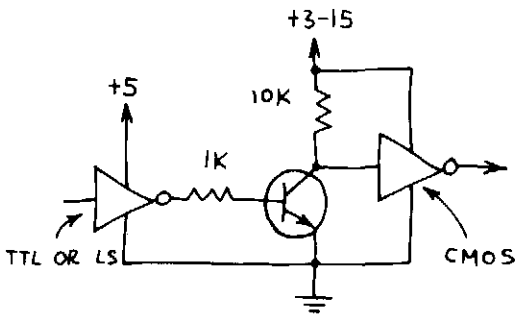
1. NEVER STORE MOS IC'S IN NONCONDUCTIVE PLASTIC "SNOW," TRAYS, BAGS OR FOAM.
2. PLACE MOS IC'S PINS DOWN ON AN ALUMINUM FOIL SHEET OR TRAY WHEN THEY ARE NOT IN A CIRCUIT OR STORED IN CONDUCTIVE FOAM.
3. USE A BATTERY POWERED IRON TO SOLDER MOS CHIPS. DO NOT USE AN AC POWERED IRON.

INTERFACING CMOS

1. IF SUPPLY VOLTAGES ARE EQUAL:

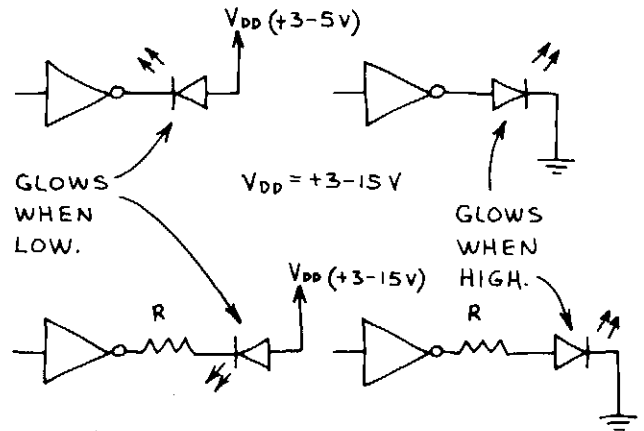


2. DIFFERENT SUPPLY VOLTAGES:



NOTE THAT CMOS MUST BE POWERED BY AT LEAST 5 VOLTS WHEN CMOS IS INTERFACED WITH TTL. OTHERWISE THE CMOS INPUT WILL EXCEED V_{DD} .

3. CMOS LED DRIVERS:

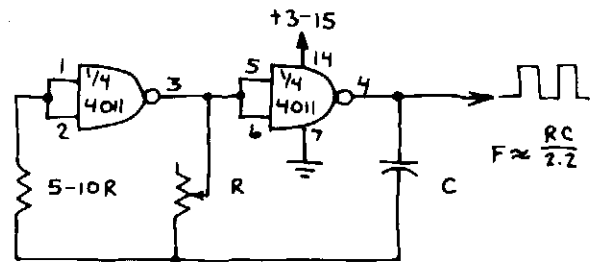


$$R = \frac{V_{DD} - 1.7}{.01} \quad (\text{FOR } 10 \text{ mA LED CURRENT})$$

USE 1000 OHMS FOR MOST APPLICATIONS.

CMOS LOGIC CLOCK

MANY CIRCUITS IN THIS SECTION REQUIRE A SOURCE OF PULSES. HERE'S A SIMPLE CMOS CLOCK:



TYPICAL VALUES: $R=100K$, $C=0.01-0.1 \mu F$

OK TO USE 4049... BUT MUCH MORE CURRENT WILL BE REQUIRED.

CMOS TROUBLESHOOTING

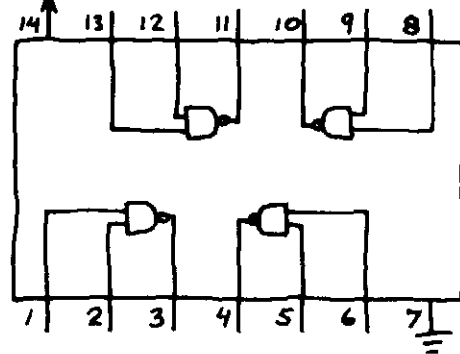
1. DO ALL INPUTS GO SOMEWHERE?
2. ARE ALL IC PINS INSERTED INTO THE BOARD OR SOCKET?
3. IS THE IC HOT? IF SO, SEE 1-2 ABOVE AND MAKE SURE THE OUTPUT IS NOT OVERLOADED.
4. DOES THE CIRCUIT OBEY ALL CMOS OPERATING REQUIREMENTS?
5. HAVE YOU FORGOTTEN A CONNECTION?

QUAD NAND GATE

4011

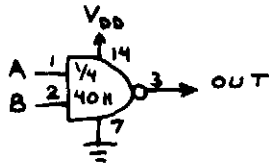
THE BASIC CMOS BUILDING BLOCK CHIP. MORE APPLICATIONS THAN TTL 7400/74LS00 QUAD NAND GATE.

$V_{DD} (+3-15V)$



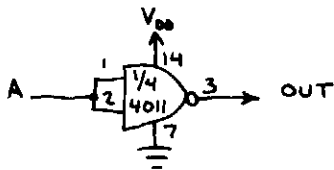
IMPORTANT: CONNECT ALL UNUSED INPUTS TO PIN 7 OR 14!

CONTROL GATE



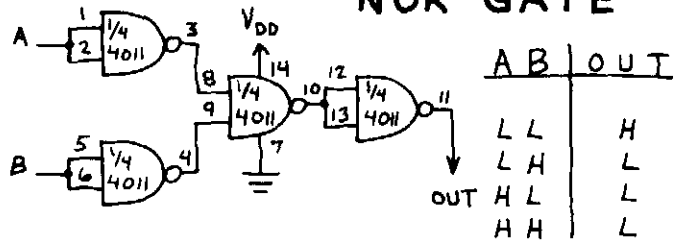
A	B	OUT
L	L	H
L	H	H
H	L	H
H	H	L

INVERTER



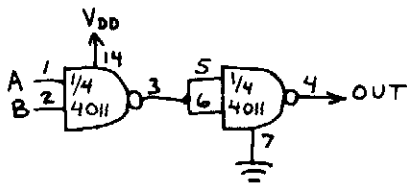
A	OUT
L	H
H	L

NOR GATE



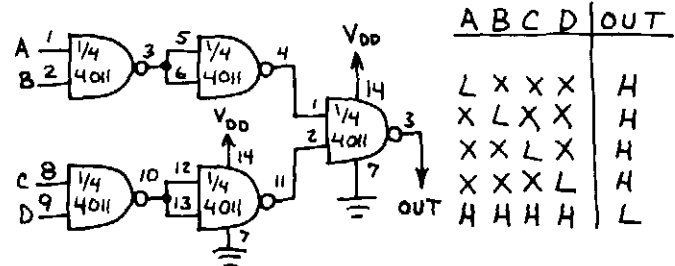
A	B	OUT
L	L	H
L	H	L
H	L	L
H	H	L

AND GATE



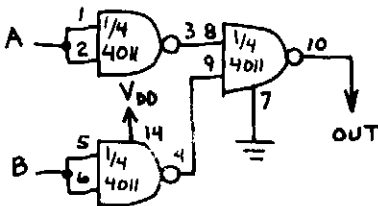
A	B	OUT
L	L	L
L	H	L
H	L	L
H	H	H

4-INPUT NAND GATE



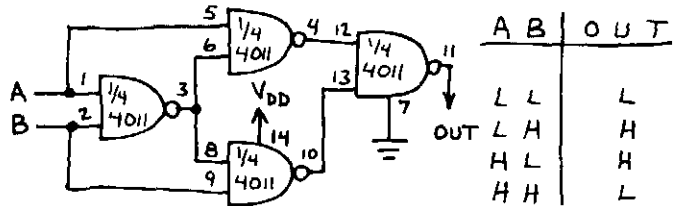
A	B	C	D	OUT
L	X	X	X	H
X	L	X	X	H
X	X	L	X	H
X	X	X	L	H
H	H	H	H	L

OR GATE



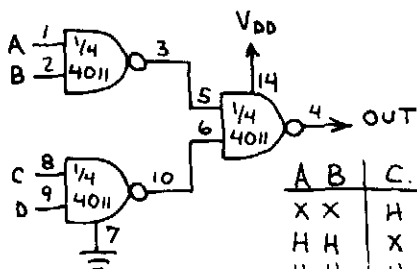
A	B	OUT
L	L	L
L	H	H
H	L	H
H	H	H

EXCLUSIVE-OR GATE



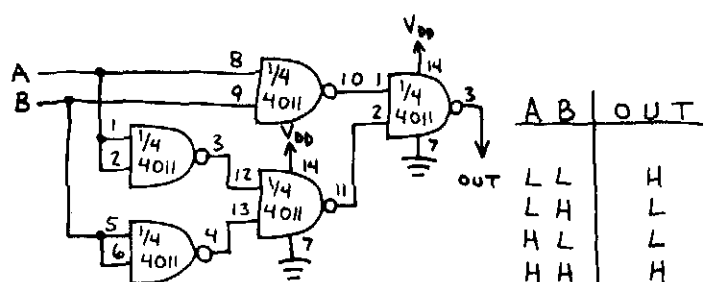
A	B	OUT
L	L	L
L	H	H
H	L	H
H	H	L

AND-OR GATE



A	B	C	D	OUT
X	X	H	H	H
H	H	X	X	H
H	H	H	H	H

EXCLUSIVE-NOR GATE

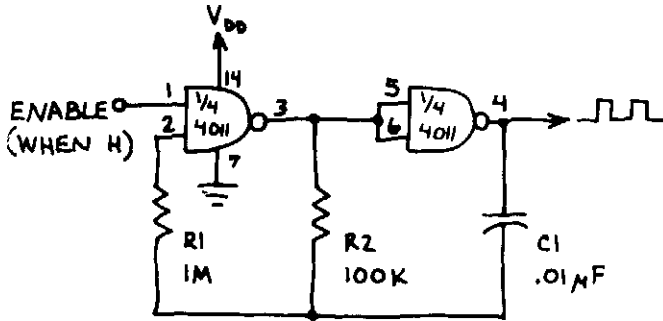


A	B	OUT
L	L	H
L	H	L
H	L	L
H	H	H

QUAD NAND GATE (CONTINUED)

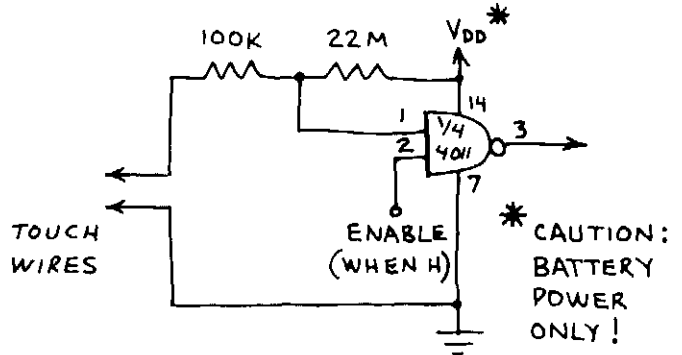
4011

GATED OSCILLATOR



OUTPUT FREQUENCY IS 1 KHz SQUARE WAVE.

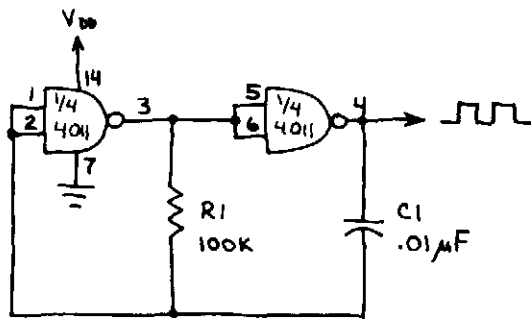
TOUCH SWITCH



OUTPUT GOES HIGH WHEN TOUCH WIRES ARE BRIDGED BY A FINGER.

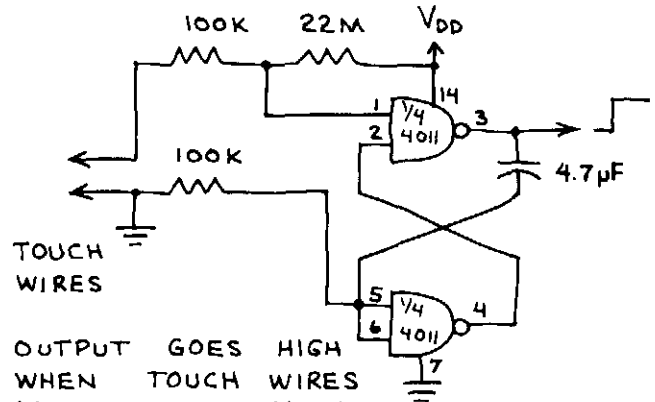
* CAUTION: BATTERY POWER ONLY!

SIMPLE OSCILLATOR



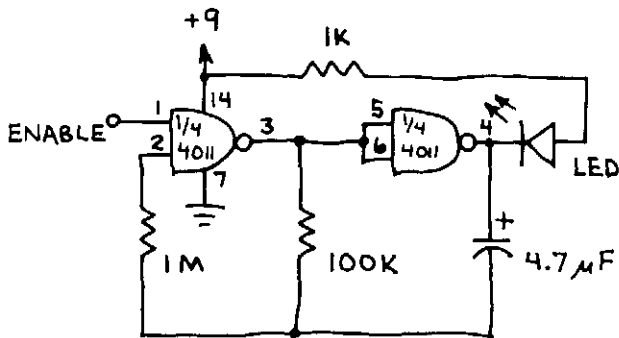
OUTPUT NOT AS SYMMETRICAL AS ABOVE CIRCUIT.

ONE-SHOT TOUCH SWITCH



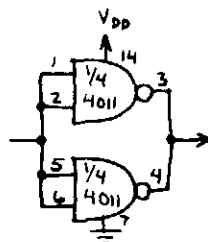
OUTPUT GOES HIGH WHEN TOUCH WIRES ARE BRIDGED BY A FINGER. OUTPUT THEN RETURNS LOW AFTER ABOUT 1 SECOND.

GATED FLASHER

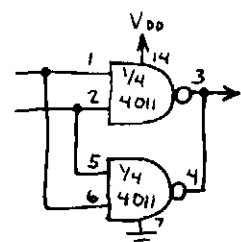


LED FLASHES 1-2 Hz WHEN ENABLE IS HIGH. LED STAYS ON WHEN ENABLE IS LOW.

INCREASED OUTPUT DRIVE



INVERTER.



NAND GATE

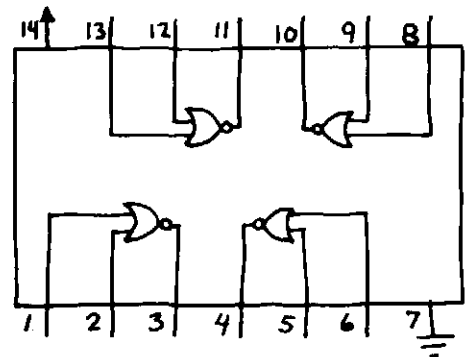
USE THIS METHOD TO INCREASE CURRENT THE 4011 CAN SOURCE OR SINK. OK TO ADD MORE GATES.

QUAD NOR GATE

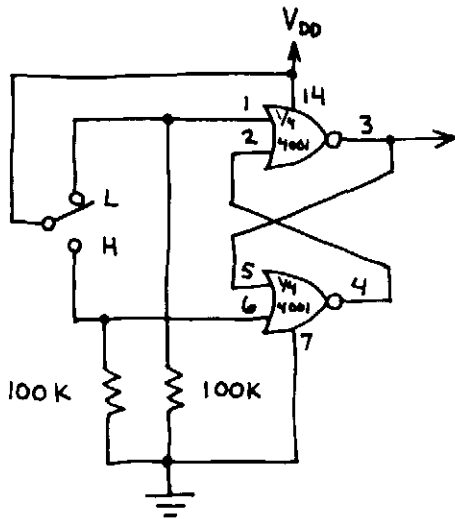
4001

AN IMPORTANT CMOS BUILDING BLOCK CHIP. ITS HIGH IMPEDANCE INPUT MAKES POSSIBLE MORE APPLICATIONS THAN THE TTL 7402/74LS02 QUAD NOR GATE.

V_{DD} (+3-15V)

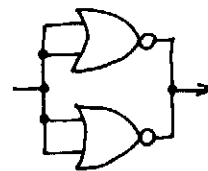


BOUNCELESS SWITCH

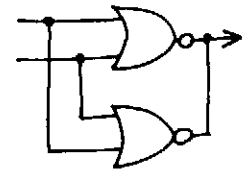


IMPORTANT: CONNECT ALL UNUSED INPUTS TO PIN 7 OR 14.

INCREASED OUTPUT DRIVE



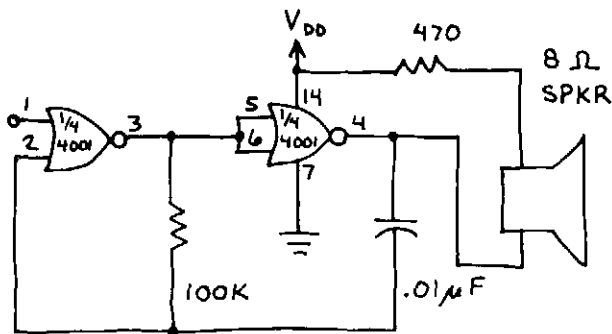
INVERTER



NOR GATE

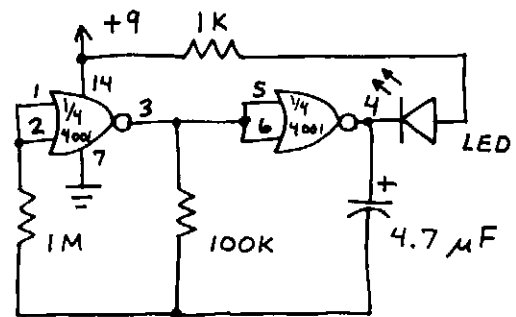
USE THIS METHOD TO INCREASE CURRENT THE 4001 CAN SOURCE OR SINK. OK TO ADD MORE GATES.

GATED TONE SOURCE



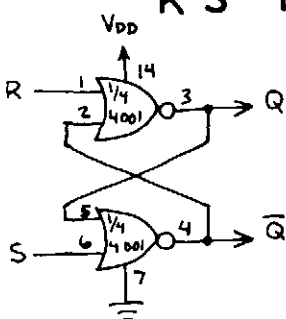
TONE FREQUENCY IS ABOUT 1KHz.

LED FLASHER



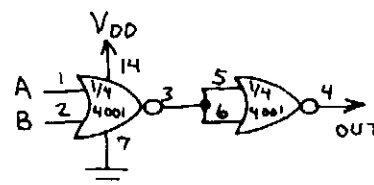
LED FLASHES 1-2 TIMES/SECOND.

RS LATCH



R	S	Q	\bar{Q}
L	L	NO CHANGE	
L	H	H	L
H	L	L	H
H	H	NOT ALLOWED	

OR GATE

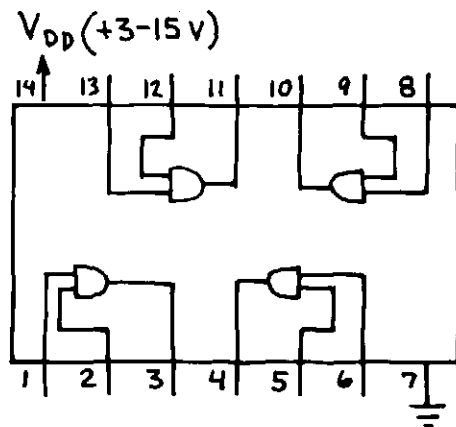


A	B	OUT
L	L	L
L	H	H
H	L	H
H	H	H

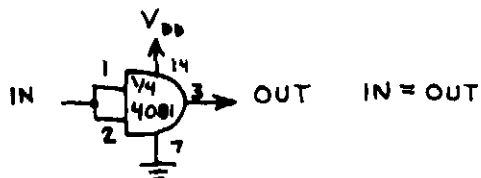
QUAD AND GATE

4081

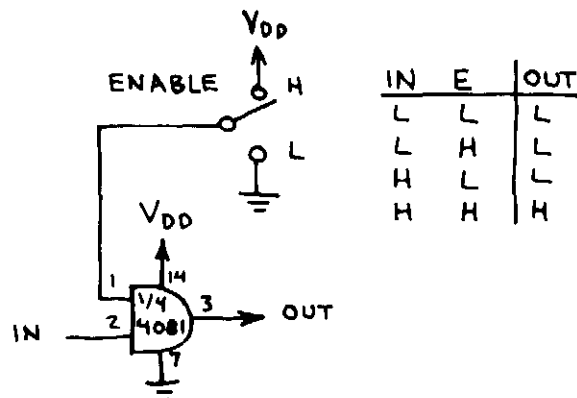
BUILDING BLOCK CHIP. USE FOR BUFFERING AND LOGIC. NOT AS VERSATILE AS 4011.



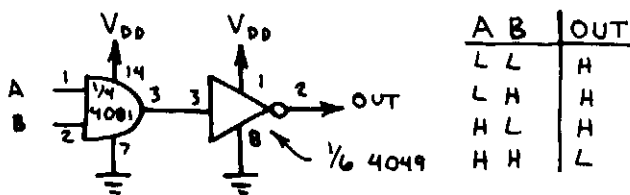
AND GATE BUFFER



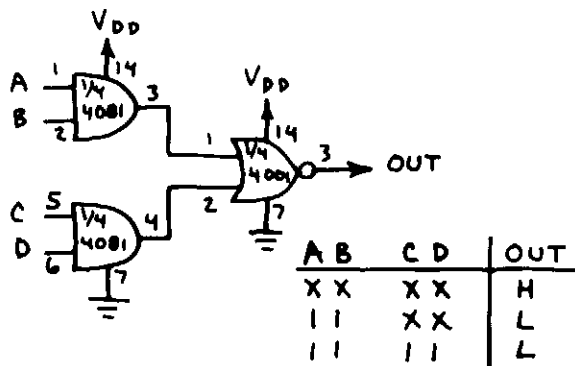
DIGITAL TRANSMISSION GATE



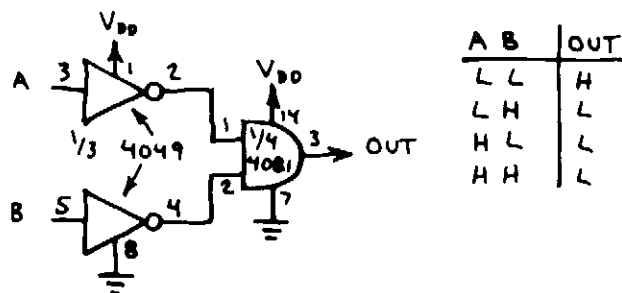
NAND GATE



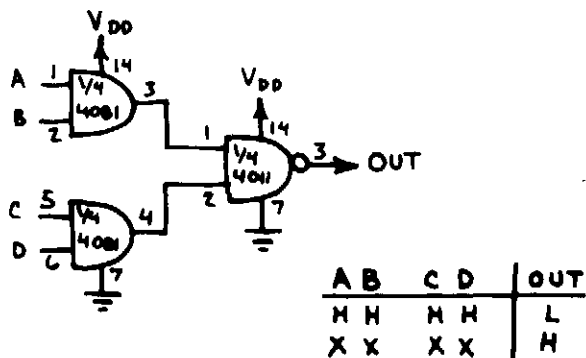
AND-OR-INVERT GATE



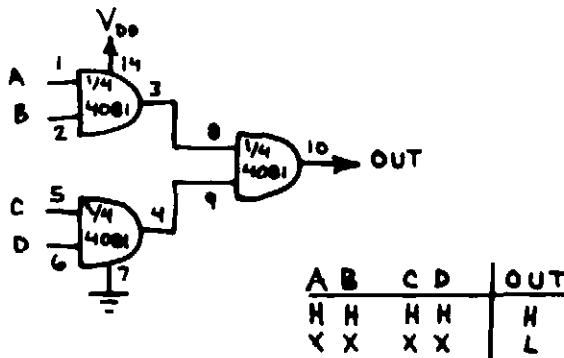
NOR GATE



4-INPUT NAND GATE



4-INPUT AND GATE

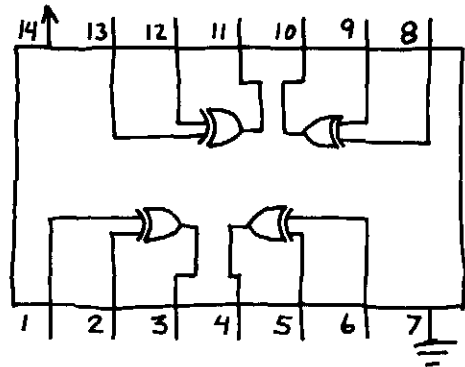


QUAD EXCLUSIVE-OR GATE 4070

THE OUTPUT OF EACH GATE GOES LOW WHEN BOTH INPUTS ARE EQUAL. THE OUTPUT GOES HIGH IF THE INPUTS ARE UNEQUAL. MANY APPLICATIONS INCLUDING BINARY ADDITION, COMPARING BINARY WORDS AND PHASE DETECTION.

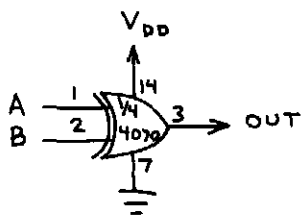
IMPORTANT: CONNECT UNUSED INPUTS TO PIN 7 OR 14.

V_{DD} (+3-15V)



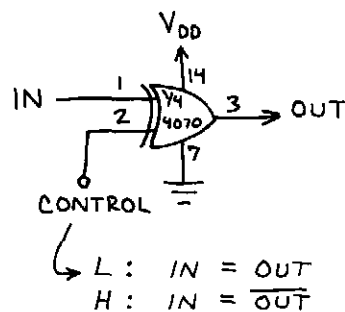
1-BIT COMPARATOR

THIS CIRCUIT IS ALSO A HALF-ADDER WITHOUT A CARRY OUTPUT.



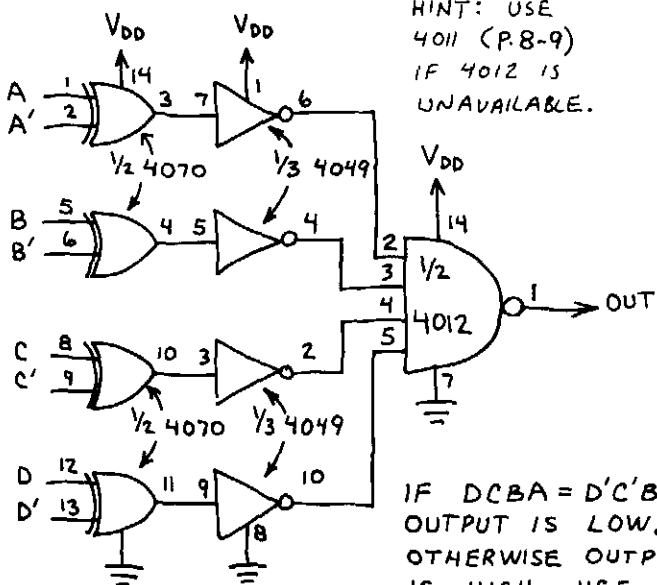
A	B	OUT
L	L	L
L	H	H
H	L	H
H	H	L

CONTROLLED INVERTER



4-BIT COMPARATOR

DETERMINES IF TWO 4-BIT WORDS ARE EQUAL.

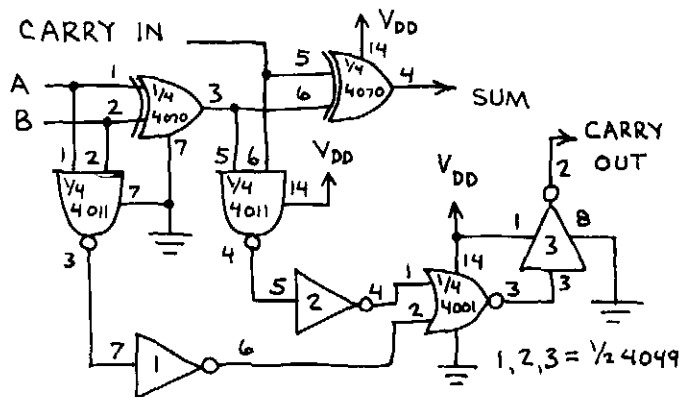


HINT: USE 4011 (P.8-9) IF 4012 IS UNAVAILABLE.

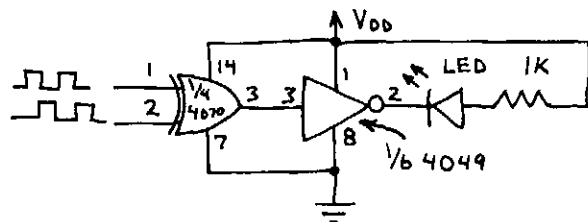
IF DCBA = D'C'B'A' OUTPUT IS LOW. OTHERWISE OUTPUT IS HIGH. USE SECOND HALF OF 4012 AS INVERTER TO REVERSE OPERATION.

4012 AS INVERTER TO REVERSE OPERATION.

BINARY FULL ADDER



PHASE DETECTOR

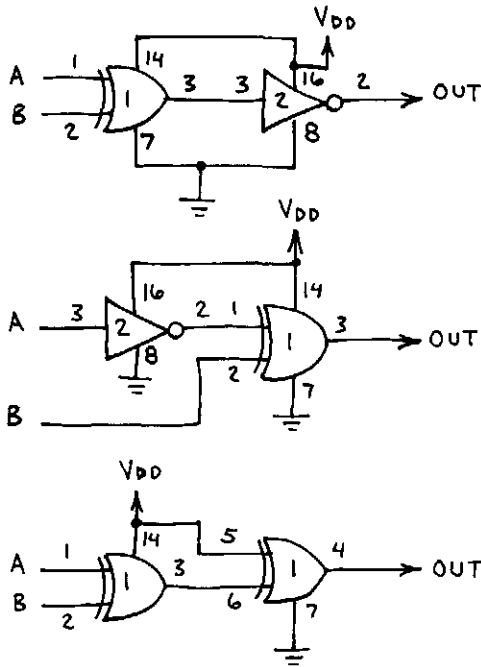


LED STOPS GLOWING WHEN THE INPUT FREQUENCIES ARE EQUAL.

QUAD EXCLUSIVE-OR GATE (CONTINUED)

4070

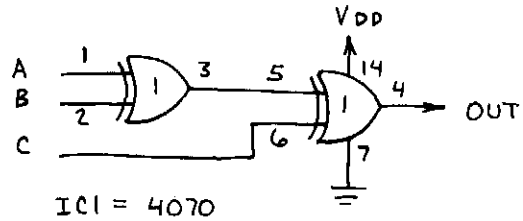
EXCLUSIVE-NOR



IC1 = 1/4 4070
IC2 = 1/6 4049

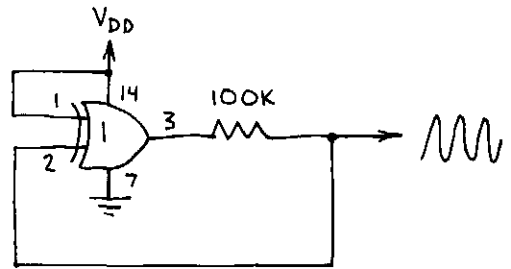
A	B	OUT
L	L	H
L	H	L
H	L	L
H	H	H

3-INPUT EX-OR



IC1 = 4070

10 MHz OSCILLATOR

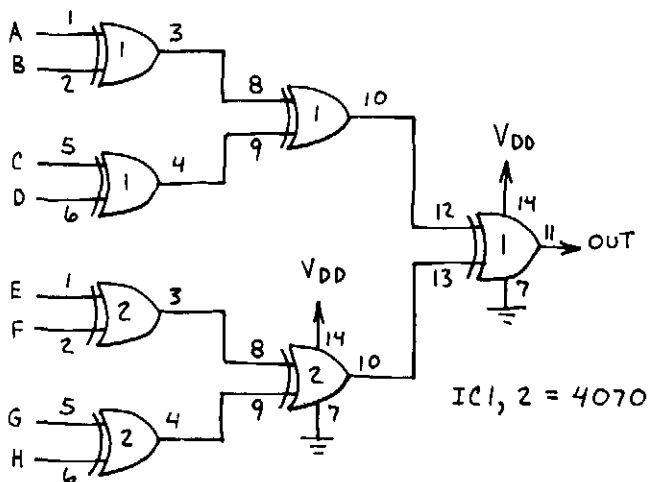


V_{DD} = 3 TO 15 VOLTS

FREQUENCY VARIES WITH V_{DD}:

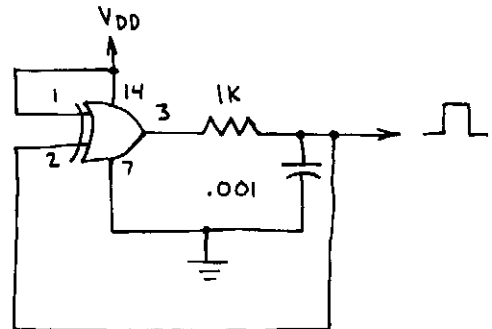
V _{DD}	FREQUENCY	AMPLITUDE
5	2.4 MHz	3.5 V
10	9.4 MHz	8.0 V
15	11.0 MHz	12.0 V

8-INPUT EX-OR



IC1, 2 = 4070

SQUARE WAVE GENERATOR

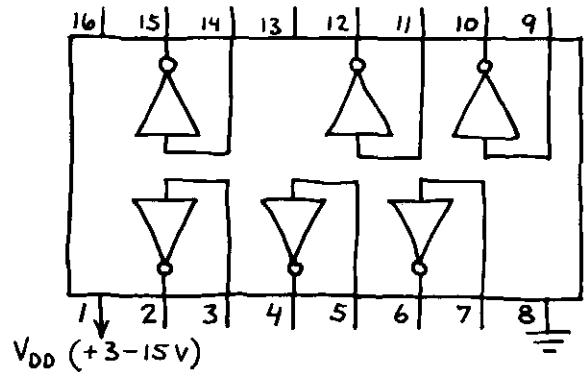


V_{DD} = 3 TO 15 VOLTS

RISETIME = 50 NANoseconds
FREQUENCY = 2 MHz WHEN
V_{DD} = 10 VOLTS

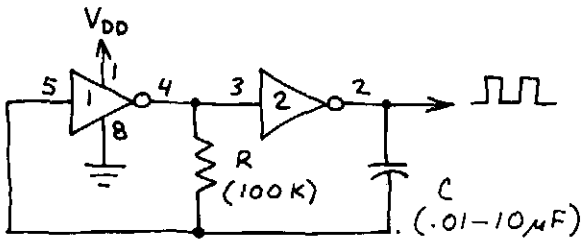
HEX INVERTING BUFFER 4049

IN ADDITION TO STANDARD LOGIC AND CMOS TO TTL INTERFACING, OFTEN USED IN OSCILLATORS AND PULSE GENERATORS. FOR LOW CURRENT APPLICATIONS, USE 4011 CONNECTED AS INVERTER. (OK TO USE 4011 FOR CIRCUITS ON THIS PAGE.)



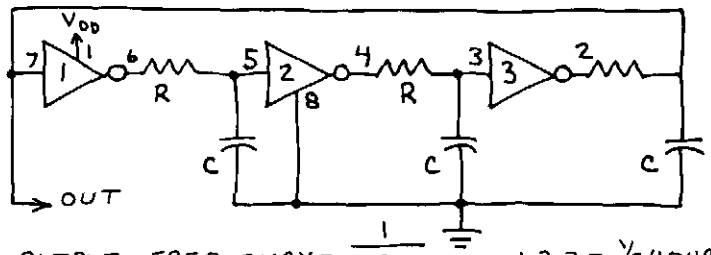
NOTE UNUSUAL LOCATION OF POWER SUPPLY PINS.

CLOCK PULSE GENERATOR



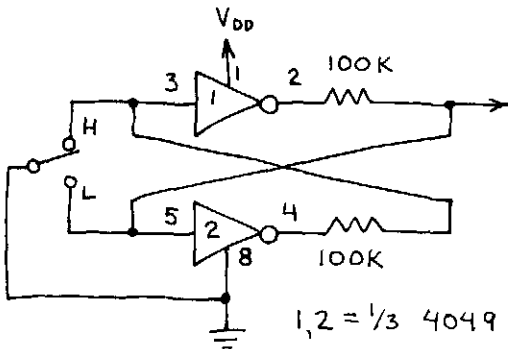
$1, 2 = \frac{1}{3}$ 4049 PULSE RATE = $\frac{1}{1.4RC}$

PHASE SHIFT OSCILLATOR



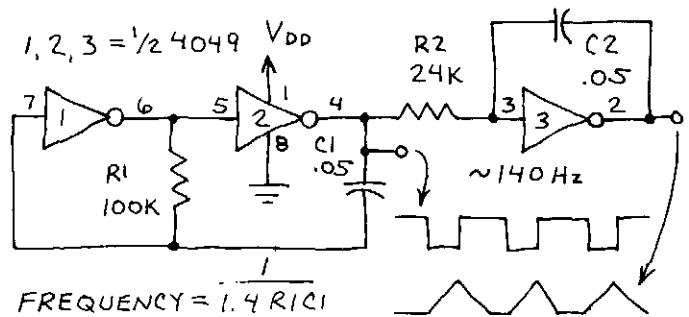
OUTPUT FREQUENCY = $\frac{1}{3.3RC}$ $1, 2, 3 = \frac{1}{2}$ 4049

BOUNCELESS SWITCH



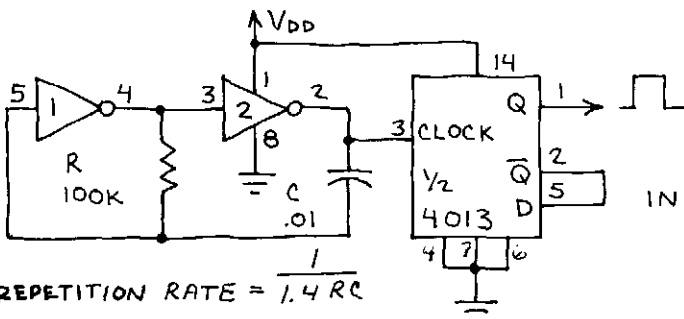
$1, 2 = \frac{1}{3}$ 4049

TRIANGLE WAVE SOURCE



FREQUENCY = $\frac{1}{1.4R1C1}$

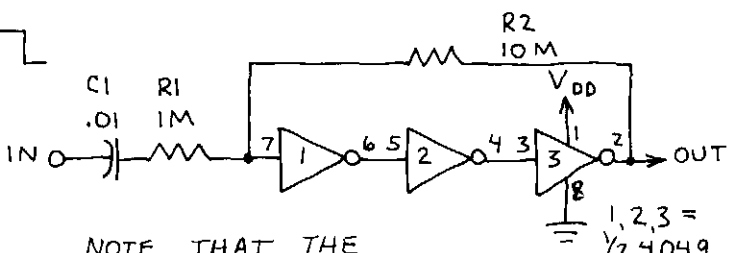
SQUARE WAVE GENERATOR



REPETITION RATE = $\frac{1}{1.4RC}$

$1, 2 = \frac{1}{3}$ 4049

LINEAR IOX AMPLIFIER

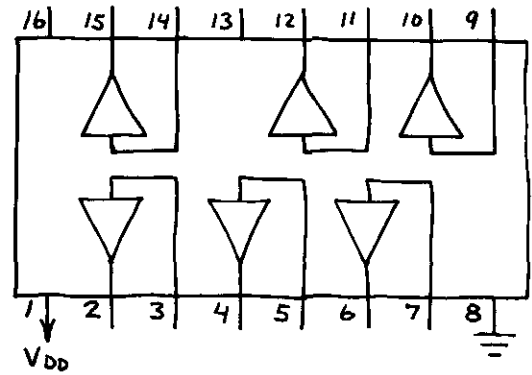


NOTE THAT THE INVERTERS ARE USED IN A LINEAR MODE. GAIN = $\frac{R2}{R1}$.

HEX NON-INVERTING BUFFER 4050

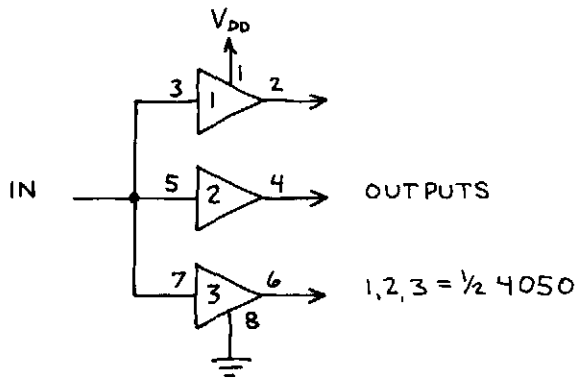
PRIMARILY INTENDED FOR
INTERFACING CMOS TO TTL.
SUPPLIES MORE CURRENT
THAN STANDARD CMOS.

IMPORTANT: ALL UNUSED INPUTS
MUST GO TO PIN 1 OR 8.

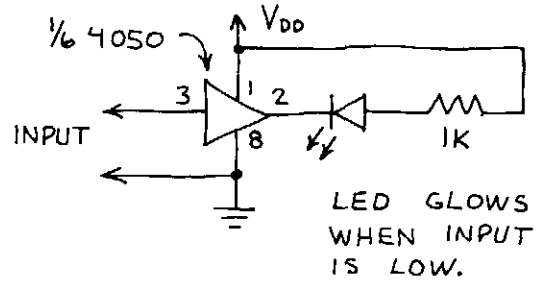


NOTE UNUSUAL LOCATION
OF POWER SUPPLY PINS.

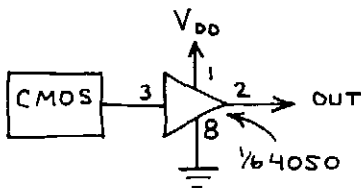
OUTPUT EXPANDER



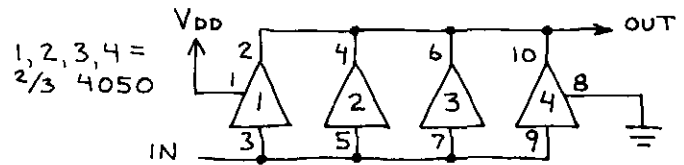
LOGIC PROBE



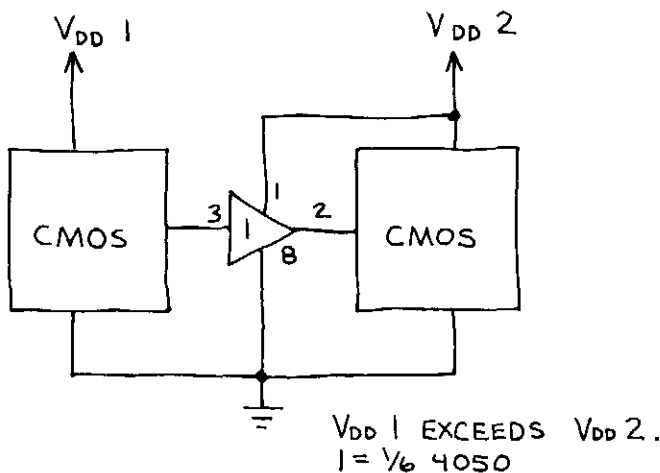
OUTPUT BUFFER



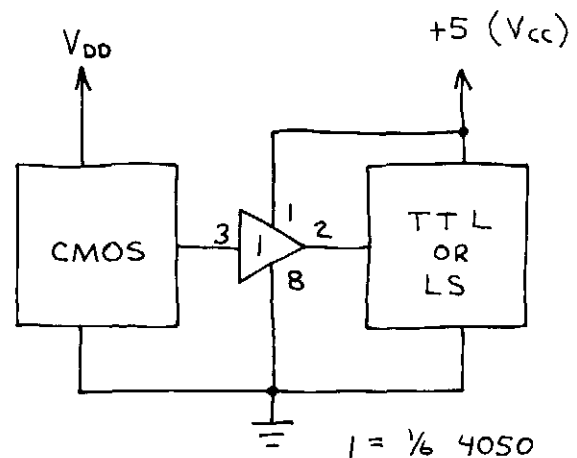
INCREASED OUTPUT DRIVE



CMOS TO CMOS AT LOWER V_{DD}



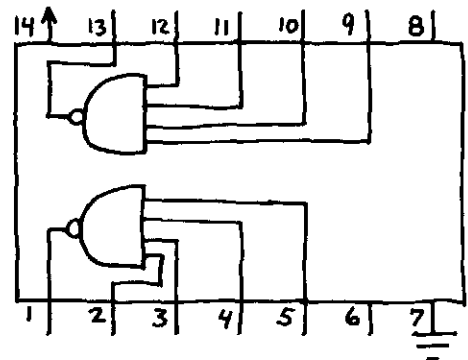
CMOS TO TTL/LS AT LOWER V_{CC}



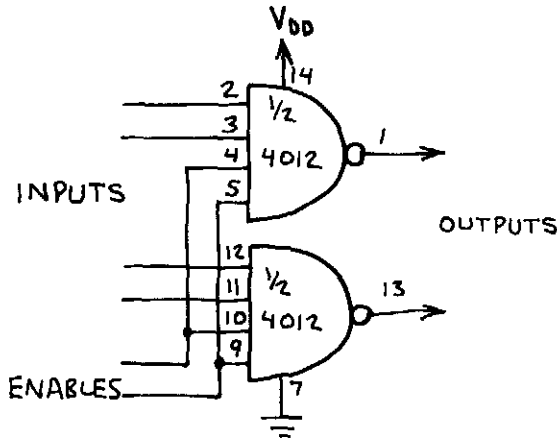
DUAL 4-INPUT NAND GATE 4012

VERY USEFUL IN MAKING DECODERS. ALSO CAN BE USED TO ADD ONE OR MORE ENABLE INPUTS TO VARIOUS CIRCUITS.

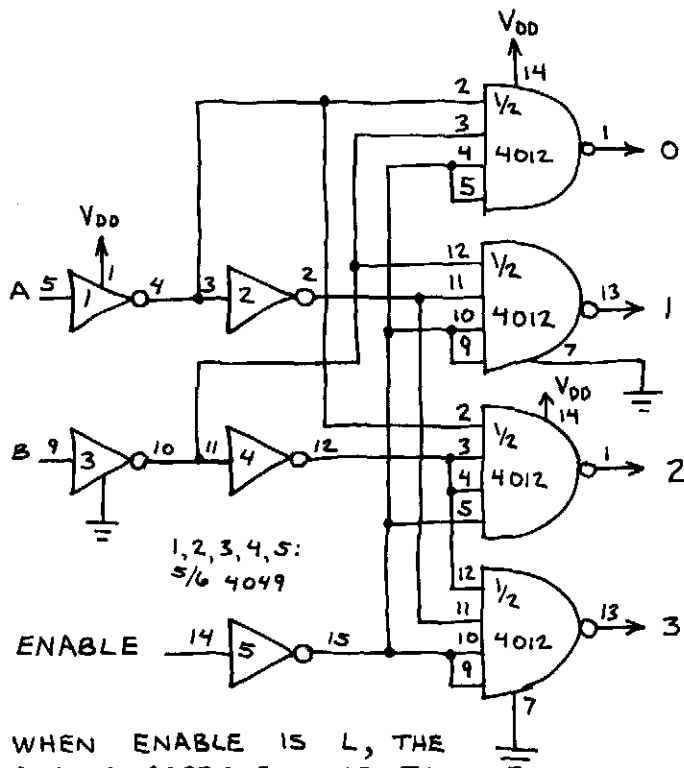
$V_{DD} (+3-15V)$



ENABLE INPUT



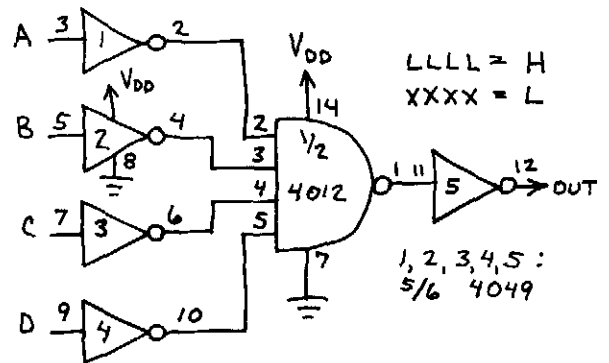
1-OF-4 DECODER



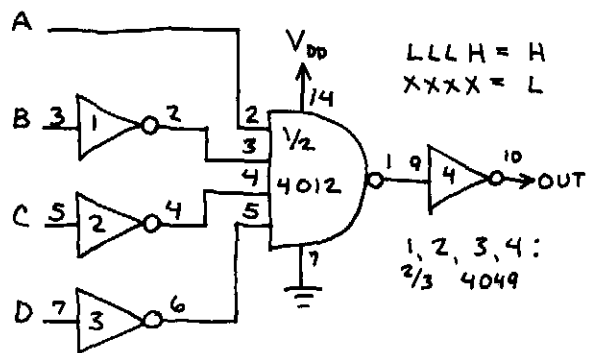
WHEN ENABLE IS L, THE OUTPUT CORRESPONDING TO THE BA BINARY INPUTS GOES LOW. ALL OTHER OUTPUTS GO HIGH WHEN ENABLE IS H.

BCD DECODERS

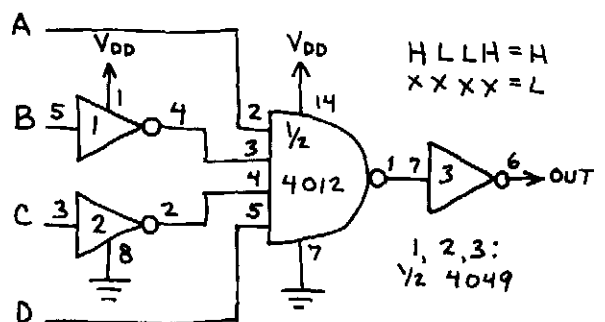
DECIMAL 0



DECIMAL 1

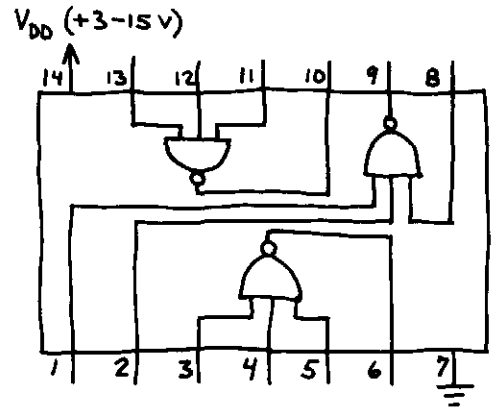


DECIMAL 9

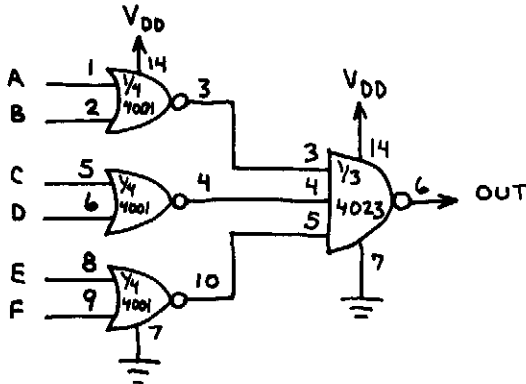


TRIPLE 3-INPUT NAND GATE 4023

HANDY FOR MAKING CUSTOM DECODERS,
CONVERTERS AND MULTIPLE INPUT GATES.

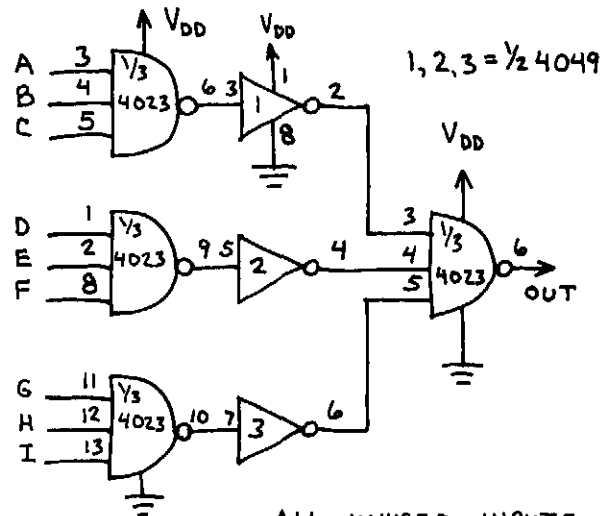


6-INPUT OR GATE



IMPORTANT: CONNECT ALL UNUSED
INPUTS TO PIN 7 OR 14.

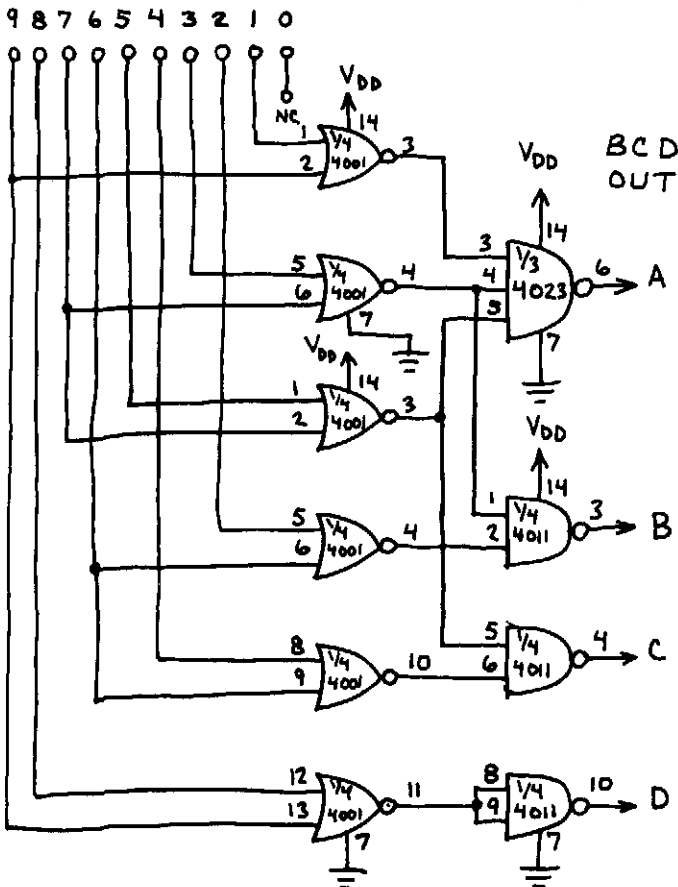
9-INPUT NAND GATE



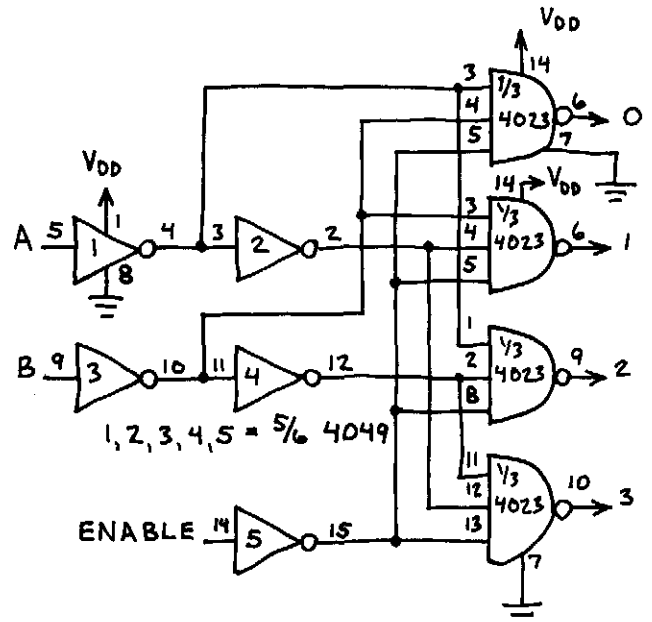
ALL UNUSED INPUTS
MUST BE GROUNDED.

DECIMAL-TO-BCD CONVERTER

DECIMAL IN (SELECTED DIGIT H,
ALL OTHERS L.)

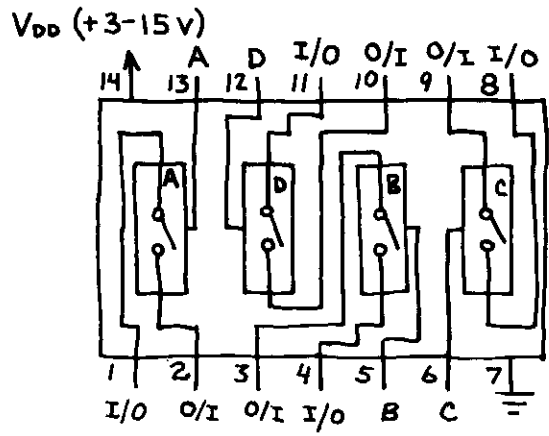


1-OF-4 DECODER

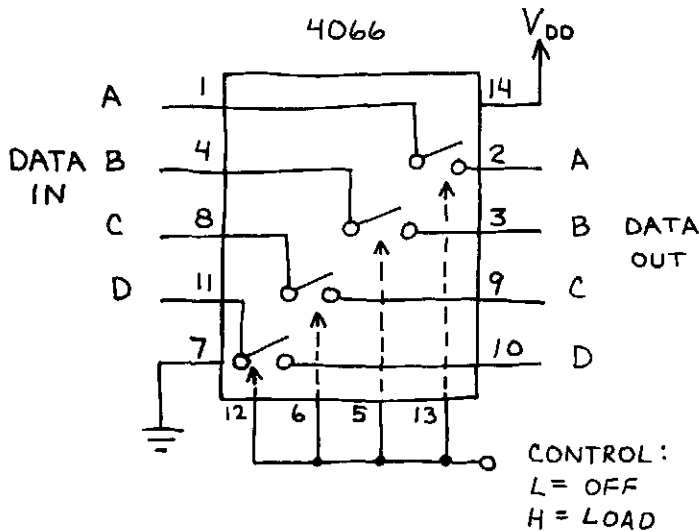


QUAD BILATERAL SWITCH 4066

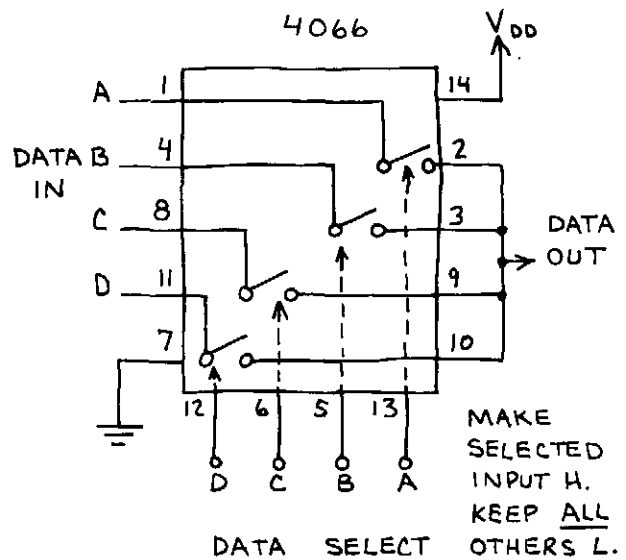
ONE OF THE MOST VERSATILE CMOS CHIPS. PINS A, B, C AND D CONTROL FOUR ANALOG SWITCHES. CLOSE A SWITCH BY CONNECTING ITS CONTROL PIN TO V_{DD} . ON RESISTANCE = 80-250 OHMS. OPEN A SWITCH BY CONNECTING ITS CONTROL PIN TO GROUND (PIN 7). OFF RESISTANCE = 10^9 OHMS. I/O (INPUT/OUTPUT) AND O/I PINS ARE REVERSIBLE.



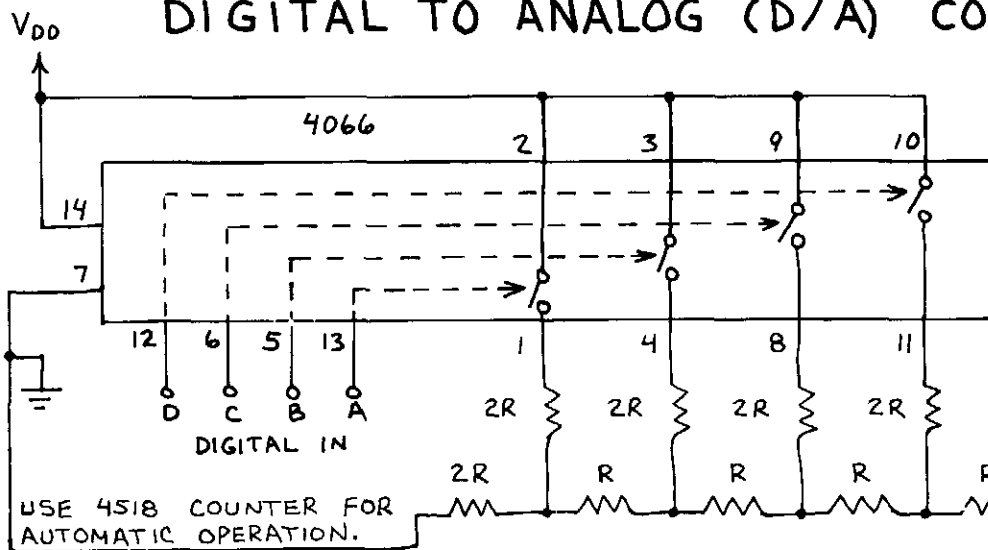
DATA BUS CONTROL



DATA SELECTOR



DIGITAL TO ANALOG (D/A) CONVERTER

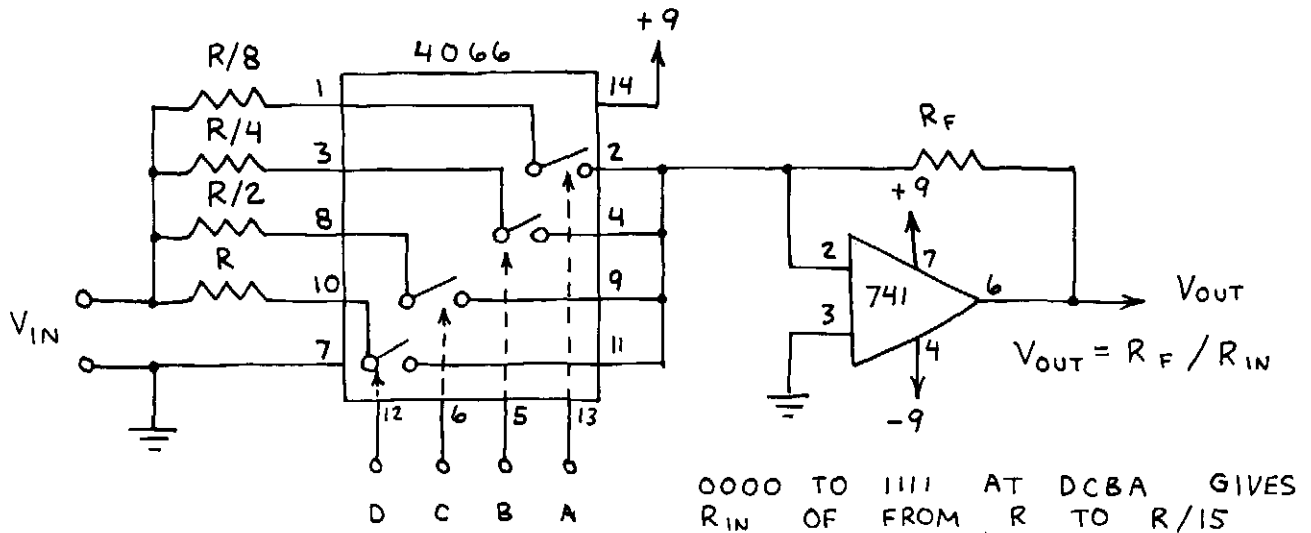


THIS IS NOT A LINEAR D/A CONVERTER. INSTEAD IT PRODUCES A PSEUDO-RANDOM OUTPUT THAT RANGES FROM 3.06 - 5.62 VOLTS ($V_{DD} = 9V$). USE TO DRIVE 4046 VCO OR PRODUCE UNUSUAL WAVEFORMS. $R = 47K$ AND $2R = 100K$.

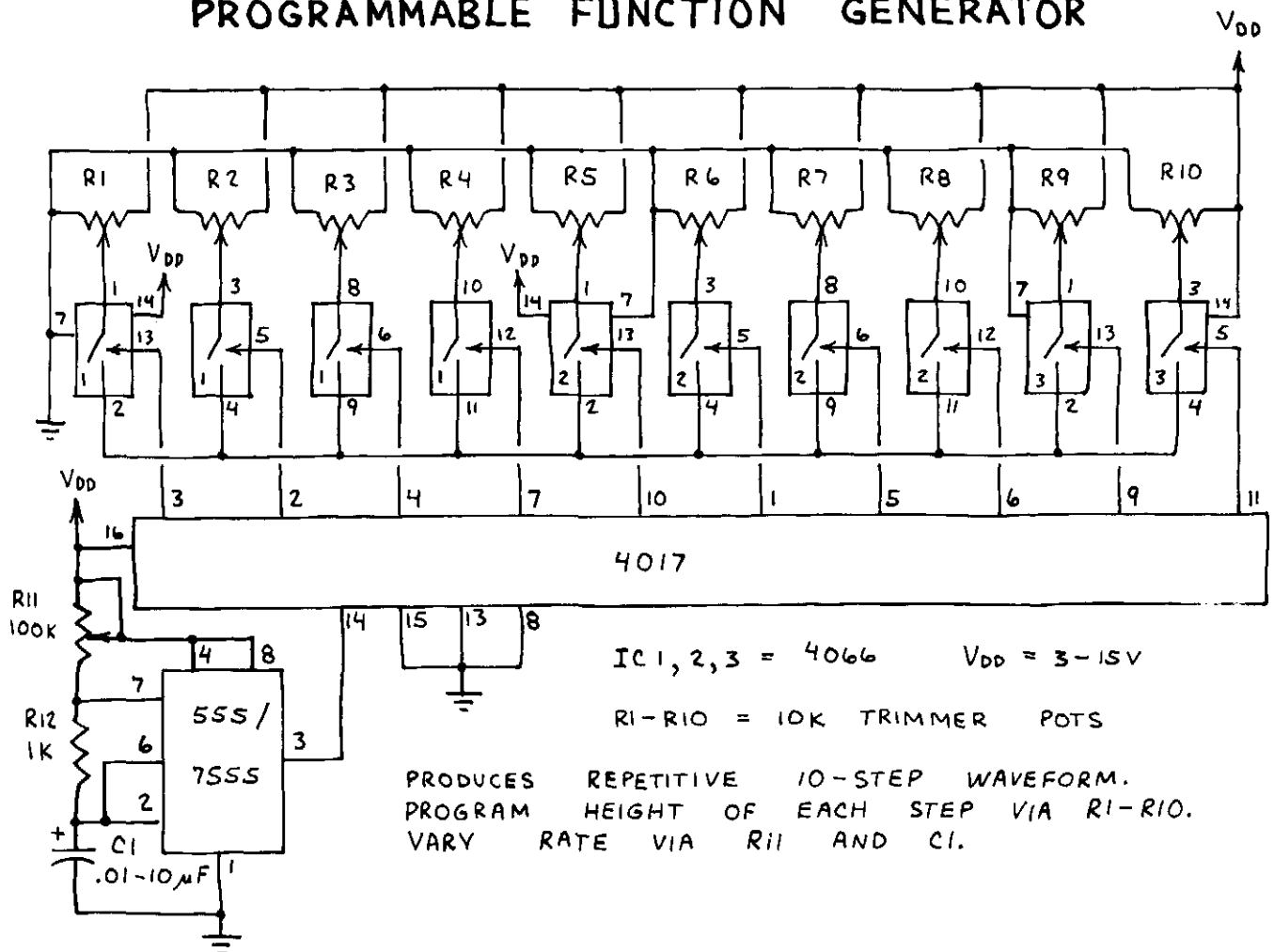
QUAD BILATERAL SWITCH (CONTINUED)

4066

PROGRAMMABLE GAIN AMPLIFIER



PROGRAMMABLE FUNCTION GENERATOR



1024-BIT STATIC RAM

2102L

1024 1-BIT STORAGE LOCATIONS ADDRESSED BY PINS A0-A9. TTL/LS COMPATIBLE. CE (CHIP ENABLE) INPUT CONTROLS R/W (READ/WRITE) OPERATIONS). 3-STATE OUTPUTS.

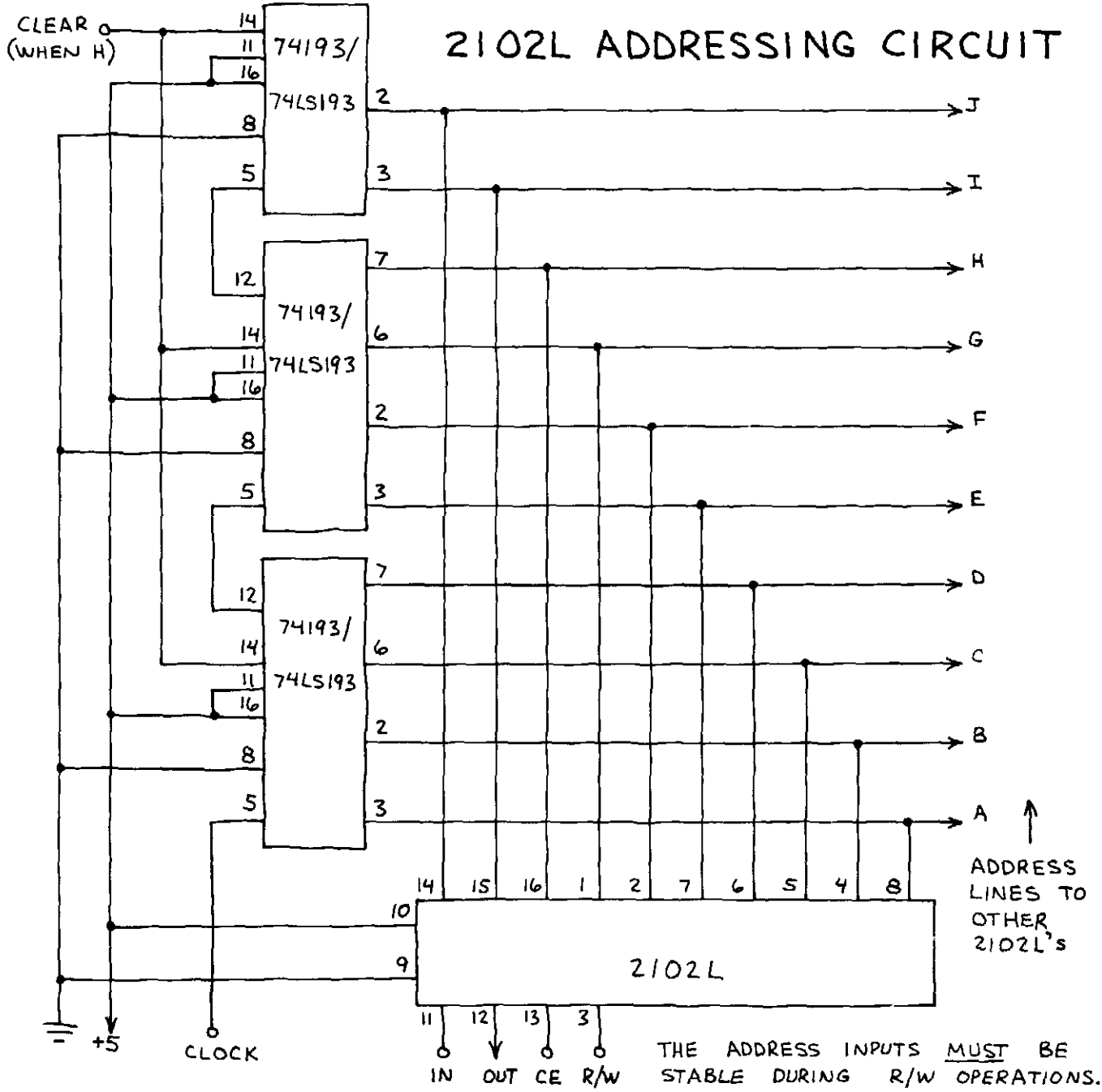
A7 A8 A9 CE OUT IN +5 GND
16 15 14 13 12 11 10 9

NOTE UNUSUAL LOCATION OF POWER SUPPLY PINS.
(A0-A9: ADDRESS INPUTS)

CE	R/W	OPERATION
L	L	WRITE (LOADS BIT AT PIN 11)
L	H	READ (OUTPUTS BIT AT PIN 12)
H	X	HI Z (OUTPUT ENTERS THIRD STATE)

1 2 3 4 5 6 7 8
A6 A5 R/W A1 A2 A3 A4 A0

2102L ADDRESSING CIRCUIT



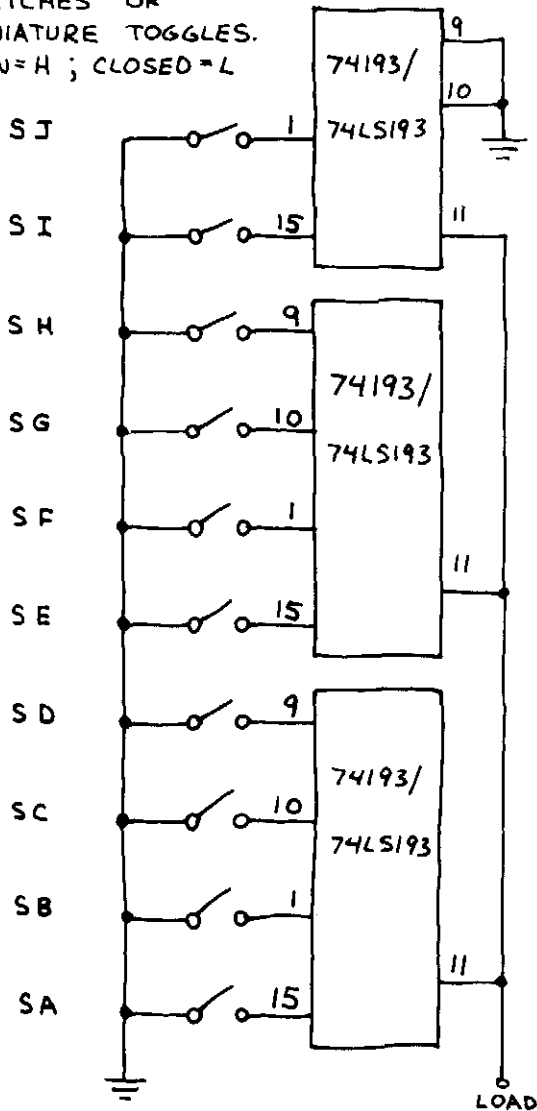
1024-BIT STATIC RAM (CONTINUED)

2102L

ADDING PROGRAMMED OR MANUAL JUMP

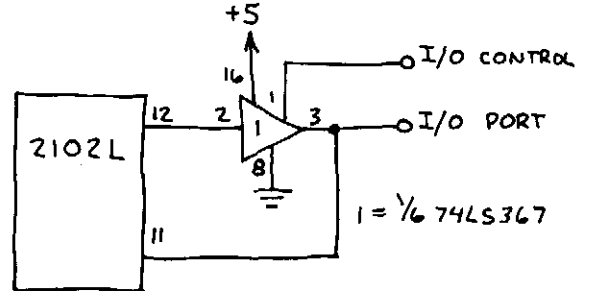
ADD THESE CONNECTIONS TO THE ADDRESSING CIRCUIT ON FACING PAGE.

SA-SJ: USE 8-POSITION DIP SWITCHES OR MINIATURE TOGGLES. OPEN=H; CLOSED=L



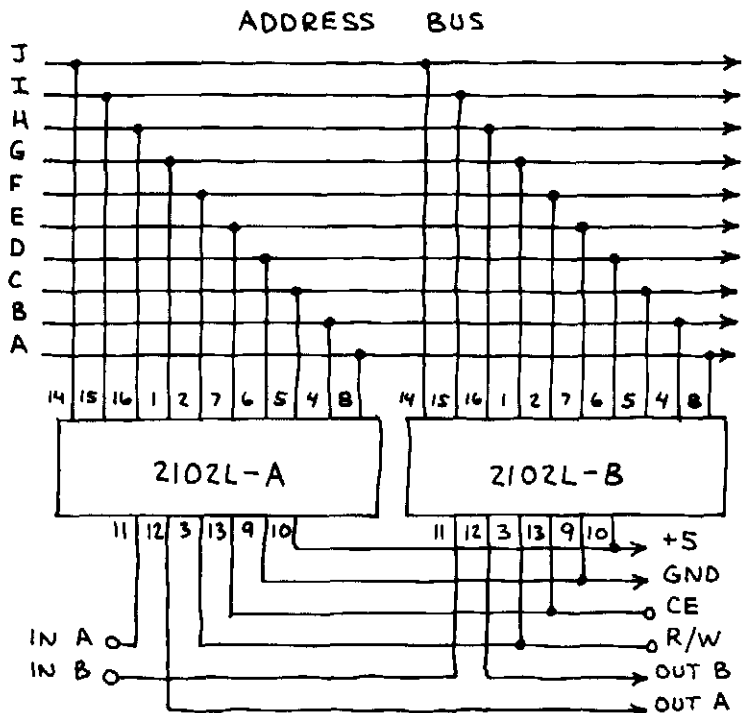
NORMALLY THE LOAD INPUT IS HIGH. MAKING LOAD LOW LOADS THE ADDRESS PROGRAMMED IN SWITCHES SA-SJ INTO THE 74193'S. THIS PERMITS A PROGRAMMED JUMP OR A MANUAL JUMP TO ANY ADDRESS.

SINGLE I/O PORT



ADD THIS CIRCUIT TO THE ADDRESSING CIRCUIT ON FACING PAGE. WHEN I/O (INPUT/OUTPUT) CONTROL IS H, PIN 3 OF THE 74LS367 ENTERS THIRD STATE (HI-Z) AND I/O PORT ACCEPTS INPUT DATA. WHEN PIN 3 OF THE 74LS367 IS L, I/O PORT OUTPUTS DATA. BOTH THESE OPERATIONS ARE DEPENDENT UPON THE STATUS OF THE 2102L CONTROL INPUTS.

CASCADING 2102L'S

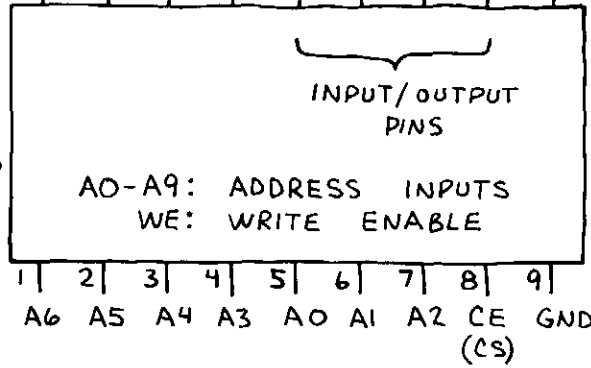


1024 x 4-BIT RAM

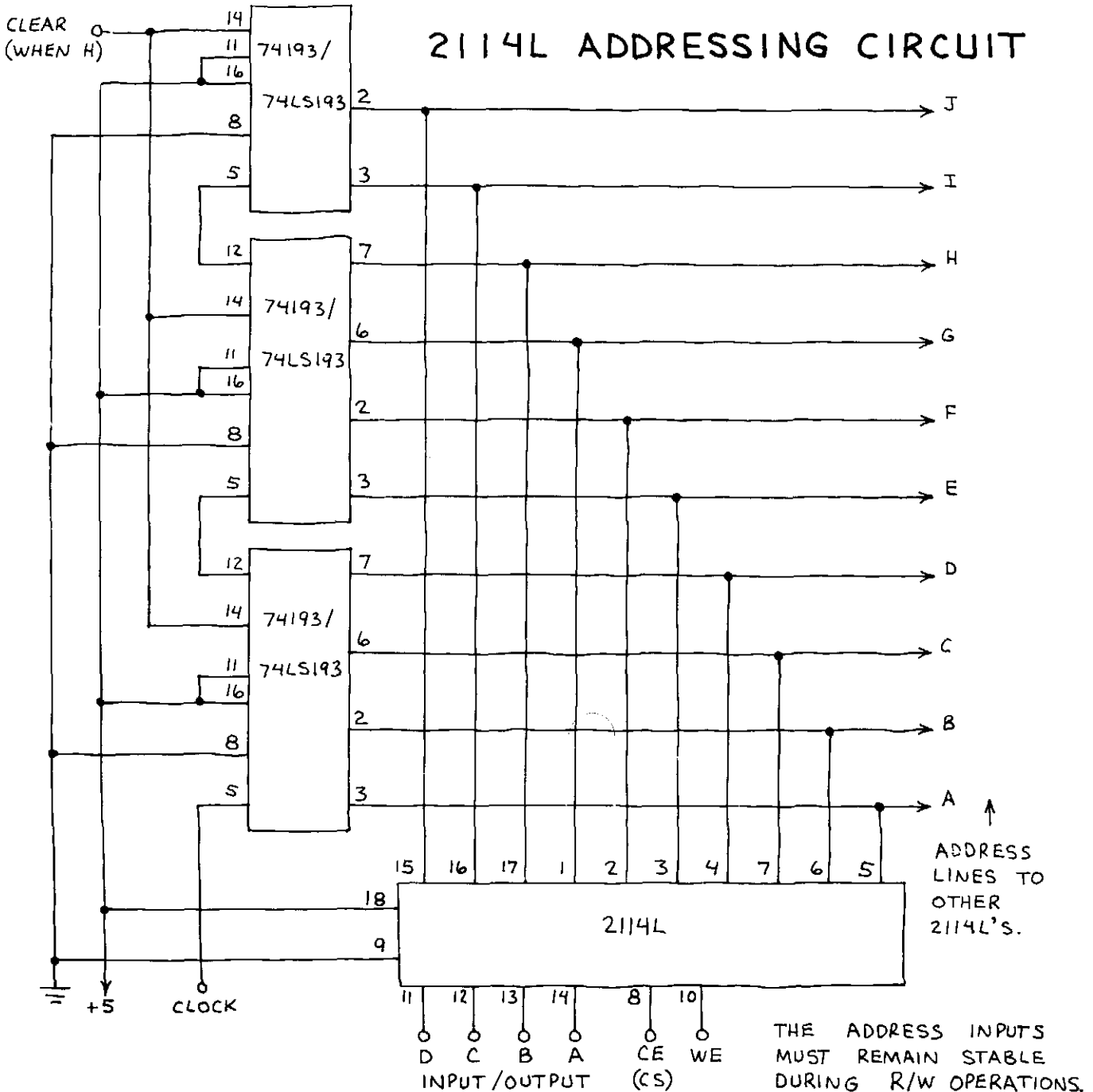
2114L / 4045

1024-4-BIT STORAGE LOCATIONS ADDRESSED BY PINS AO-A9. TTL/LS COMPATIBLE. FOR READ/WRITE OPERATIONS, CE (CHIP ENABLE, ALSO CALLED CHIP SELECT) MUST BE LOW. WE INPUT MUST BE LOW TO WRITE (LOAD) DATA INTO CHIP. WHEN WE IS HIGH, DATA IN ADDRESSED LOCATION APPEARS AT INPUT/OUTPUT PINS. IDEAL CHIP FOR DO-IT-YOURSELF MICROCOMPUTERS AND CONTROLLERS.

+5 A7 AB A9 A B C D WE
18| 17| 16| 15| 14| 13| 12| 11| 10|



2114L ADDRESSING CIRCUIT



1024 x 4-BIT RAM (CONTINUED)

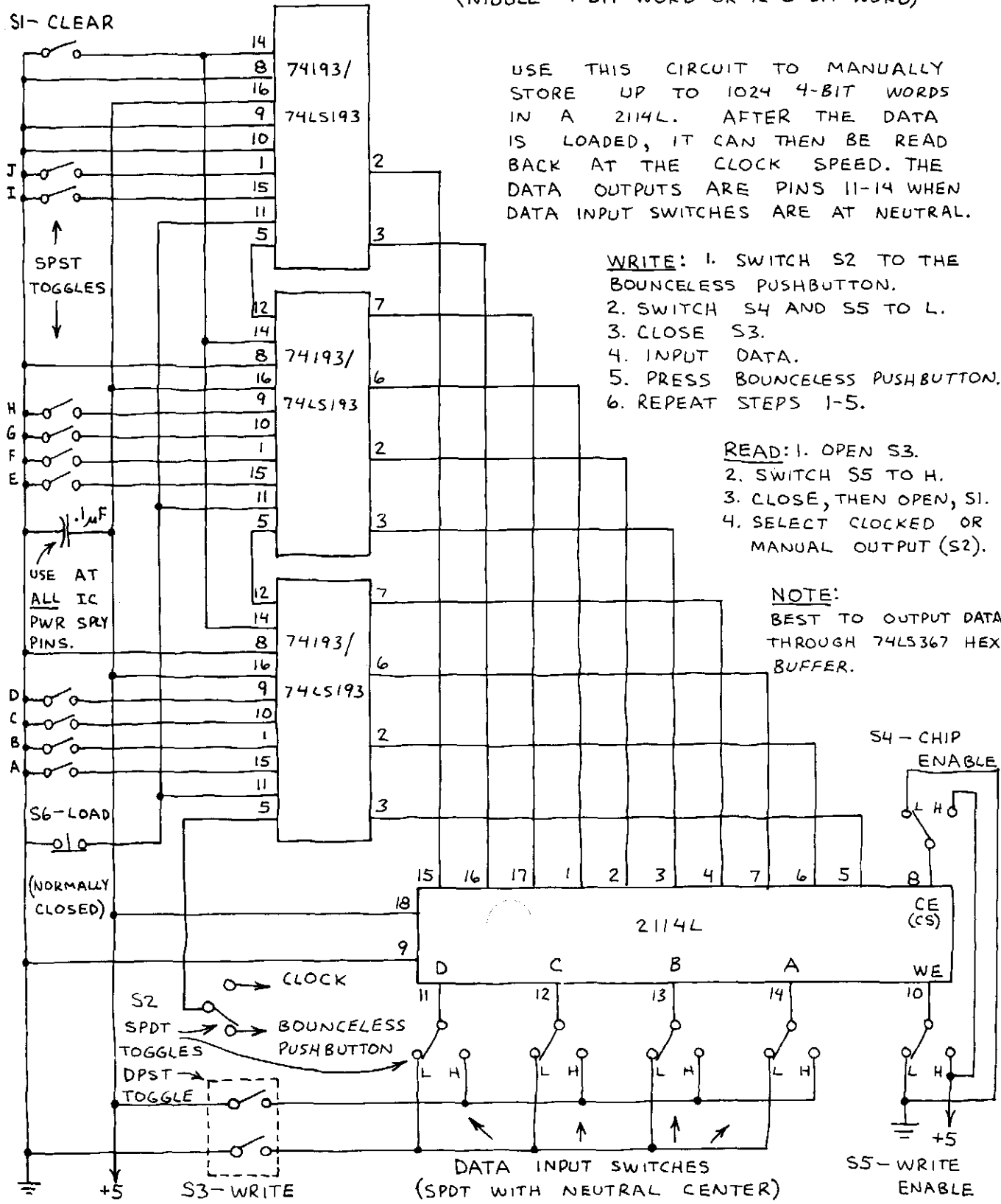
2114L/4045

1024-NIBBLE

DATA LOADING CIRCUIT

MANUAL JUMP: 1. SET SWITCHES A-J TO DESIRED ADDRESS; 2. PRESS S6.

(NIBBLE = 4-BIT WORD OR 1/2 8-BIT WORD)



USE THIS CIRCUIT TO MANUALLY STORE UP TO 1024 4-BIT WORDS IN A 2114L. AFTER THE DATA IS LOADED, IT CAN THEN BE READ BACK AT THE CLOCK SPEED. THE DATA OUTPUTS ARE PINS 11-14 WHEN DATA INPUT SWITCHES ARE AT NEUTRAL.

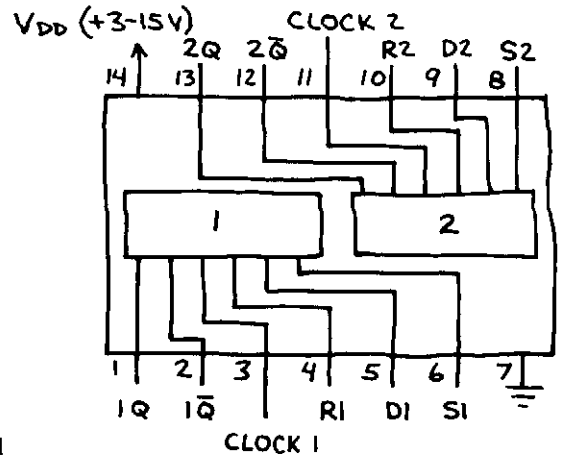
- WRITE:**
1. SWITCH S2 TO THE BOUNCELESS PUSHBUTTON.
 2. SWITCH S4 AND S5 TO L.
 3. CLOSE S3.
 4. INPUT DATA.
 5. PRESS BOUNCELESS PUSHBUTTON.
 6. REPEAT STEPS 1-5.

- READ:**
1. OPEN S3.
 2. SWITCH S5 TO H.
 3. CLOSE, THEN OPEN, S1.
 4. SELECT CLOCKED OR MANUAL OUTPUT (S2).

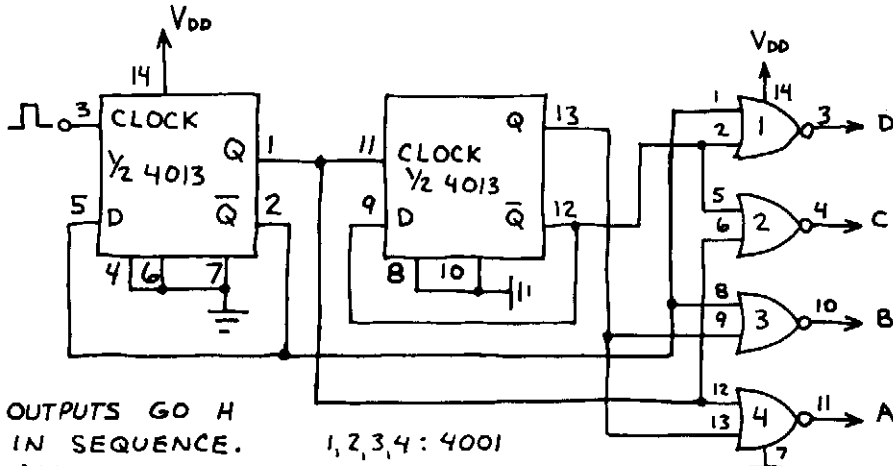
NOTE:
BEST TO OUTPUT DATA THROUGH 74LS367 HEX BUFFER.

DUAL D FLIP-FLOP 4013

VERY VERSATILE PAIR OF D-TYPE
FLIP-FLOPS. GROUND UNUSED INPUTS.



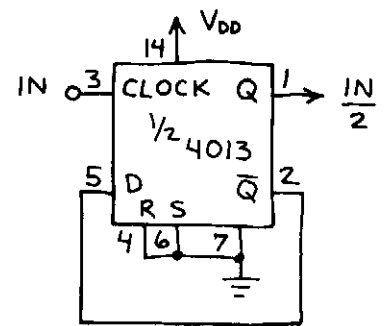
1-OF-4 SEQUENCER



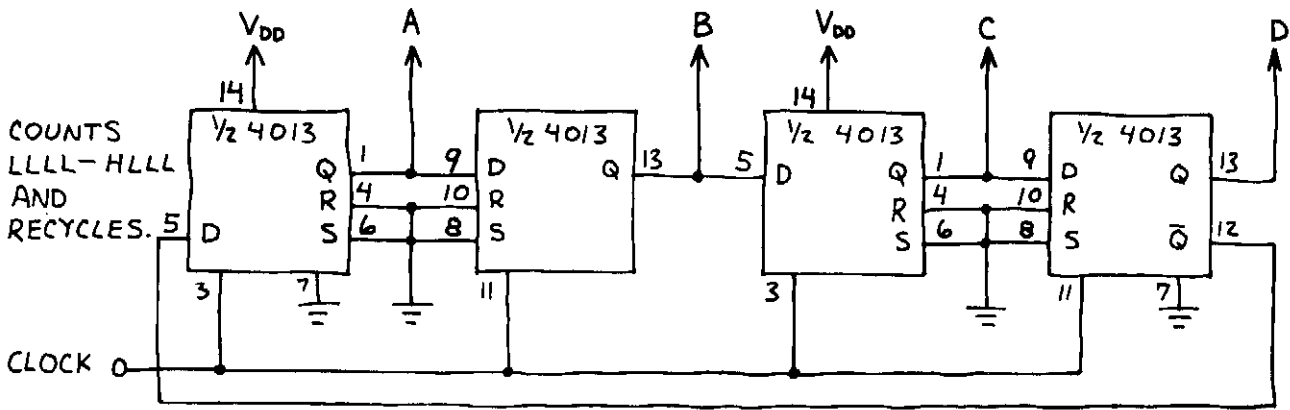
OUTPUTS GO H
IN SEQUENCE.
ALL OTHERS
STAY L.

1,2,3,4: 4001

DIVIDE-BY-2

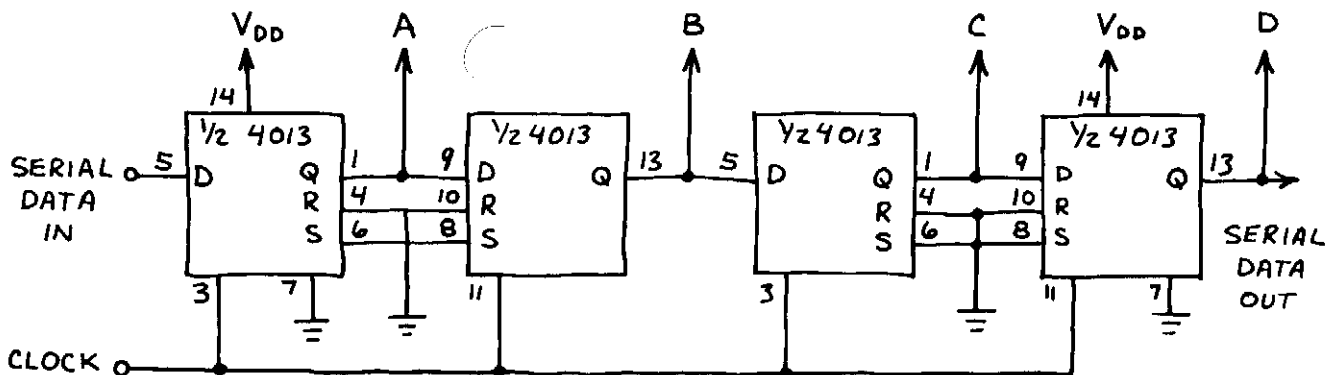


MODULO-8 COUNTER



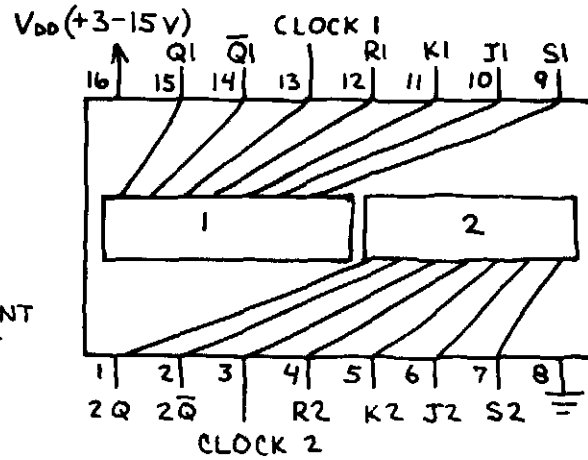
COUNTS
LLLL-HLLL
AND
RECYCLES.

SERIAL IN/OUT, PARALLEL OUT SHIFT REGISTER

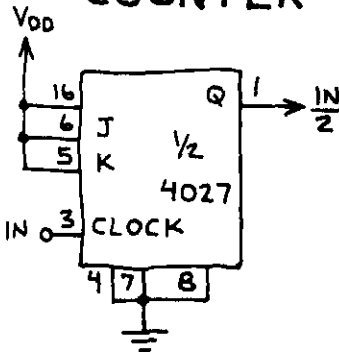


DUAL JK FLIP FLOP 4027

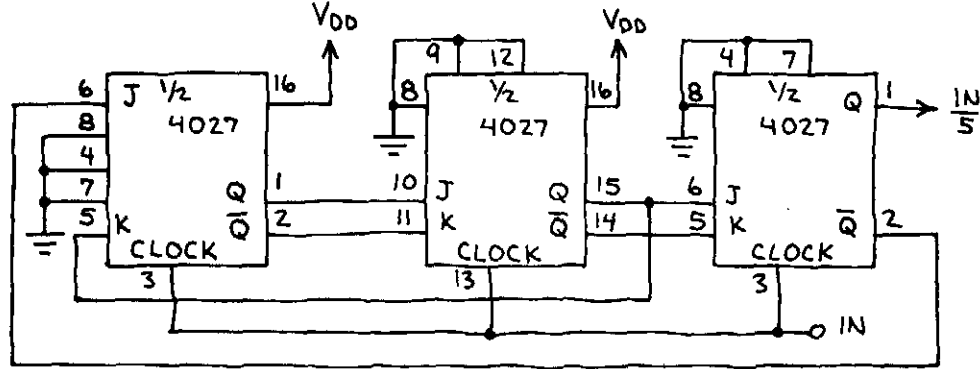
USE FOR DIVIDERS, COUNTERS AND REGISTERS. S (SET) AND R (RESET) INPUTS MUST BE LOW FOR CLOCKING TO OCCUR. MAKING S OR R HIGH SETS OR RESETS FLIP-FLOP INDEPENDENT OF CLOCK. IMPORTANT: ALL INPUTS MUST GO SOMEWHERE!



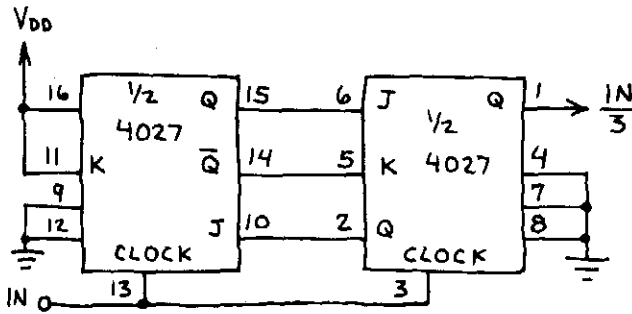
DIVIDE-BY-2 COUNTER



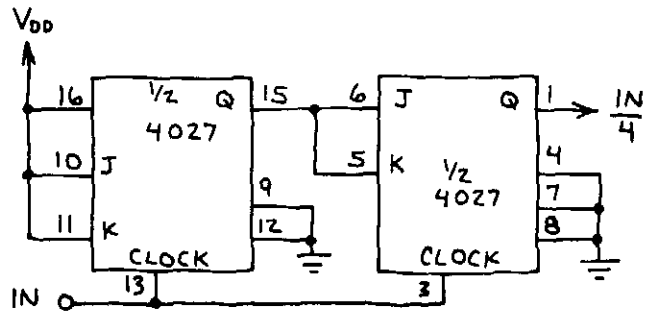
DIVIDE-BY-5 COUNTER



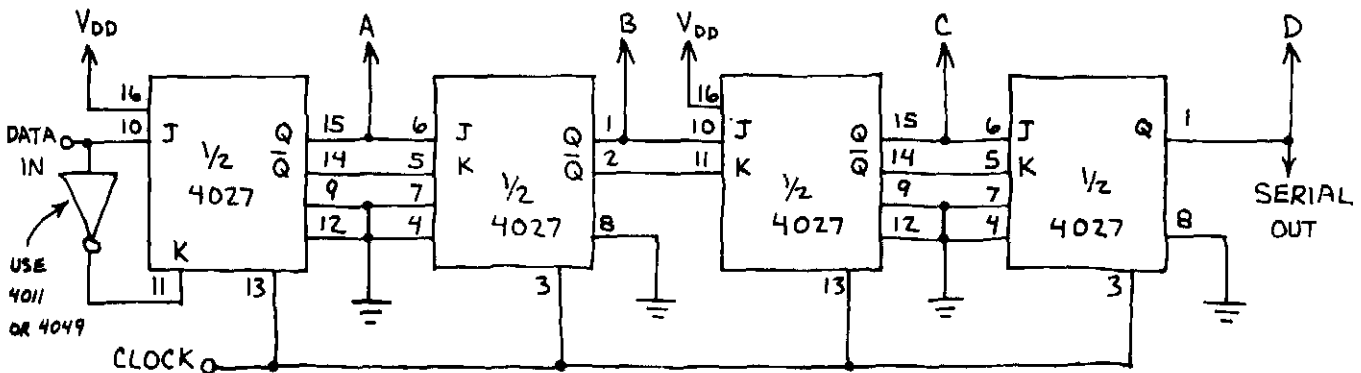
DIVIDE-BY-3 COUNTER



DIVIDE-BY-4 COUNTER

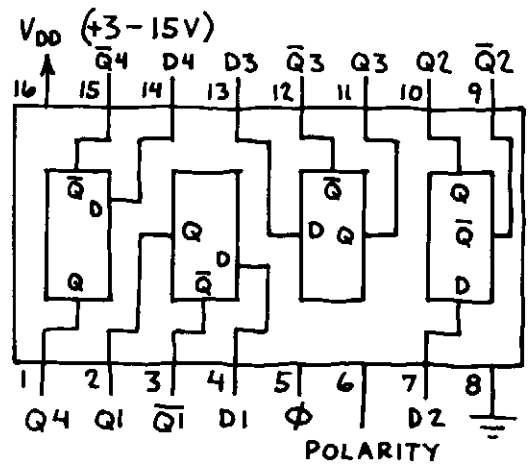


4-BIT SERIAL SHIFT REGISTER

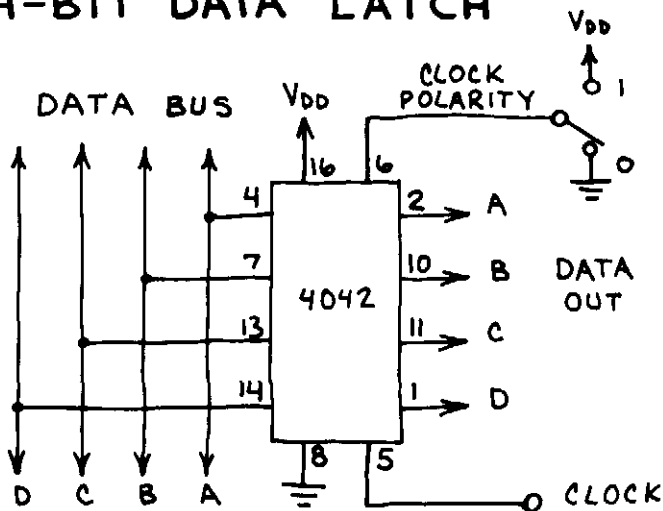


QUAD LATCH 4042

FOUR BISTABLE LATCHES.
CAN BE USED AS A
4-BIT DATA REGISTER.
ALL FOUR LATCHES ARE
CLOCKED SIMULTANEOUSLY.
POLARITY PIN PROVIDES
CLOCKING FLEXIBILITY.



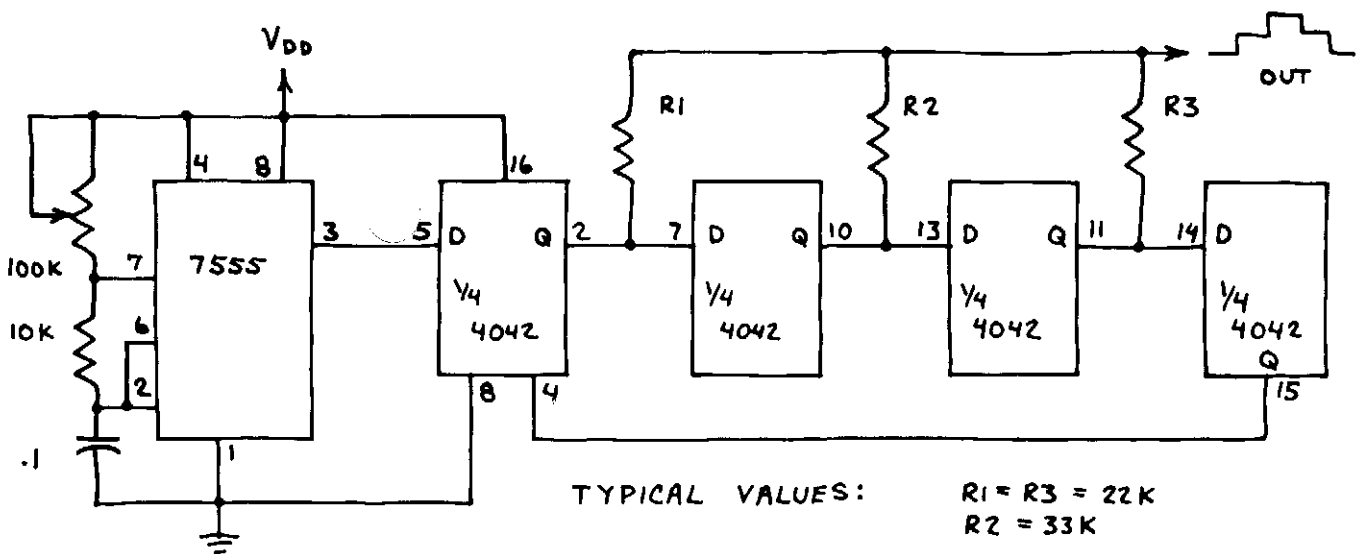
4-BIT DATA LATCH



CLOCK	POLARITY	Q
0	0	D
1	0	LATCH
0	1	D
1	1	LATCH

DATA ON BUS APPEARS
AT OUTPUTS. DATA
IS LATCHED (SAVED)
WHEN CLOCK SWITCHES.

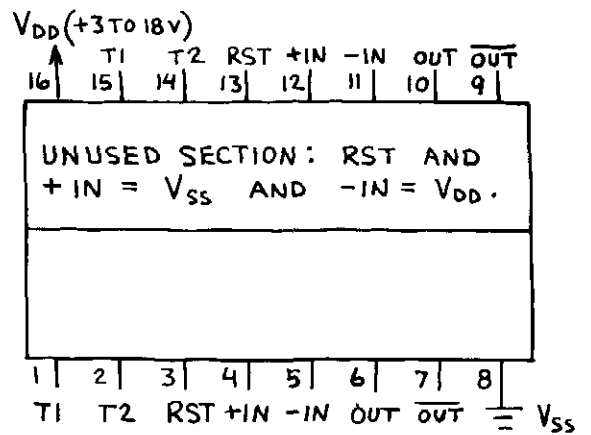
STEPPED WAVE GENERATOR



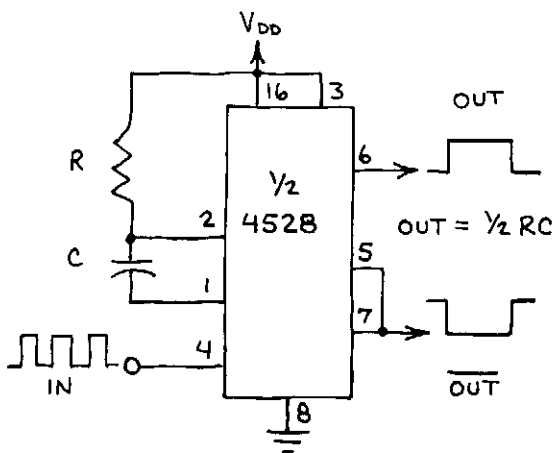
TYPICAL VALUES: $R_1 = R_3 = 22K$
 $R_2 = 33K$

DUAL ONE-SHOT 4528

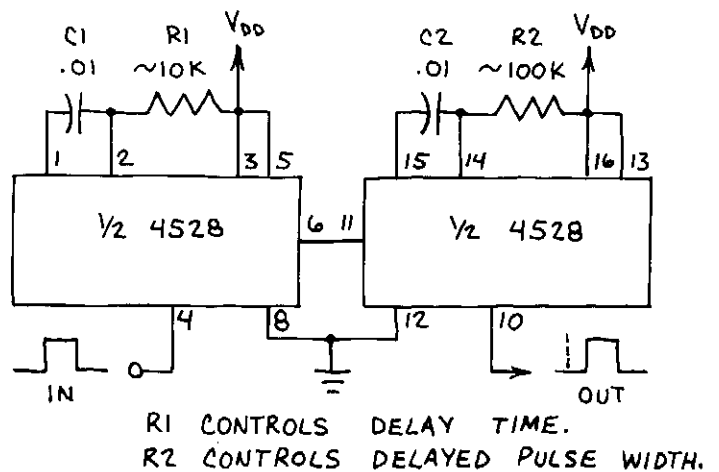
TWO FULLY INDEPENDENT MONOSTABLE MULTIVIBRATORS. BOTH CAN BE RETRIGGERED. TRIGGER CAN BE RISING OR FALLING EDGE OF PULSE. T1 AND T2 ARE TIMING INPUTS. RST IS RESET AND $\pm IN$ ARE TRIGGER INPUTS.



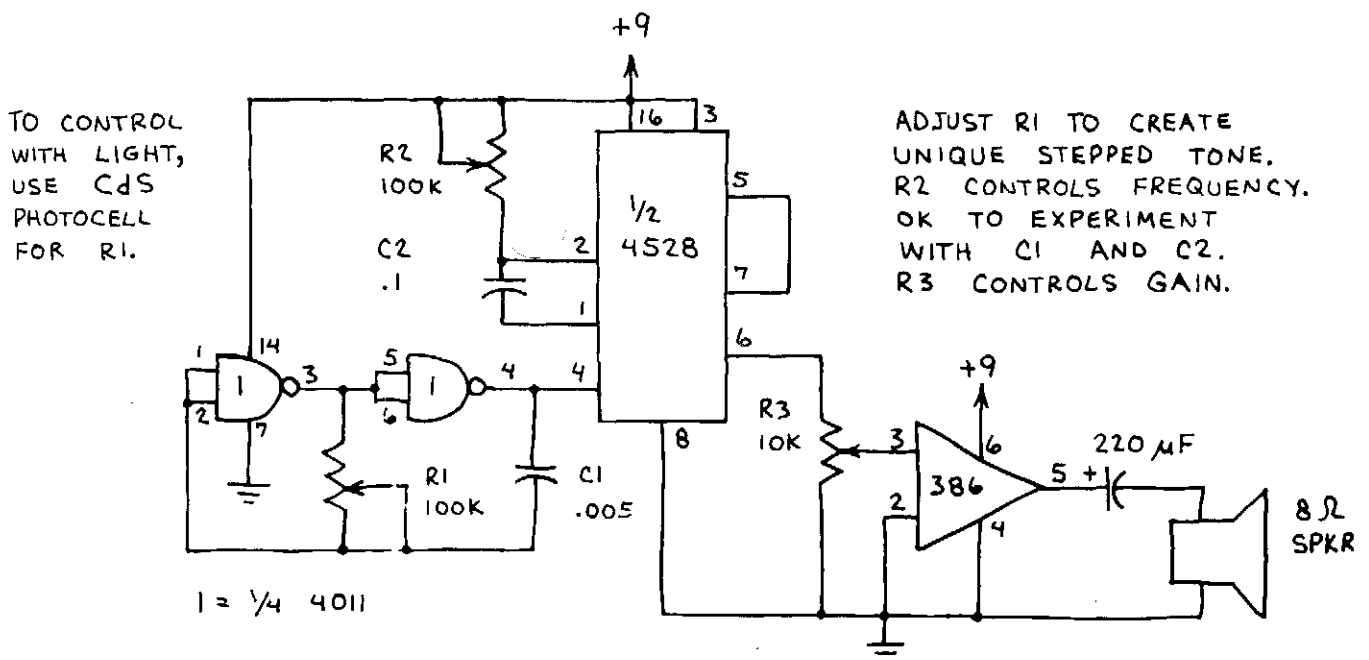
POSITIVE ONE-SHOT



PULSE DELAYER

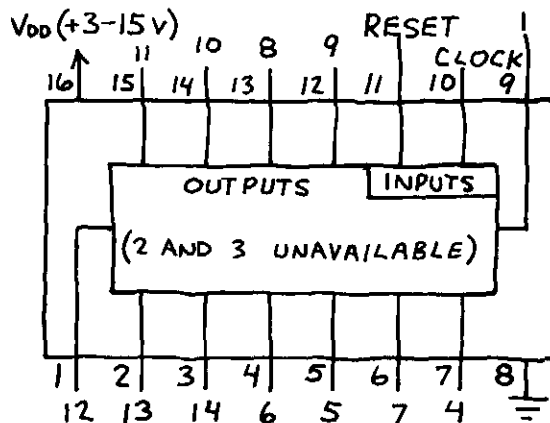


STEPPED TONE GENERATOR



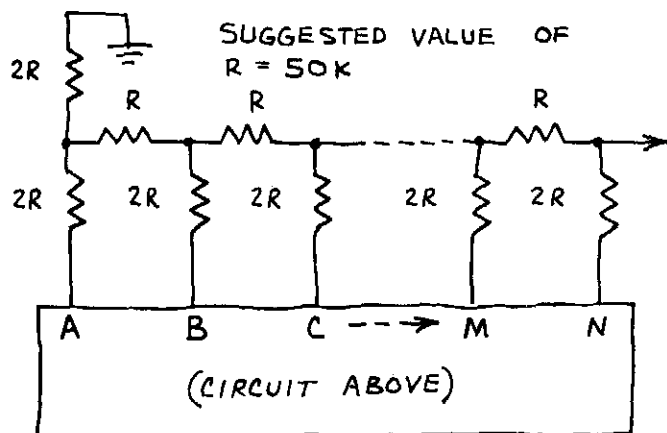
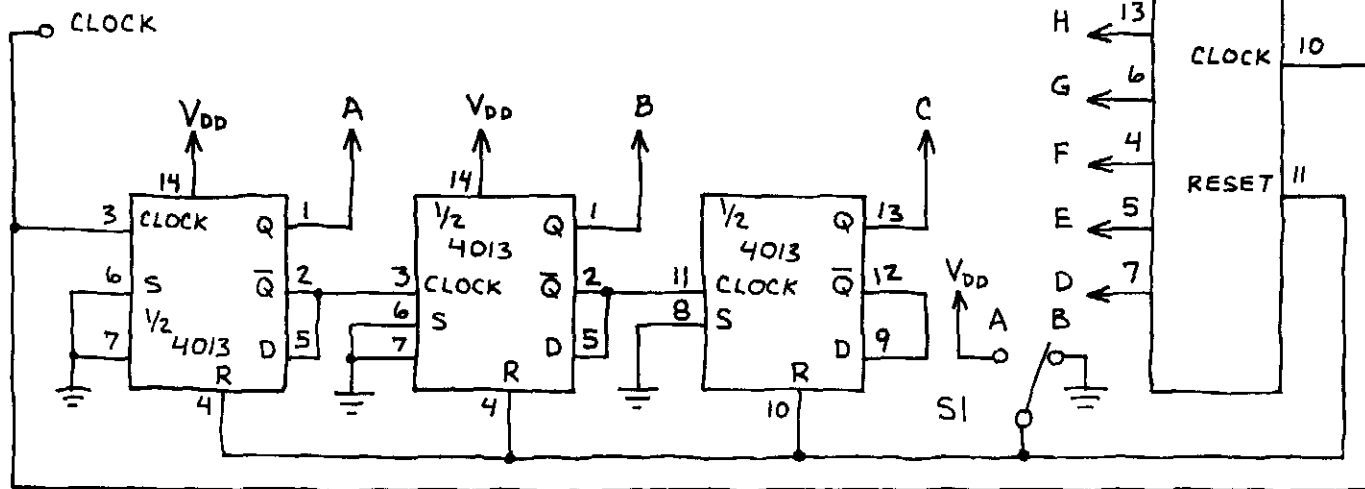
14-STAGE BINARY COUNTER 4020

A RIPPLE COUNTER WITH CARRY OUTPUT. THE 14-STAGE BINARY COUNT IS COMPLETED IN 16,384 CLOCK PULSES. THIS MAKES POSSIBLE VERY LONG DURATION TIMERS, ASSUMING THE OUTPUTS ARE DECODED. THE OUTPUTS REQUIRE A BRIEF SETTLING TIME AFTER EACH CLOCK PULSE.

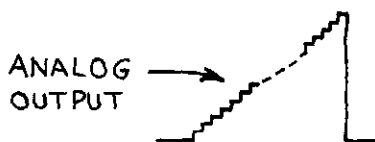


14-BIT BINARY COUNTER

THE SECOND AND THIRD OUTPUTS ($\div 4$ AND $\div 8$) OF THE 4020 ARE NOT AVAILABLE. THIS CIRCUIT INCLUDES A 3-BIT COUNTER TO SUPPLY THE MISSING OUTPUTS. A IS THE LOWEST ORDER OUTPUT.



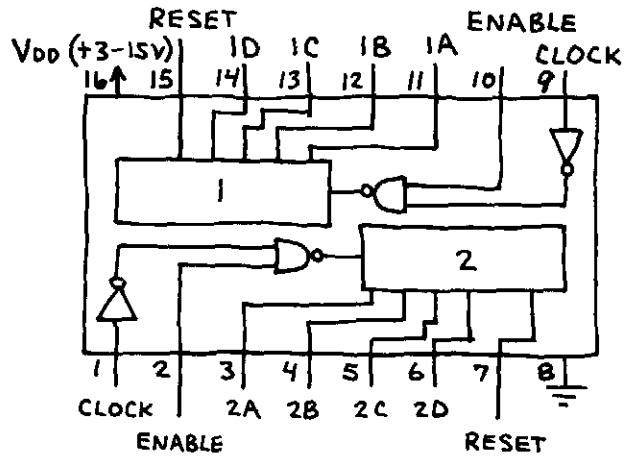
STAIRCASE GENERATOR



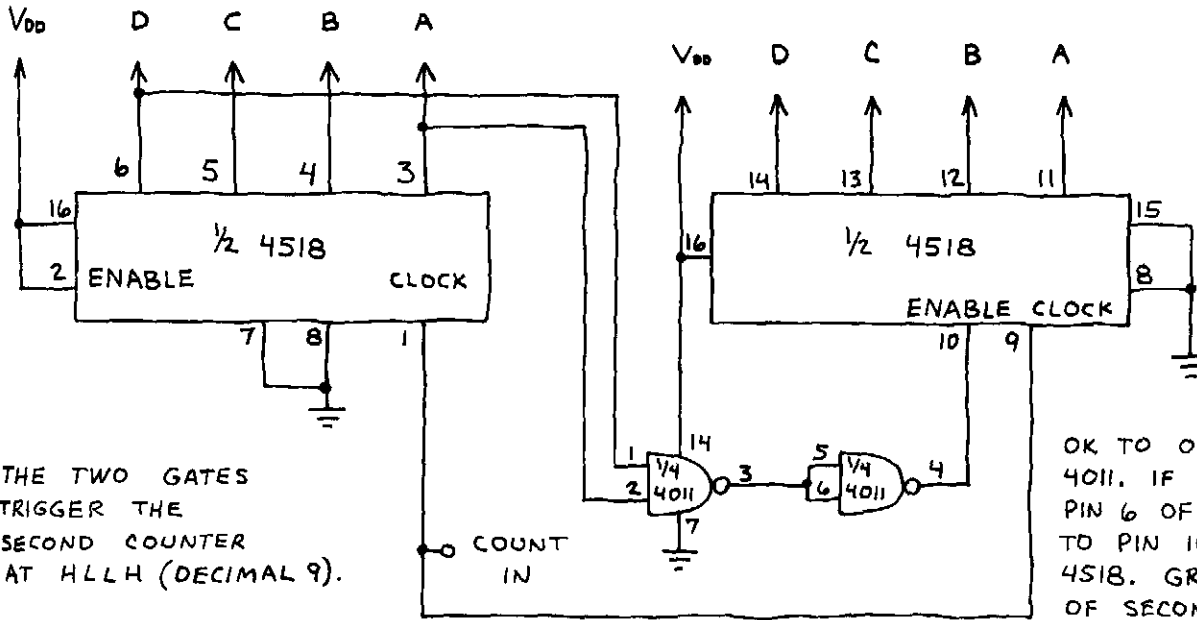
OUTPUT IS A STEPPED VOLTAGE. APPLICATIONS INCLUDE ANALOG-TO-DIGITAL CONVERSION AND WAVEFORM SYNTHESIS.

DUAL BCD COUNTER 4518

TWO SYNCHRONOUS DECADE COUNTERS IN ONE PACKAGE. WHEN ENABLE IS HIGH AND RESET IS LOW, EACH COUNTER ADVANCES ONE COUNT PER CLOCK PULSE.



CASCADED BCD COUNTERS



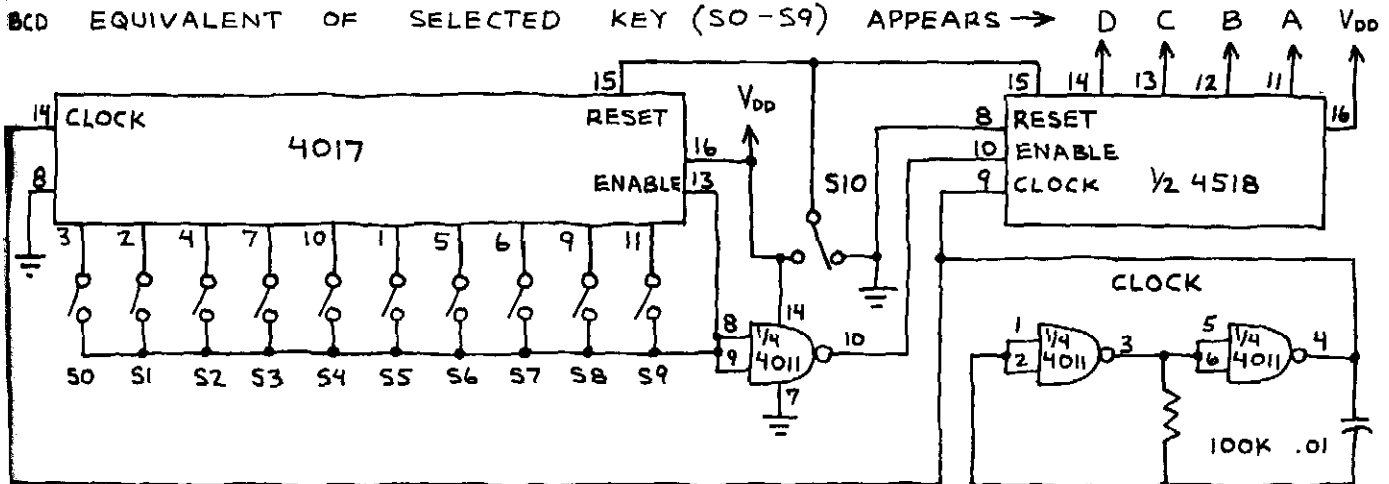
THE TWO GATES TRIGGER THE SECOND COUNTER AT HLLH (DECIMAL 9).

OK TO OMIT THE 4011. IF SO, CONNECT PIN 6 OF FIRST 4518 TO PIN 10 OF SECOND 4518. GROUND PIN 9 OF SECOND 4518 AND APPLY INPUT TO PIN 1 OF FIRST 4518.

BCD KEYBOARD ENCODER

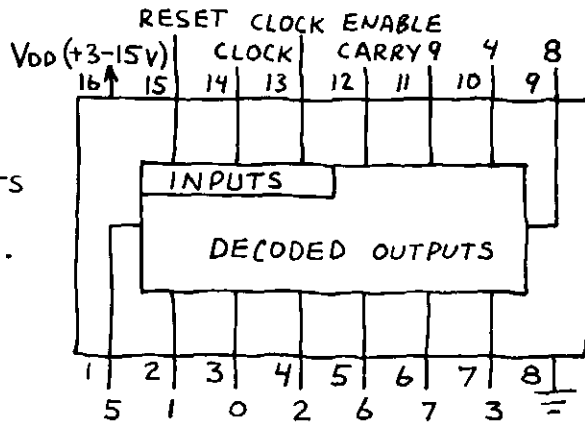
PRESS S0-S9, THEN TOGGLE RESET SWITCH S10 TO VDD AND BACK TO GROUND.

BCD EQUIVALENT OF SELECTED KEY (S0-S9) APPEARS →

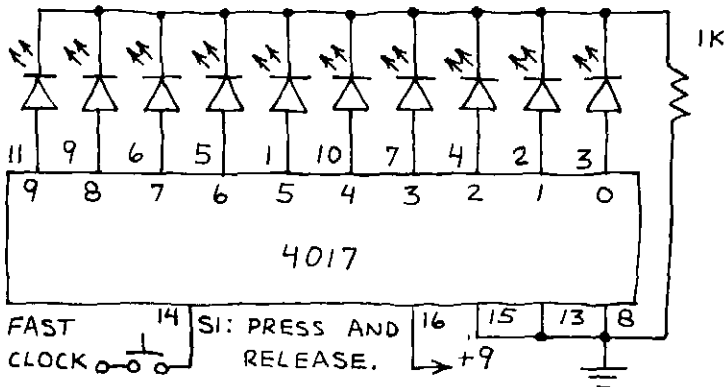


DECADE COUNTER/DIVIDER 4017

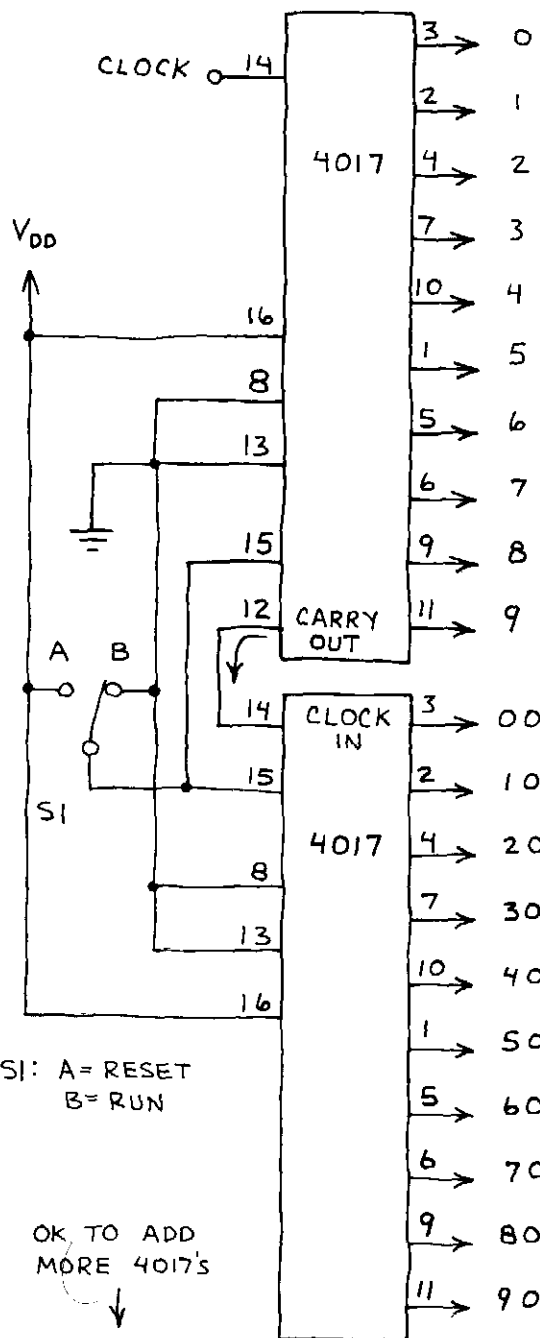
SEQUENTIALLY MAKES 1-OF-10 OUTPUTS HIGH (OTHERS STAY LOW) IN RESPONSE TO CLOCK PULSES. MANY APPLICATIONS. COUNT TAKES PLACE WHEN PINS 13 AND 15 ARE LOW.



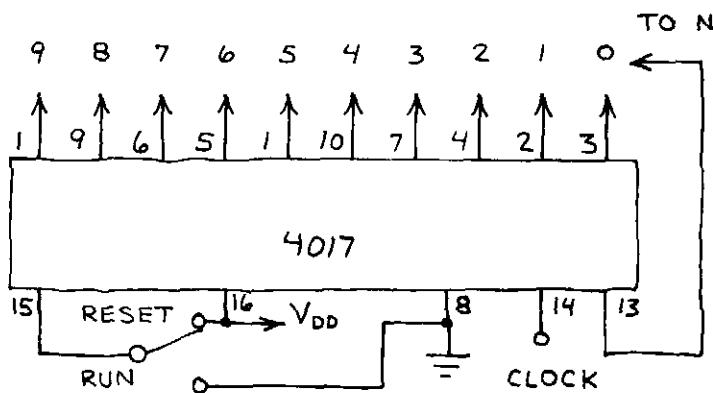
RANDOM NUMBER GENERATOR



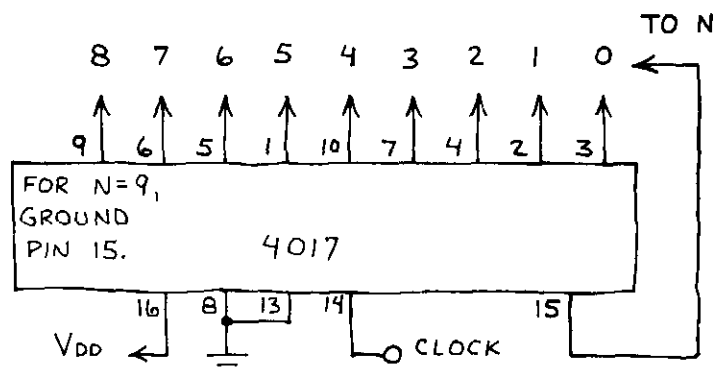
0-99 COUNTER



COUNT TO N AND HALT



COUNT TO N AND RECYCLE



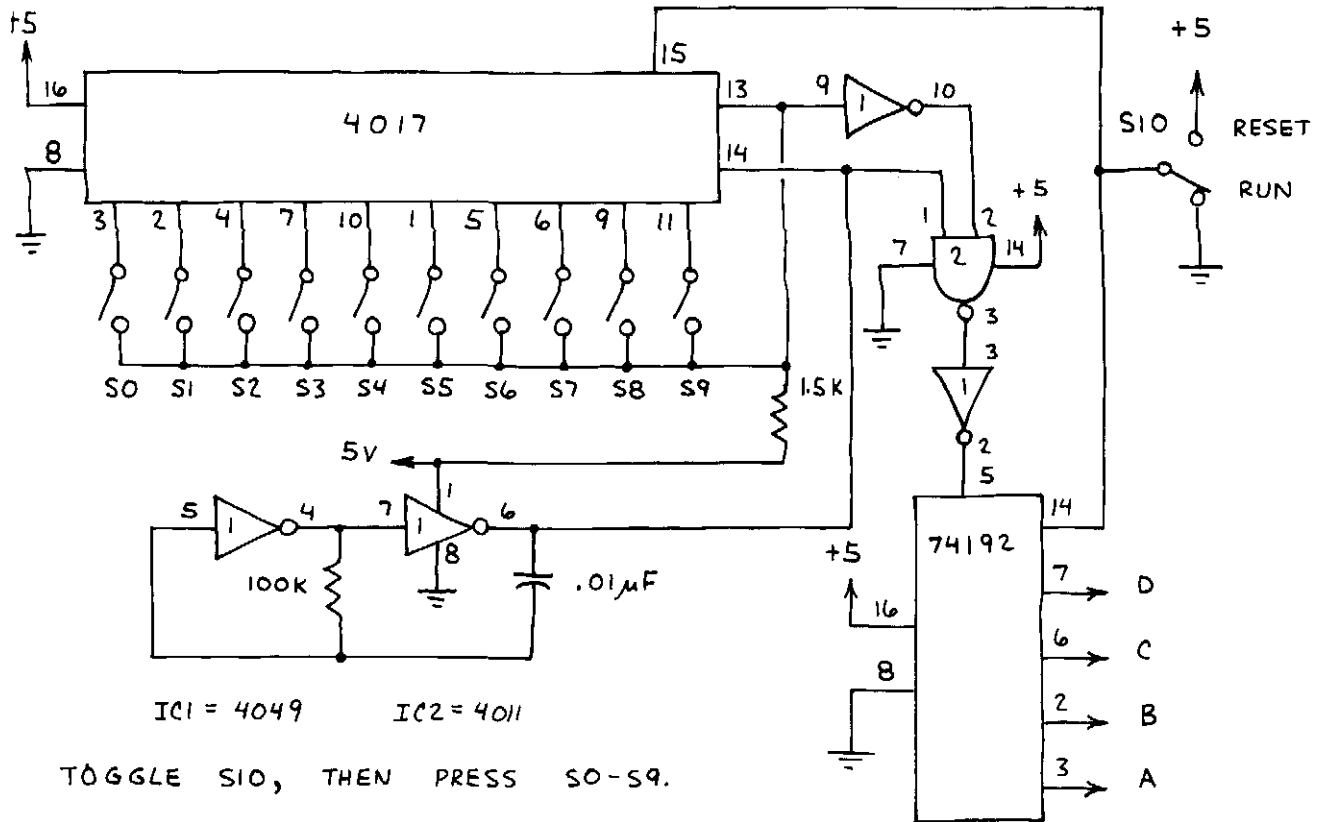
SI: A = RESET
B = RUN

OK TO ADD
MORE 4017'S

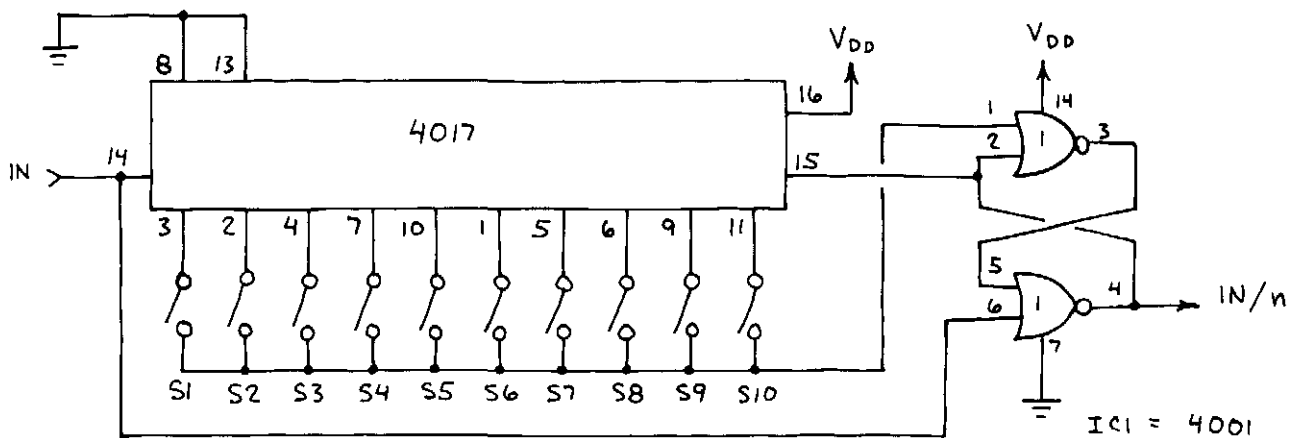
DECADE COUNTER/DIVIDER (CONTINUED)

4017

BCD KEYBOARD ENCODER



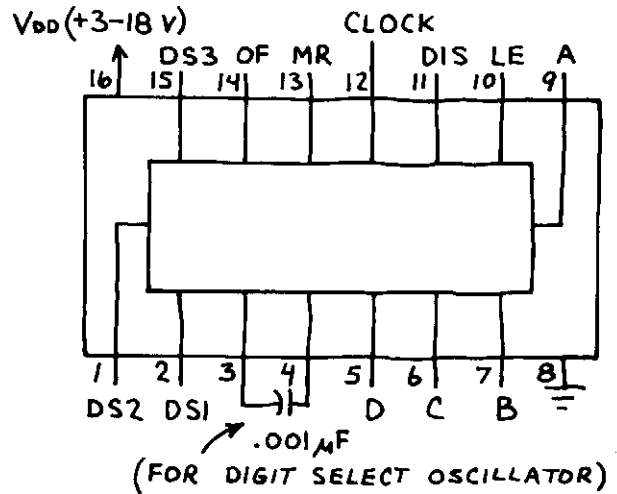
FREQUENCY DIVIDER



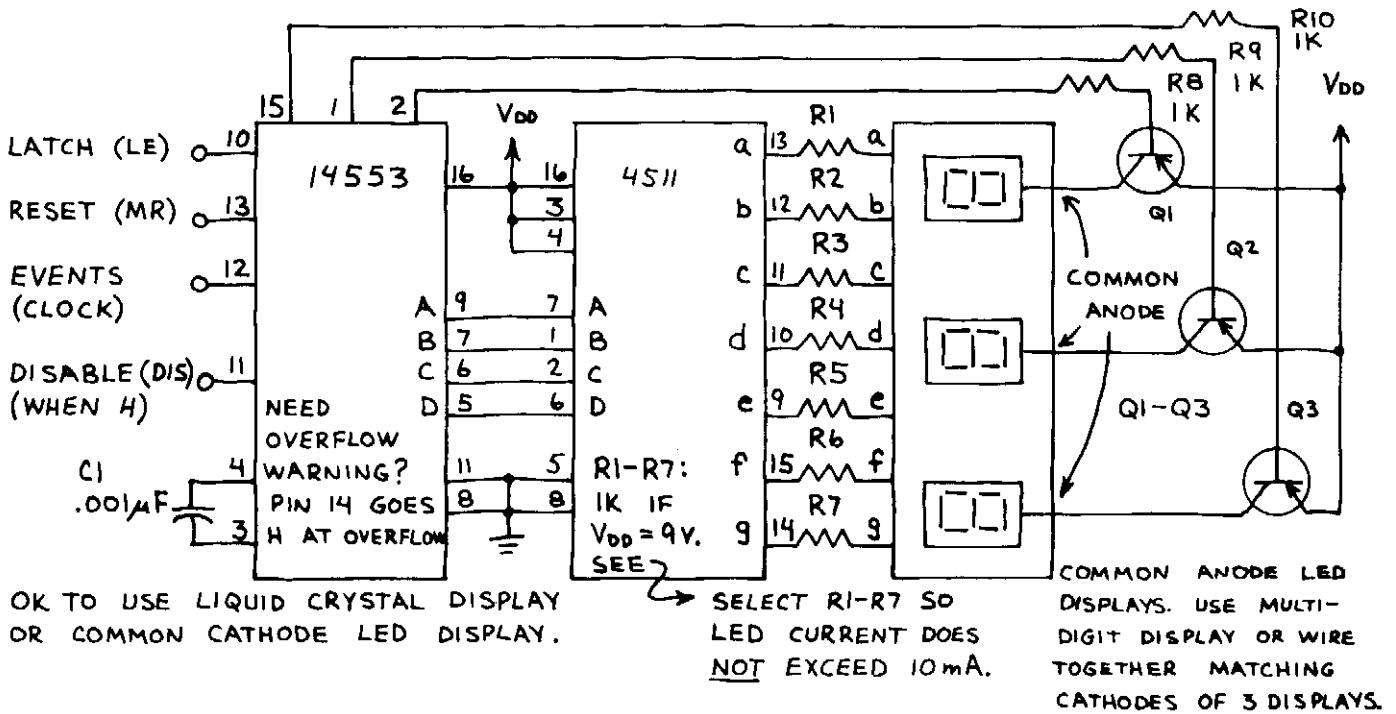
CLOSE S1-S10 TO DIVIDE
FREQUENCY BY FROM 1 TO 10.

3-DIGIT BCD COUNTER MC14553

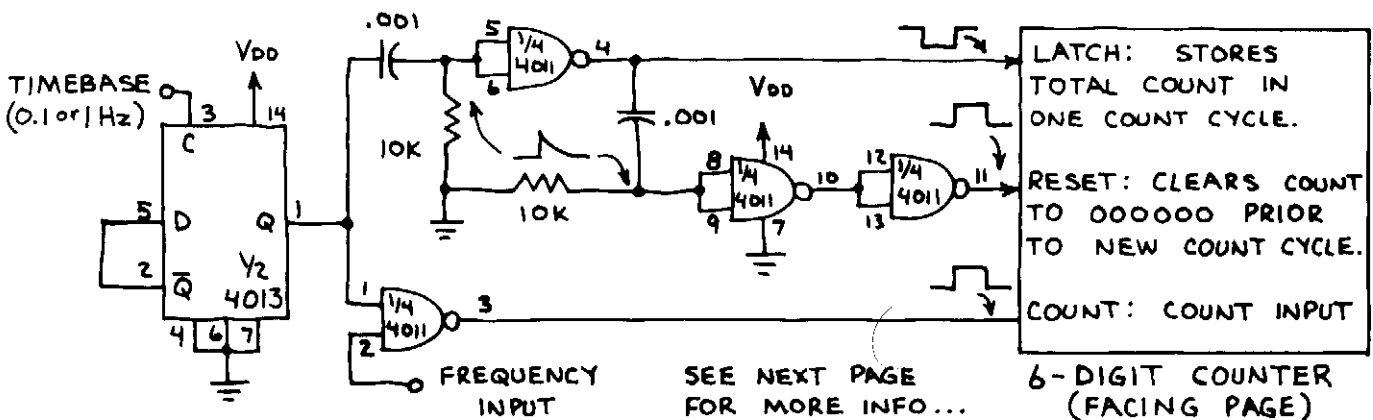
COMPLETE 3-DIGIT COUNTER. USE FOR DO-IT-YOURSELF EVENT AND FREQUENCY COUNTERS. BEGINNERS: GET SOME PRACTICAL CIRCUIT EXPERIENCE BEFORE USING THIS CHIP. PIN EXPLANATIONS: DS (DIGIT SELECT) 1,2,3—SEQUENTIALLY STROBES READOUTS. LE—LATCH ENABLE (WHEN H). DIS—INHIBITS INPUT WHEN H. CLOCK—INPUT. MR—MASTER RESET (WHEN H). OF—OVERFLOW. A, B, C, D—BCD OUTPUTS.



3-DIGIT EVENT COUNTER



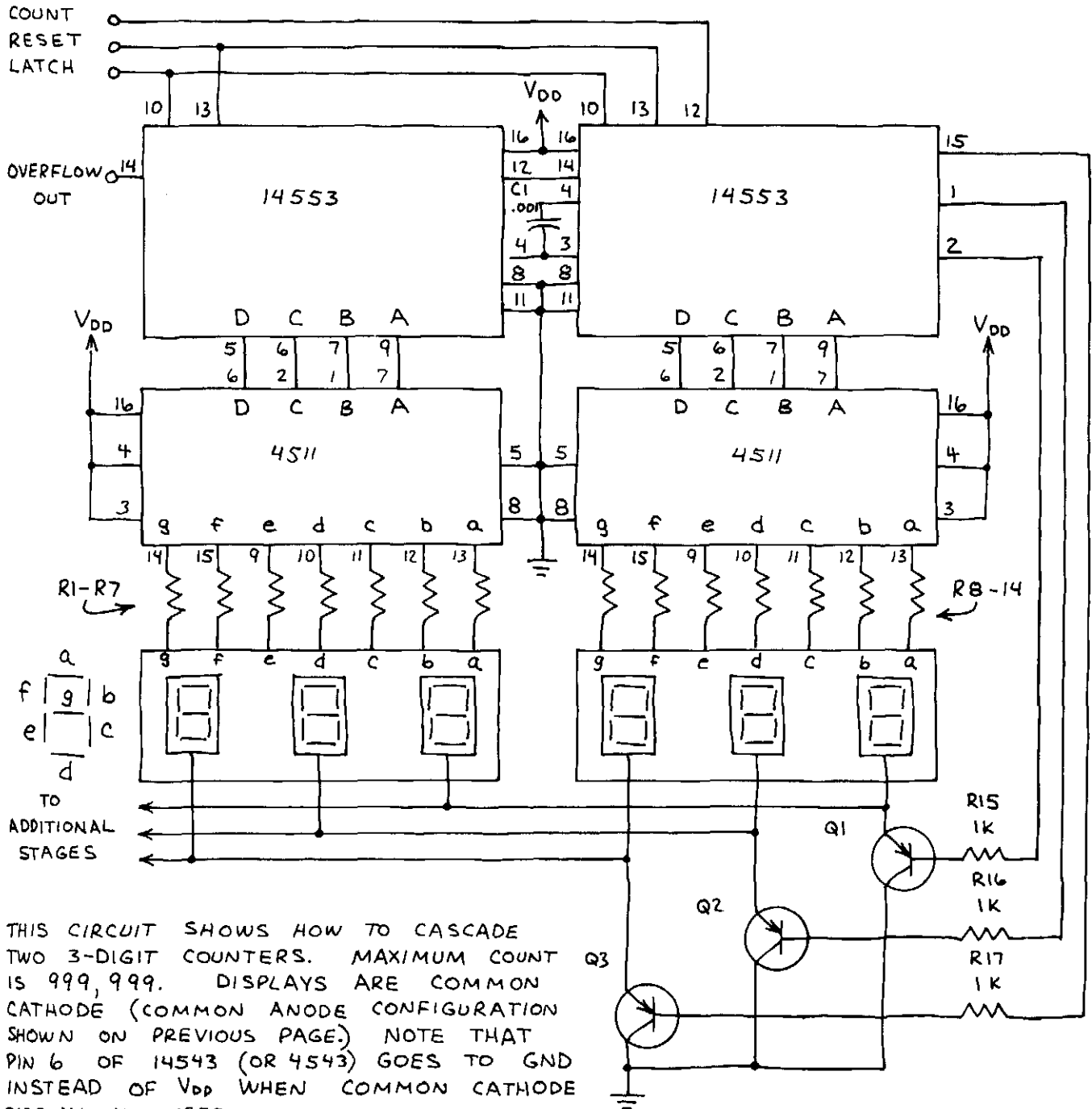
6-DIGIT FREQUENCY COUNTER



3-DIGIT BCD COUNTER (CONTINUED)

MC14553

6-DIGIT COUNTER

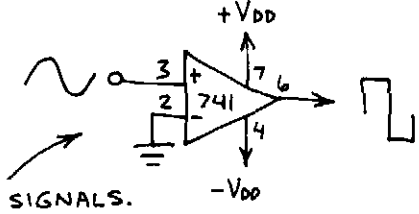


THIS CIRCUIT SHOWS HOW TO CASCADE TWO 3-DIGIT COUNTERS. MAXIMUM COUNT IS 999,999. DISPLAYS ARE COMMON CATHODE (COMMON ANODE CONFIGURATION SHOWN ON PREVIOUS PAGE.) NOTE THAT PIN 6 OF 14543 (OR 4543) GOES TO GND INSTEAD OF V_{DD} WHEN COMMON CATHODE DISPLAY IS USED.

FREQUENCY COUNTER:

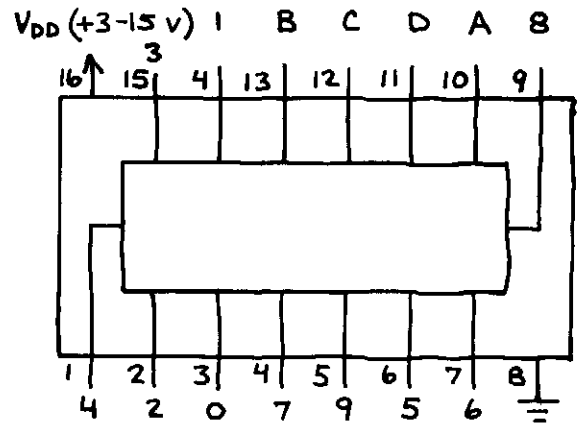
USE INPUT AND CONTROL CIRCUIT ON PREVIOUS PAGE. INPUT FREQUENCY SHOULD NOT EXCEED V_{DD}. NON-SQUARE WAVE INPUTS MAY REQUIRE INPUT TAILORING. USE COMPARATOR TO SHARPEN SLOW RISING AUDIO SIGNALS.

INPUT BUFFER

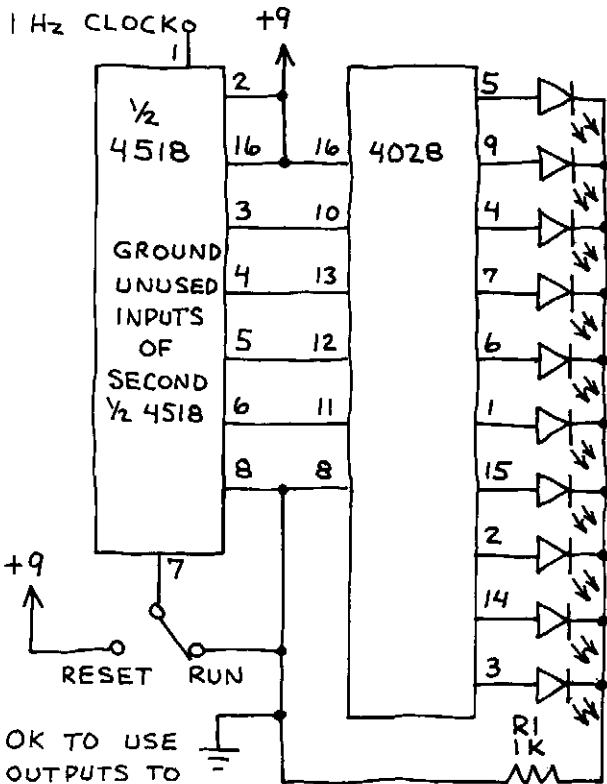


BCD-TO-DECIMAL DECODER 4028

DECODES 4-BIT BCD INPUT INTO 1-OF-10 OUTPUTS. SELECTED OUTPUT GOES HIGH; ALL OTHERS STAY LOW. USE FOR DECIMAL READOUTS, SEQUENCERS, PROGRAMMABLE COUNTERS, ETC.

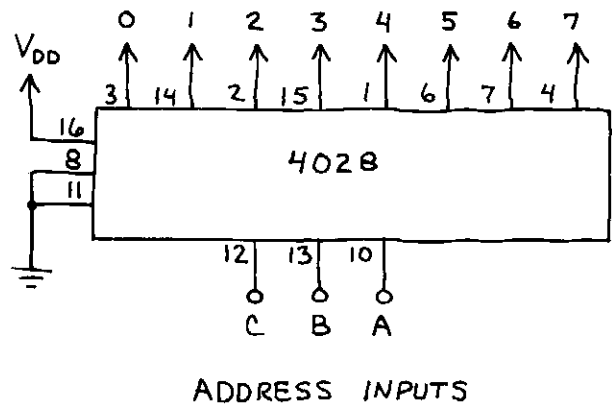


0-9 SECOND TIMER

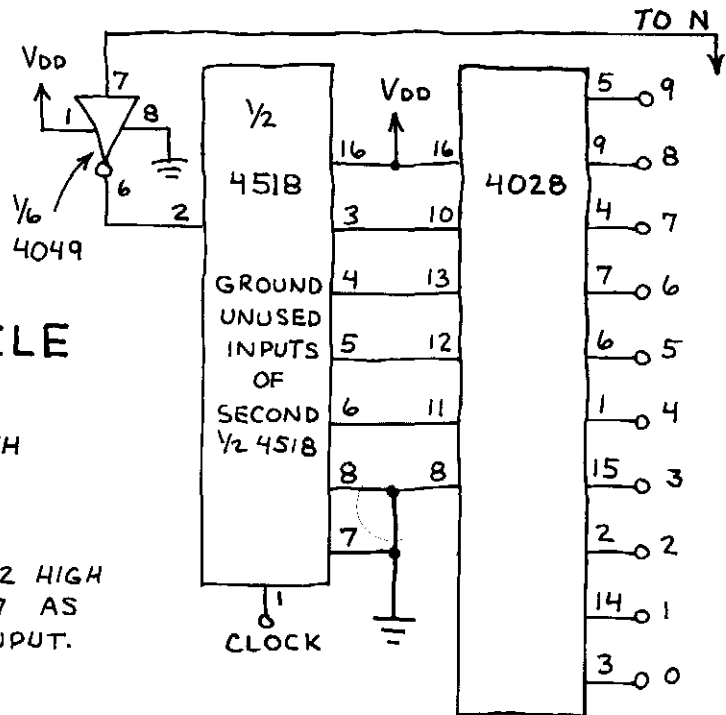


OK TO USE OUTPUTS TO CONTROL EXTERNAL LOGIC OR DEVICES.

1-OF-8 DECODER

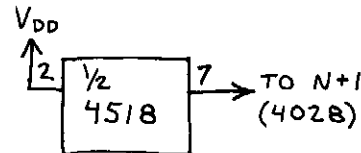


COUNT TO N AND HALT



COUNT TO N AND RECYCLE

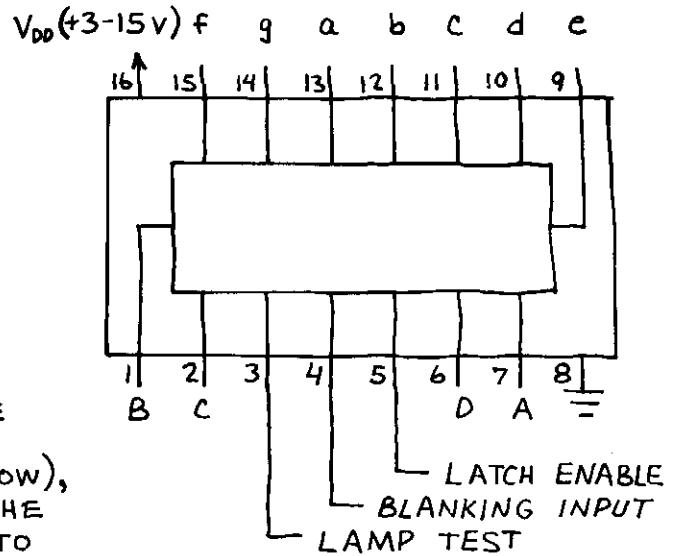
USE THE ADJACENT CIRCUIT WITH THESE CHANGES:



1. OMIT 4049
2. MAKE PIN 2 HIGH
3. USE PIN 7 AS CONTROL INPUT.

BCD-TO-7-SEGMENT LATCH/DECODER/DRIVER 4511

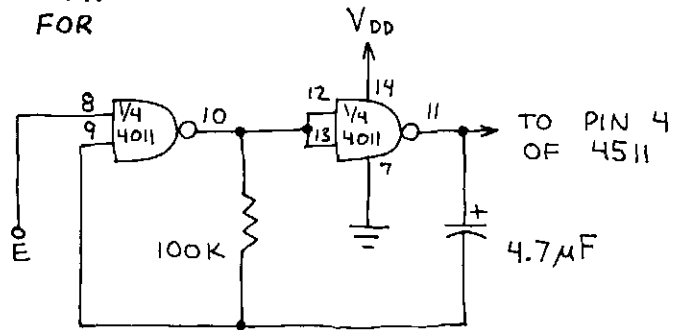
CONVERTS BCD DATA INTO FORMAT SUITABLE FOR PRODUCING DECIMAL DIGITS ON 7-SEGMENT LED DISPLAY. INCLUDES BUILT-IN 4-BIT LATCH TO STORE DATA TO BE DISPLAYED (WHEN PIN 5 IS HIGH). WHEN LATCH IS NOT USED (PINS 5 LOW), THE 7-SEGMENT OUTPUTS FOLLOW THE BCD INPUTS. MAKE PIN 4 LOW TO EXTINGUISH THE DISPLAY AND HIGH FOR NORMAL OPERATION. MAKE PIN 3 LOW TO TEST THE DISPLAY AND HIGH FOR NORMAL OPERATION.



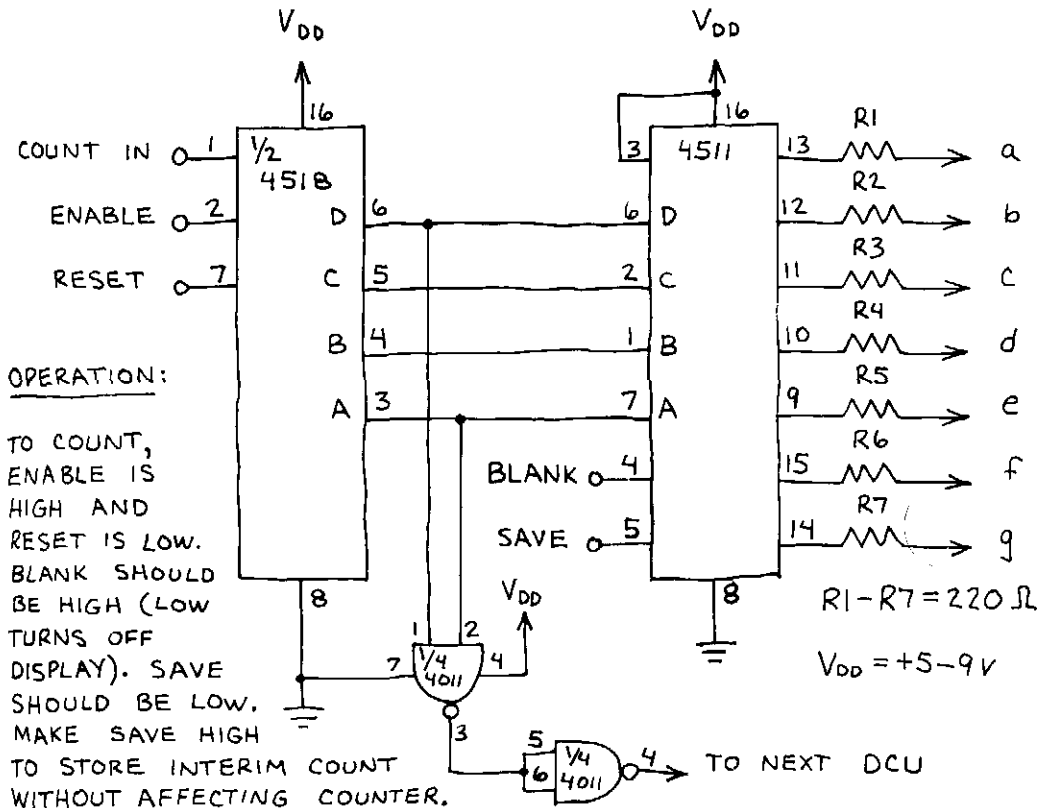
DISPLAY FLASHER

DISPLAY FLASHES ONCE PER SECOND WHEN E IS HIGH.

E	DISPLAY
H	FLASHES
L	OFF



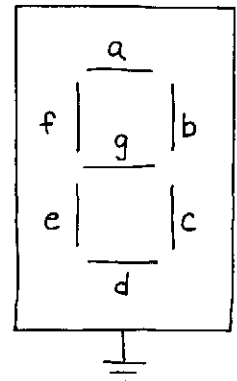
DECIMAL COUNTING UNIT (DCU)



OPERATION:

TO COUNT, ENABLE IS HIGH AND RESET IS LOW. BLANK SHOULD BE HIGH (LOW TURNS OFF DISPLAY). SAVE SHOULD BE LOW. MAKE SAVE HIGH TO STORE INTERIM COUNT WITHOUT AFFECTING COUNTER.

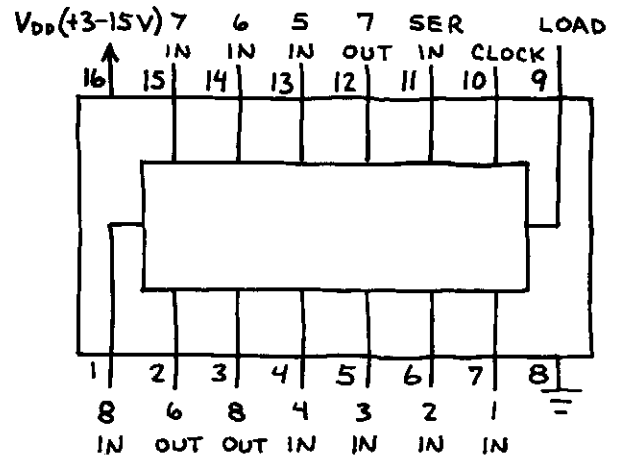
IMPORTANT: ALL INPUTS MUST GO SOMEWHERE!



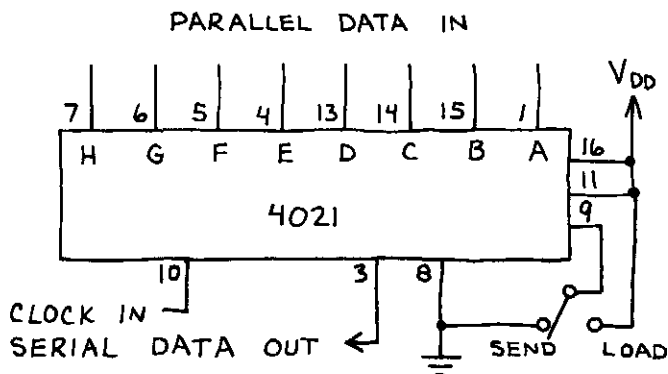
COMMON CATHODE LED DISPLAY

8-STAGE SHIFT REGISTER 4021

PARALLEL INPUT / SERIAL OUTPUT
SHIFT REGISTER. ALSO SERIAL
INPUT. DATA AT PARALLEL
INPUTS IS FORCED INTO THE
REGISTER IRRESPECTIVE OF THE
CLOCK STATUS WHEN PIN 9 IS
MADE HIGH. KEEP PIN 9 LOW
FOR NORMAL OPERATION.

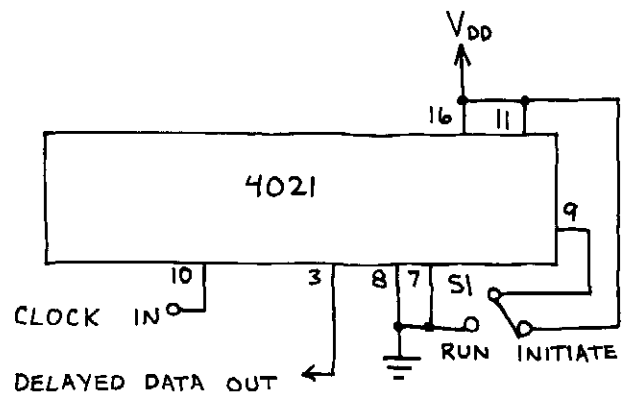


PARALLEL-TO-SERIAL DATA CONVERTER



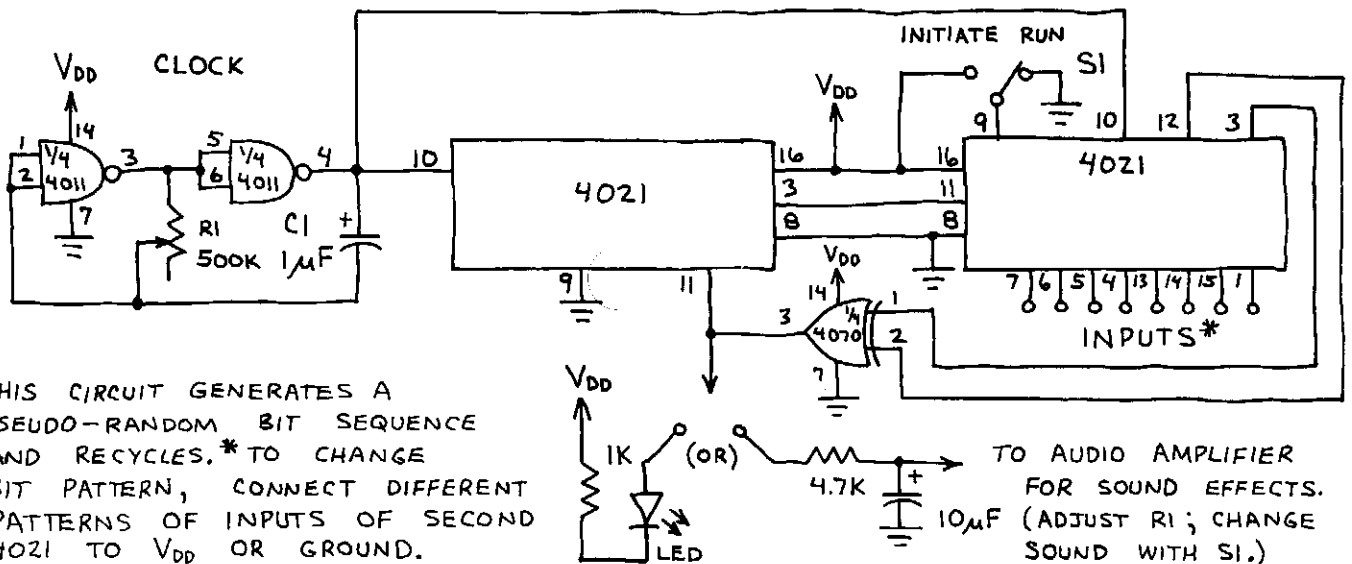
ALL 1's (H's) ARE SENT AFTER THE
8-BIT WORD IS TRANSMITTED.

8-STAGE DELAY LINE



THE FIRST PARALLEL INPUT (PIN 7)
IS GROUNDED. THIS LOADS A
SINGLE L WHEN SI IS SWITCHED
TO INITIATE. THE SINGLE L BIT
REACHES THE OUTPUT AFTER 8
CLOCK PULSES.

PSEUDO-RANDOM SEQUENCER

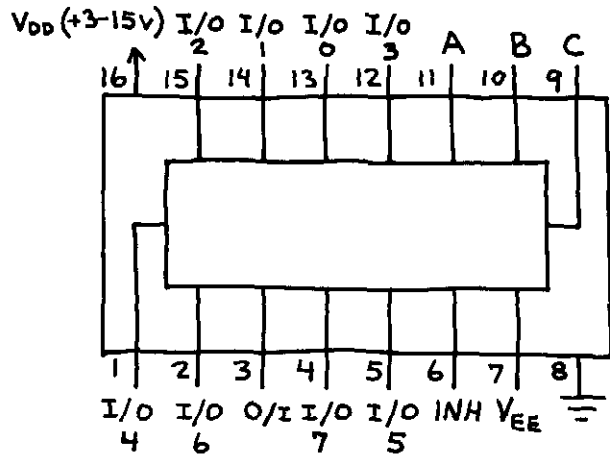


THIS CIRCUIT GENERATES A
PSEUDO-RANDOM BIT SEQUENCE
AND RECYCLES.* TO CHANGE
BIT PATTERN, CONNECT DIFFERENT
PATTERNS OF INPUTS OF SECOND
4021 TO V_{DD} OR GROUND.

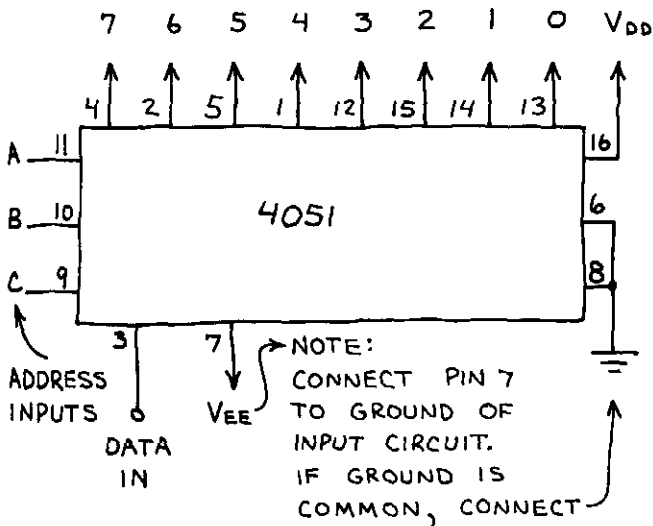
ANALOG MULTIPLEXER

4051

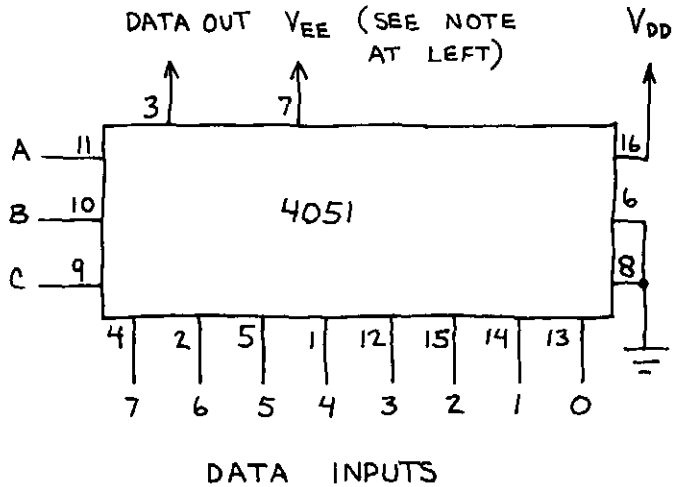
INPUT ADDRESS AT CBA SELECTS 1-OF-8 ANALOG SWITCHES. SIGNAL AT SELECTED SWITCH I/O (INPUT/OUTPUT) IS THEN APPLIED TO COMMON O/I (OUTPUT/INPUT). THE INPUT SIGNAL MUST NOT EXCEED V_{DD} . THE INHIBIT (INH) INPUT SHOULD BE GROUND FOR NORMAL OPERATION. ALL SWITCHES ARE OPEN WHEN INH IS HIGH.



1-OF-8 MULTIPLEXER

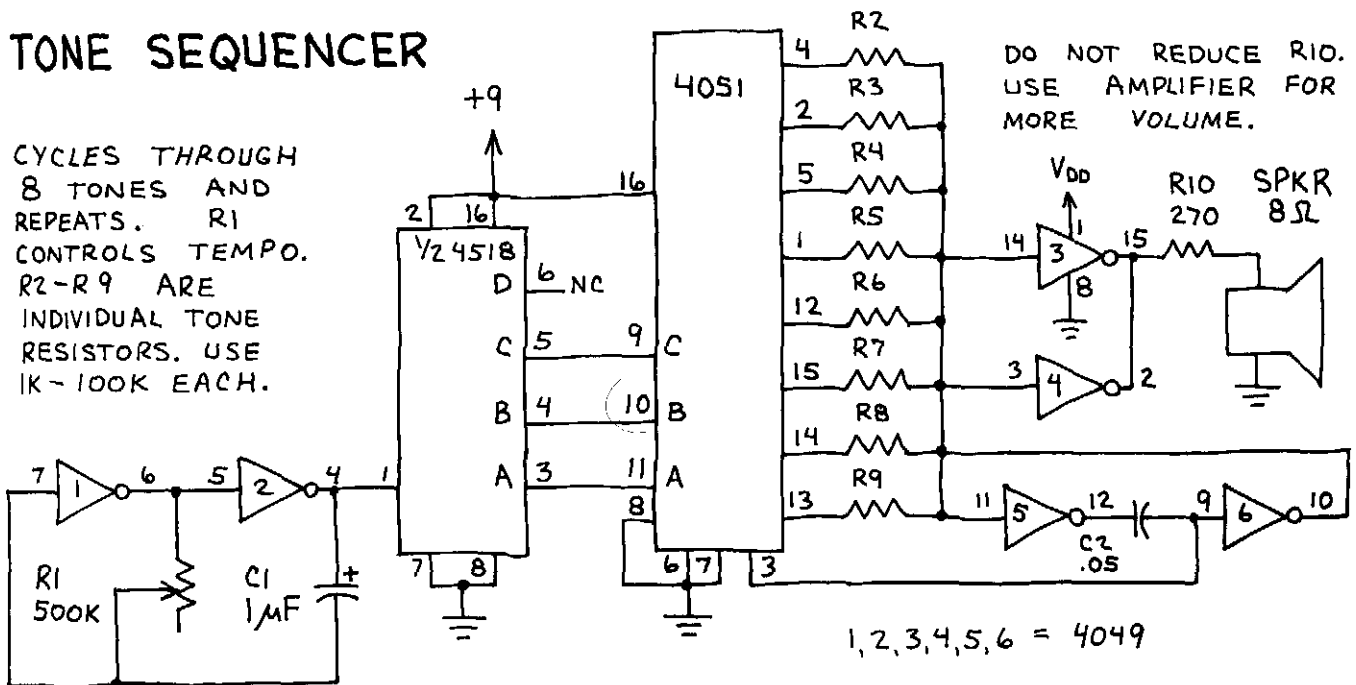


1-OF-8 DATA SELECTOR (DEMULTIPLEXER)



TONE SEQUENCER

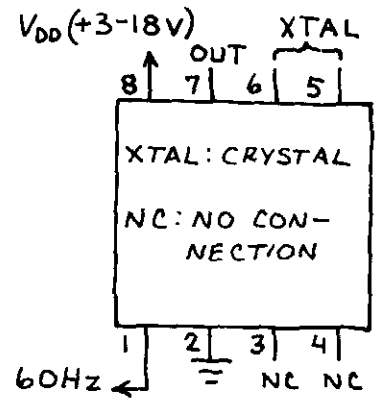
CYCLES THROUGH 8 TONES AND REPEATS. R_1 CONTROLS TEMPO. R_2-R_9 ARE INDIVIDUAL TONE RESISTORS. USE $1K-100K$ EACH.



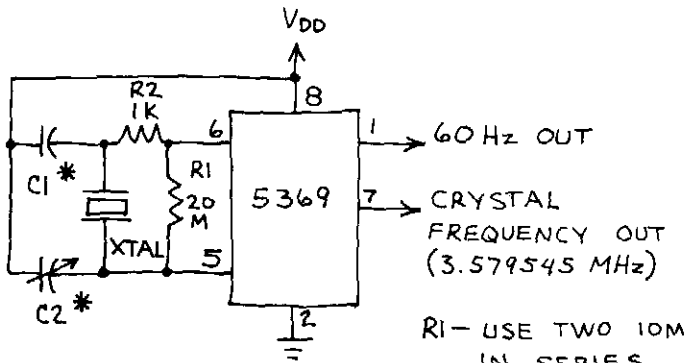
60-Hz TIMEBASE

MM5369

PROVIDES PRECISE 60 Hz SQUARE WAVE WHEN USED WITH 3.579545 MHz COLOR TV CRYSTAL. USE FOR MOST DO-IT-YOURSELF TIMERS, CLOCKS, CONTROLLERS, FUNCTION GENERATORS. INSTALL IN SMALL CABINET FOR WORKBENCH PRECISION CLOCK.



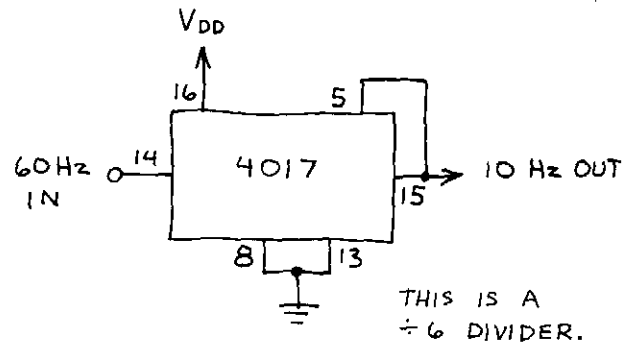
60-Hz TIMEBASE



R1 - USE TWO 10M IN SERIES.

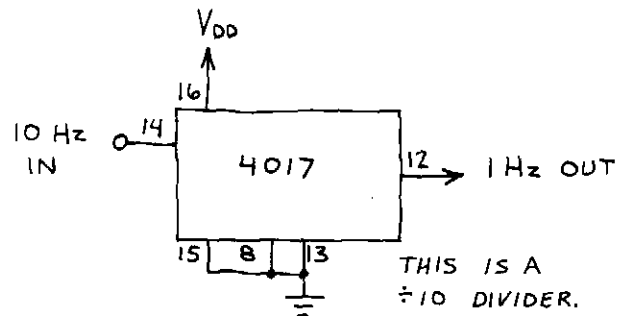
* MOTOROLA SPECIFIES THAT C1 = 30 pF AND C2 = 6.36 pF. OK TO USE SIX 4.7 pF CAPACITORS IN PARALLEL OR 47 pF CAPACITOR FOR C1. TRY TUNABLE CAPACITOR (e.g. 5-50 pF) FOR C2. TO TUNE, CONNECT FREQUENCY METER TO PIN 7. TUNE C2 UNTIL FREQUENCY IS 3,579,545 Hz. ACCURACY FAIRLY GOOD EVEN IF YOU DON'T TUNE C2.

10-Hz TIMEBASE



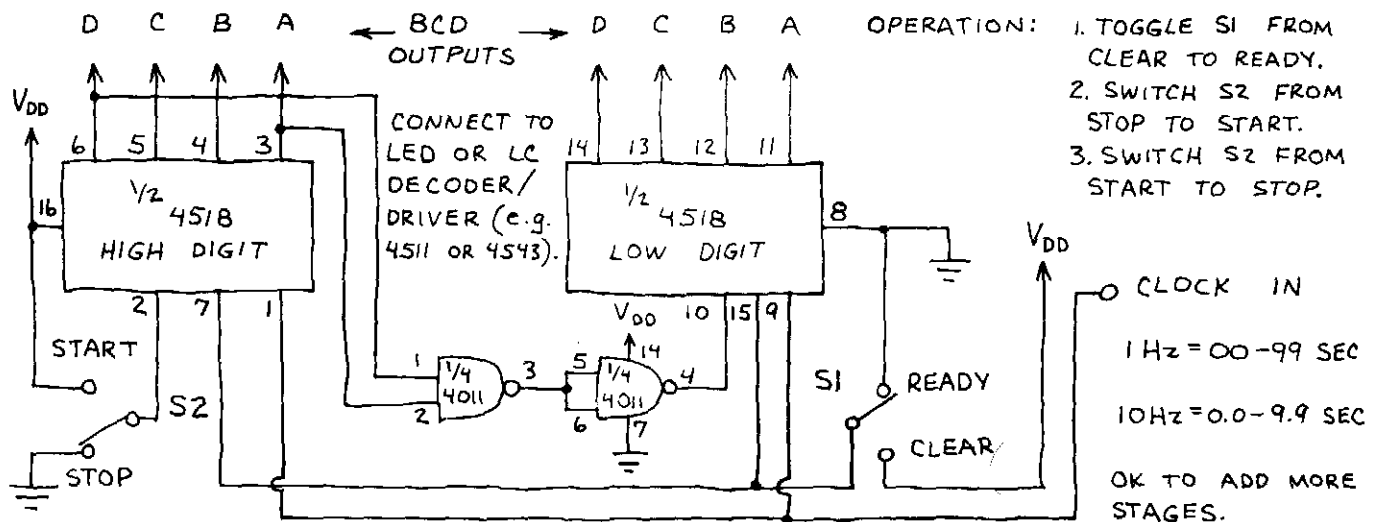
THIS IS A ÷6 DIVIDER.

1-Hz TIMEBASE



THIS IS A ÷10 DIVIDER.

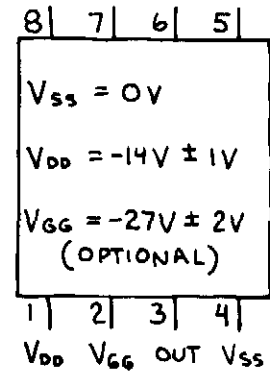
DIGITAL STOPWATCH



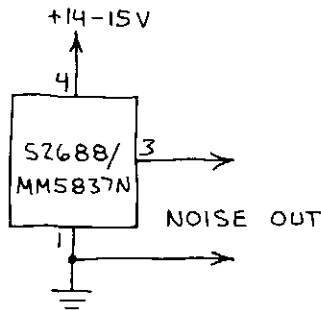
NOISE GENERATOR

S2688 / MM5837N

PRODUCES BROADBAND WHITE NOISE FOR AUDIO AND OTHER APPLICATIONS. THE NOISE QUALITY IS VERY UNIFORM. IT IS PRODUCED BY A 17-BIT SHIFT REGISTER WHICH IS CLOCKED BY AN INTERNAL OSCILLATOR.

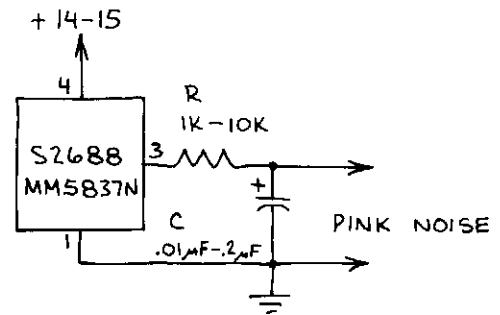


WHITE NOISE SOURCE



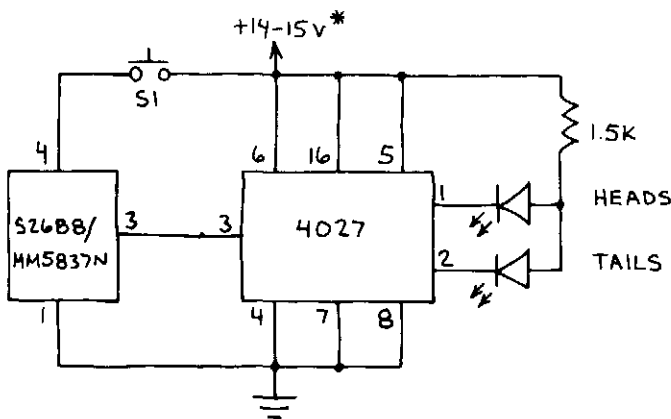
CONNECT OUTPUT TO AUDIO AMPLIFIER TO HEAR NOISE. USE 7815 VOLTAGE REGULATOR TO OBTAIN +15 VOLTS.

PINK NOISE SOURCE



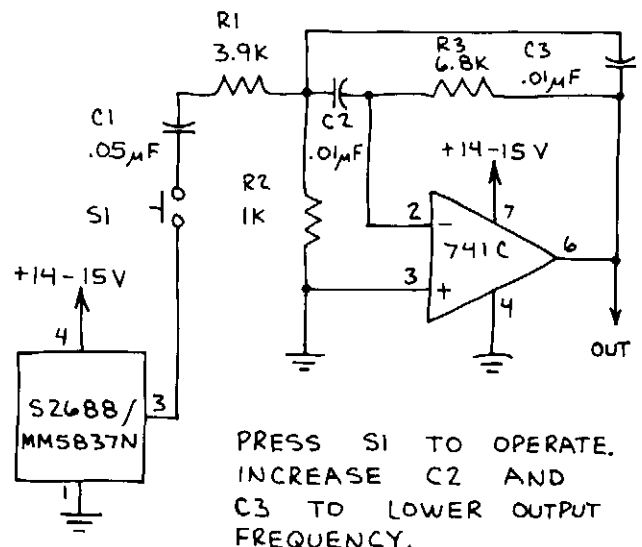
CHANGE R AND C TO ALTER NOISE SPECTRUM. ALSO, TRY LOWER SUPPLY VOLTAGES TO CHANGE SPECTRUM.

COIN TOSSEY



PRESS S1; BOTH LEDS GLOW. RELEASE S1 AND ONLY ONE GLOWS. GROUND INPUTS OF UNUSED HALF OF 4027 (PINS 9,10,11,12 AND 13).*(OK TO USE 9-VOLT BATTERY AS POWER SUPPLY.)

SNARE /BRUSH NOISE



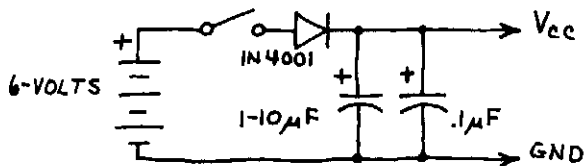
PRESS S1 TO OPERATE. INCREASE C2 AND C3 TO LOWER OUTPUT FREQUENCY.

NOTES

TTL/LS INTEGRATED CIRCUITS

INTRODUCTION

TTL IS THE BEST ESTABLISHED AND MOST DIVERSIFIED IC FAMILY. LS IS FUNCTIONALLY IDENTICAL TO TTL BUT IS SLIGHTLY FASTER AND USES 80% LESS POWER. TTL/LS CHIPS REQUIRE A REGULATED 4.75-5.25 VOLT POWER SUPPLY. HERE'S A SIMPLE BATTERY SUPPLY:



THE DIODE DROPS THE BATTERY VOLTAGE TO A SAFE LEVEL. BOTH CAPACITORS SHOULD BE INSTALLED ON THE TTL/LS CIRCUIT BOARD. CIRCUITS WITH LOTS OF TTL/LS CHIPS CAN USE LOTS OF CURRENT. USE A COMMERCIAL 5 VOLT LINE POWERED SUPPLY TO SAVE BATTERIES. OR MAKE YOUR OWN. (SEE THE 7805 ON PAGE 86.)

OPERATING REQUIREMENTS

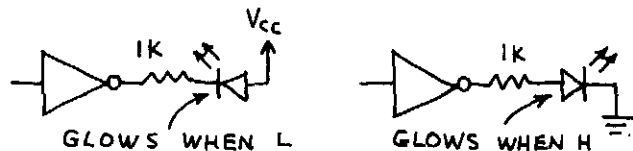
1. V_{cc} MUST NOT EXCEED 5.25 VOLTS.
2. INPUT SIGNALS MUST NEVER EXCEED V_{cc} AND SHOULD NOT FALL BELOW GND.
3. UNCONNECTED TTL/LS INPUTS USUALLY ASSUME THE H STATE ... BUT DON'T COUNT ON IT! IF AN INPUT IS SUPPOSED TO BE FIXED AT H, CONNECT IT TO V_{cc} .
4. IF AN INPUT IS SUPPOSED TO BE FIXED AT L, CONNECT IT TO GND.
5. CONNECT UNUSED AND/NAND/OR INPUTS TO A USED INPUT OF THE SAME CHIP.
6. FORCE OUTPUTS OF UNUSED GATES H TO SAVE CURRENT (NAND—ONE INPUT H; NOR—ALL INPUTS L).

7. USE AT LEAST ONE DECOUPLING CAPACITOR (0.01-0.1 μ F) FOR EVERY 5-10 GATE PACKAGES, ONE FOR EVERY 2-5 COUNTERS AND REGISTERS AND ONE FOR EACH ONE-SHOT. DECOUPLING CAPACITORS NEUTRALIZE THE HEFTY POWER SUPPLY SPIKES THAT OCCUR WHEN A TTL/LS OUTPUT CHANGES STATES. THEY MUST HAVE SHORT LEADS AND BE CONNECTED FROM V_{cc} TO GND AS NEAR THE TTL/LS ICs AS POSSIBLE.

8. AVOID LONG WIRES WITHIN CIRCUITS
9. IF THE POWER SUPPLY IS NOT ON THE CIRCUIT BOARD, CONNECT A 1-10 μ F CAPACITOR ACROSS THE POWER LEADS WHERE THEY ARRIVE AT THE BOARD.

INTERFACING TTL/LS

1. 1 TTL OUTPUT WILL DRIVE UP TO 10 TTL OR 20 LS INPUTS.
2. 1 LS OUTPUT WILL DRIVE UP TO 5 TTL OR 10 LS INPUTS.
3. TTL/LS LED DRIVERS:



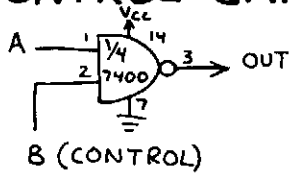
TTL/LS TROUBLESHOOTING

1. DO ALL INPUTS GO SOMEWHERE?
2. ARE ALL IC PINS INSERTED INTO THE BOARD OR SOCKET?
3. DOES THE CIRCUIT OBEY ALL TTL/LS OPERATING REQUIREMENTS?
4. HAVE YOU FORGOTTEN A CONNECTION?
5. HAVE YOU USED ENOUGH DECOUPLING CAPACITORS? ARE THEIR LEADS SHORT?
6. IS V_{cc} AT EACH CHIP WITHIN RANGE?

QUAD NAND GATE 7400/74LS00

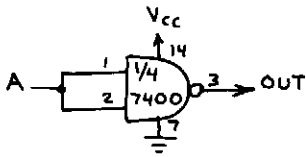
THE BASIC BUILDING BLOCK CHIP FOR THE ENTIRE TTL FAMILY. VERY EASY TO USE. HUNDREDS OF APPLICATIONS.

CONTROL GATE



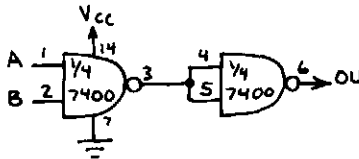
A	B	OUT
L	L	H
L	H	H
H	L	H
H	H	L

INVERTER



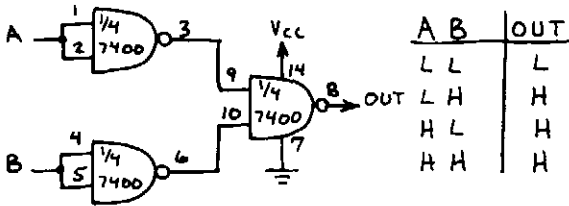
A	OUT
L	H
H	L

AND GATE



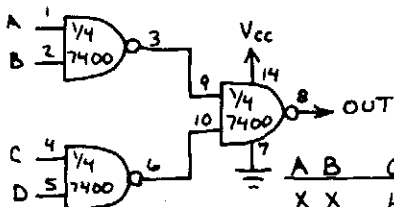
A	B	OUT
L	L	L
L	H	L
H	L	L
H	H	H

OR GATE

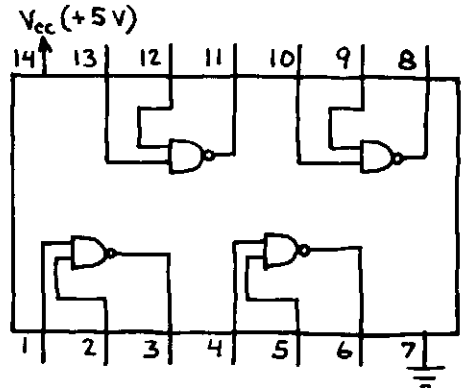


A	B	OUT
L	L	L
L	H	H
H	L	H
H	H	H

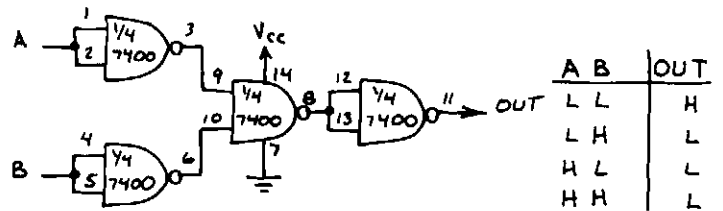
AND-OR GATE



A	B	C	D	OUT
X	X	H	H	H
H	H	X	X	H
H	H	H	H	H

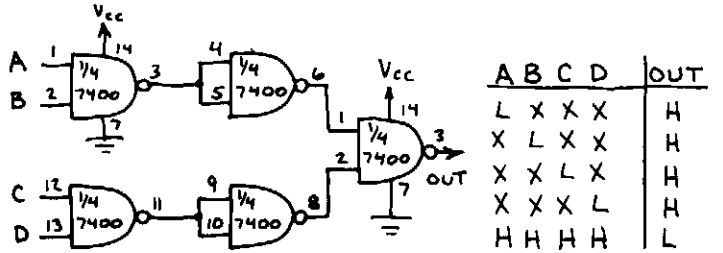


NOR GATE



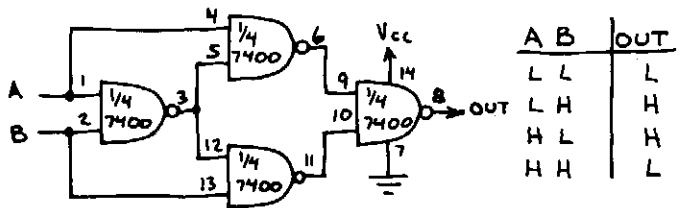
A	B	OUT
L	L	H
L	H	L
H	L	L
H	H	L

4-INPUT NAND GATE



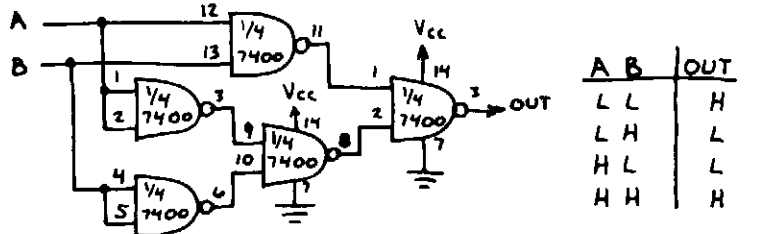
A	B	C	D	OUT
L	X	X	X	H
X	L	X	X	H
X	X	L	X	H
X	X	X	L	H
H	H	H	H	L

EXCLUSIVE-OR GATE



A	B	OUT
L	L	L
L	H	H
H	L	H
H	H	L

EXCLUSIVE-NOR GATE



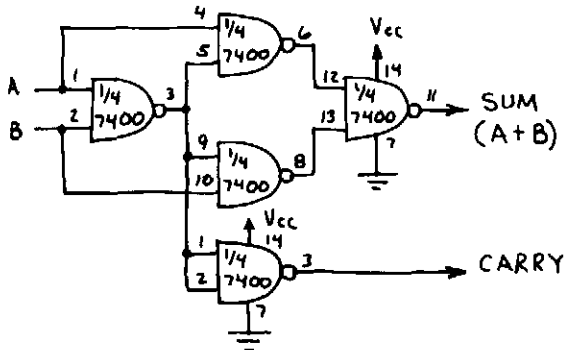
A	B	OUT
L	L	H
L	H	L
H	L	L
H	H	H

NOTE: PIN NUMBERS CAN BE REARRANGED IF DESIRED.

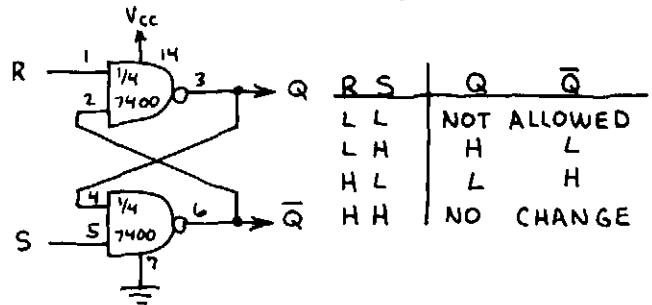
QUAD NAND GATE (CONTINUED)

7400/74LS00

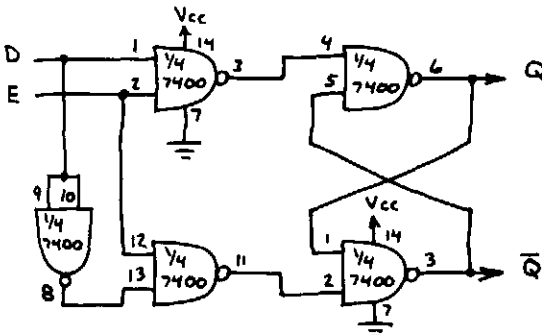
HALF ADDER



RS LATCH

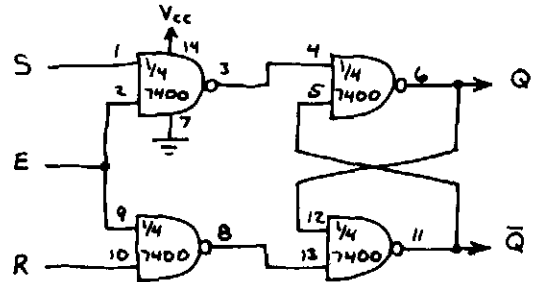


D FLIP-FLOP



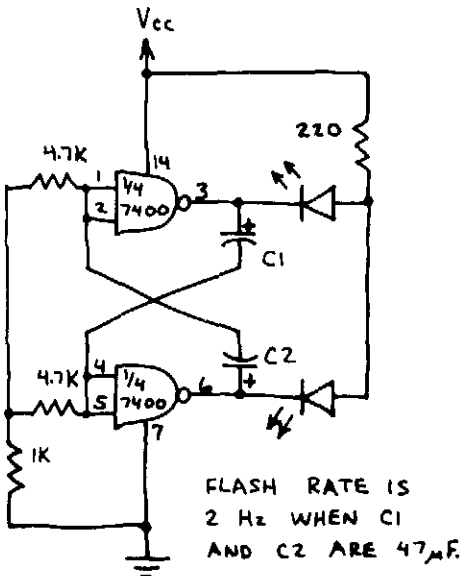
WHEN ENABLE (E) INPUT IS HIGH, Q OUTPUT FOLLOWS D INPUT. NO CHANGE WHEN E IS LOW.

GATED RS LATCH

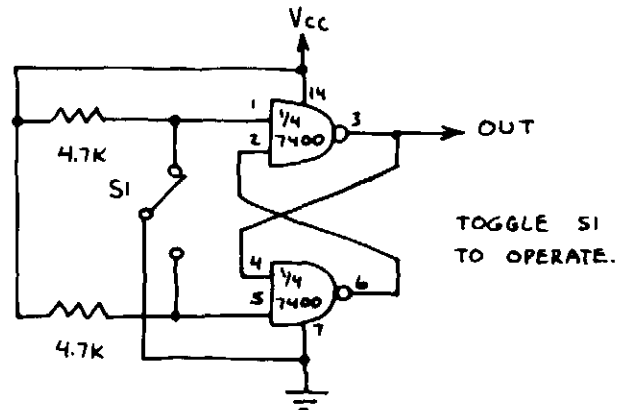


FUNCTIONS AS RS LATCH WHEN ENABLE (E) INPUT IS HIGH. IGNORES RS INPUTS WHEN E IS LOW.

LED DUAL FLASHER



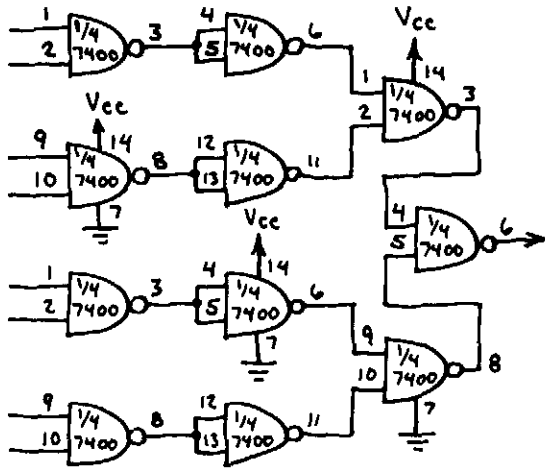
SWITCH DEBOUNCER



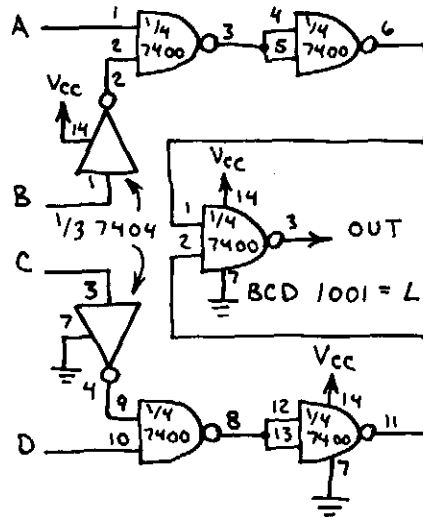
PROVIDES NOISE FREE OUTPUT FROM STANDARD SPDT TOGGLE SWITCH.

QUAD NAND GATE (CONTINUED) 7400/74LS00

8-INPUT NAND GATE



BCD DECODER

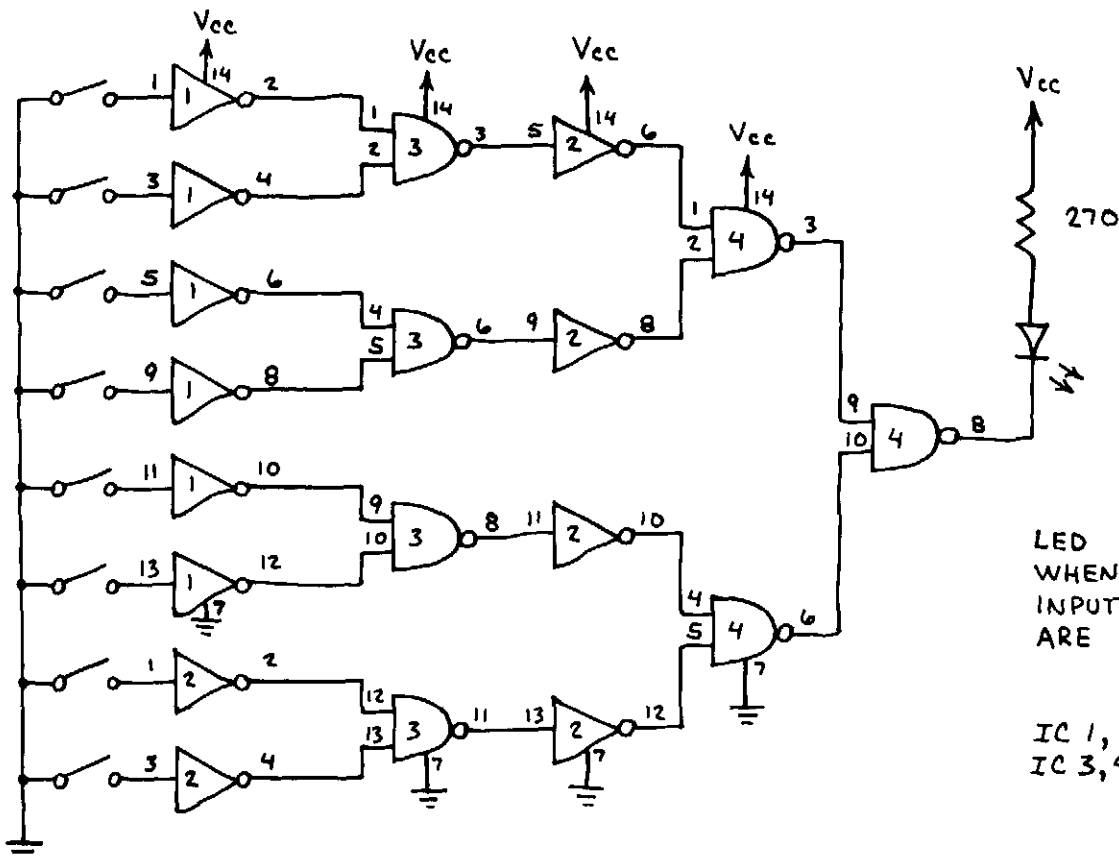


A	B	C	D	OUT
H	L	L	H	L
X	X	X	X	H

USE THIS METHOD TO DECODE ANY 4-BIT NIBBLE. JUST ADD OR REMOVE INPUT INVERTERS.

IC 1, 2 =
7400/74LS00

UNANIMOUS VOTE DETECTOR

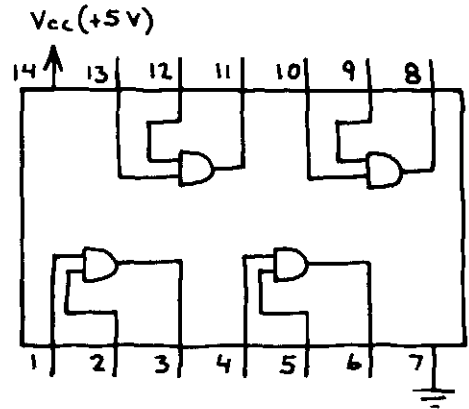


LED GLOWS WHEN ALL INPUT SWITCHES ARE CLOSED.

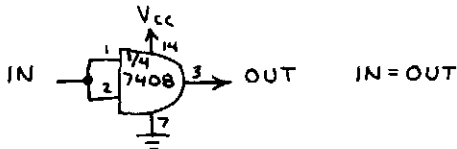
IC 1, 2 = 7404
IC 3, 4 = 7400/
74LS00

QUAD AND GATE 7408/74LS08

ONE OF THE BASIC BUILDING BLOCK CHIPS. NOT AS VERSATILE, HOWEVER, AS THE 7400/74LS00 QUAD NAND GATE.

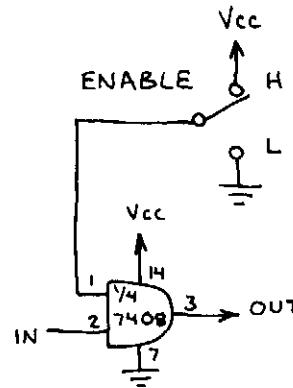


AND GATE BUFFER



USE FOR INTERFACING WITHOUT CHANGING LOGIC STATES.

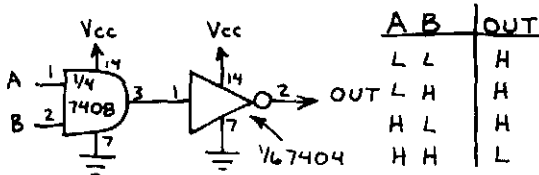
DIGITAL TRANSMISSION GATE



IN	E	OUT
L	L	L
L	H	L
H	L	L
H	H	H

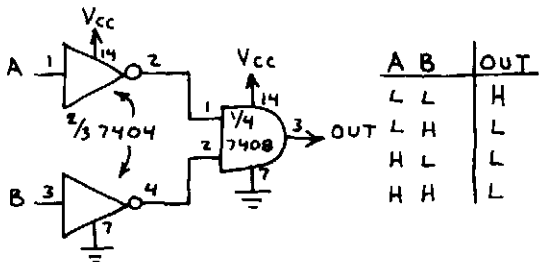
E = ENABLE

NAND GATE



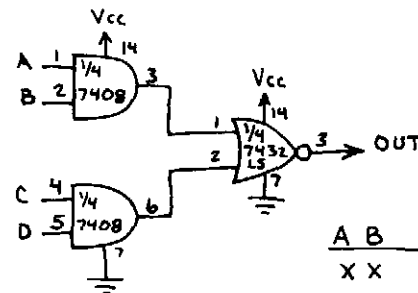
A	B	OUT
L	L	H
L	H	H
H	L	H
H	H	L

NOR GATE



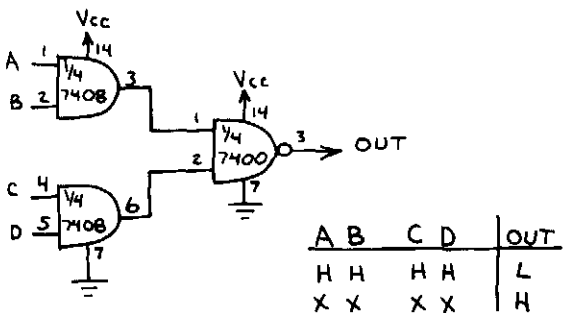
A	B	OUT
L	L	H
L	H	L
H	L	L
H	H	L

AND-OR-INVERT GATE



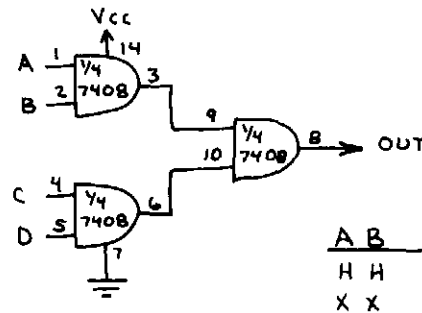
A	B	C	D	OUT
X	X	X	X	H
1	1	X	X	L
1	1	1	1	L

4-INPUT NAND GATE



A	B	C	D	OUT
H	H	H	H	L
X	X	X	X	H

4-INPUT AND GATE

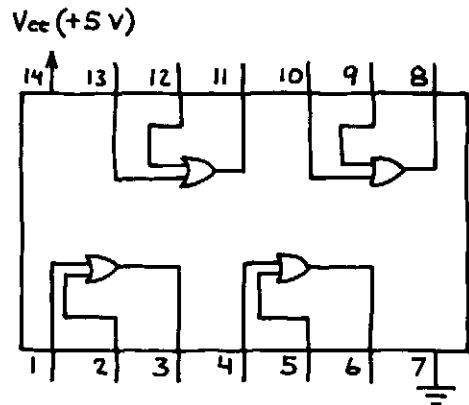


A	B	C	D	OUT
H	H	H	H	H
X	X	X	X	L

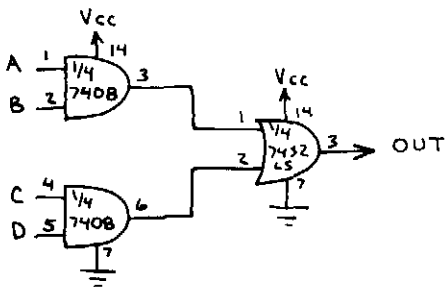
QUAD OR GATE

74LS32

FOUR 2-INPUT OR GATES.
NOT AS VERSATILE AS 7402/
74LS02 QUAD NOR GATE,
BUT VERY USEFUL IN SIMPLE
DATA SELECTORS.

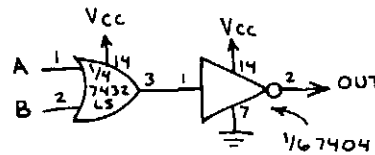


AND-OR CIRCUIT



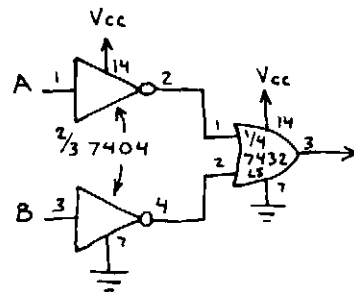
OUTPUT GOES HIGH WHEN BOTH
INPUTS OF EITHER OR BOTH AND
GATES ARE HIGH; OTHERWISE
THE OUTPUT IS LOW. THIS BASIC
CIRCUIT IS USED TO MAKE
DATA SELECTORS... AS SHOWN
BELOW ↴

NOR GATE



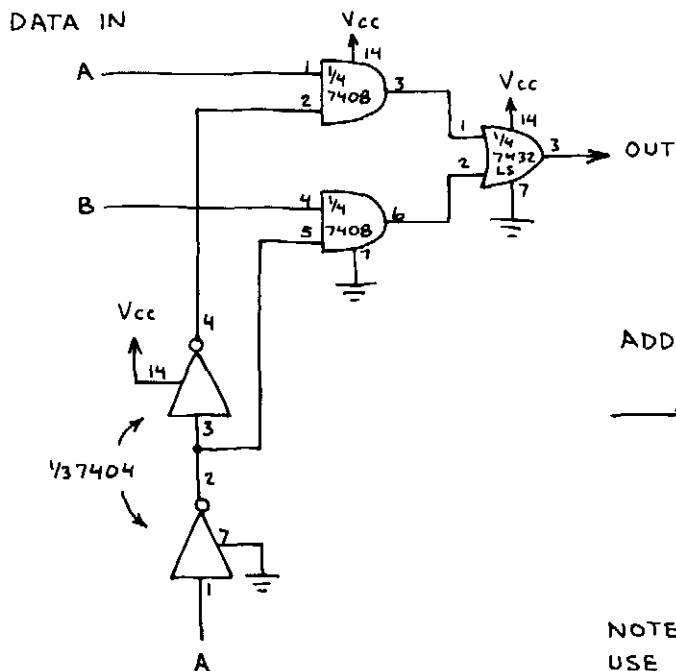
A	B	OUT
L	L	H
L	H	L
H	L	L
H	H	L

NAND GATE



A	B	OUT
L	L	H
L	H	H
H	L	H
H	H	L

2-INPUT DATA SELECTOR



SELECTS 1-OF-2 INPUTS
AND TRANSMITS ITS
LOGIC STATE TO THE
OUTPUT.

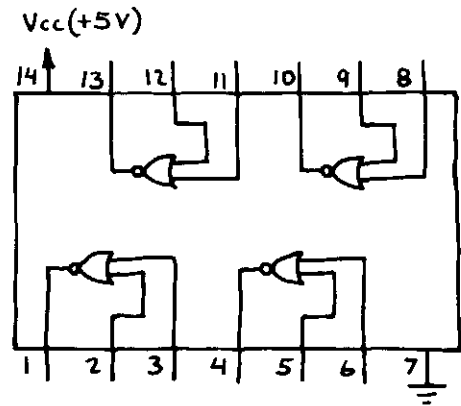
ADDRESS	DATA IN		OUT
	B	A	
L	X	L	L
L	X	H	H
H	L	X	L
H	H	X	H

NOTE: FOR 3-INPUT DATA SELECTOR,
USE 74LS27 NOR GATE FOLLOWED
BY INVERTER AND PRECEDED BY
74LS10 3-INPUT AND GATES.

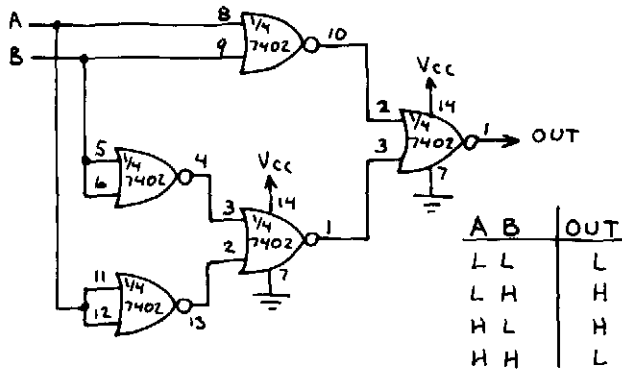
ADDRESS (DATA SELECT)

QUAD NOR GATE 7402/74LS02

JUST AS VERSATILE AS THE 7400/74LS00 QUAD NAND GATE... BUT NOT USED AS OFTEN. ADD INVERTER (7404/74LS04) TO BOTH INPUTS OF A NOR GATE AND AN AND GATE IS FORMED.

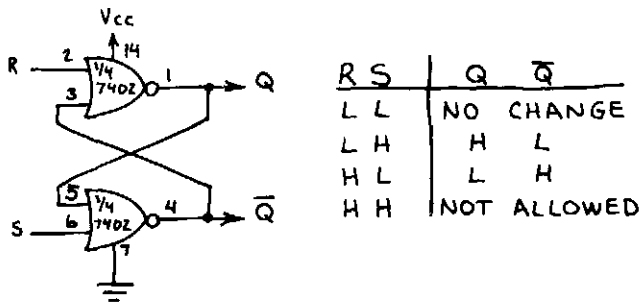


EXCLUSIVE-OR GATE

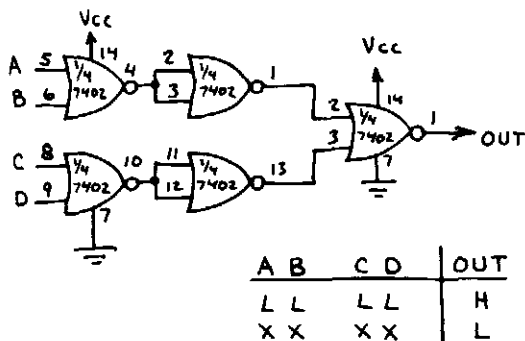


THIS CIRCUIT IS EQUIVALENT TO A BINARY HALF-ADDER.

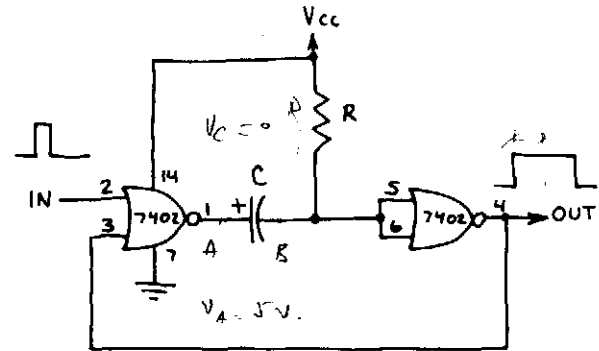
RS LATCH



4-INPUT NOR GATE

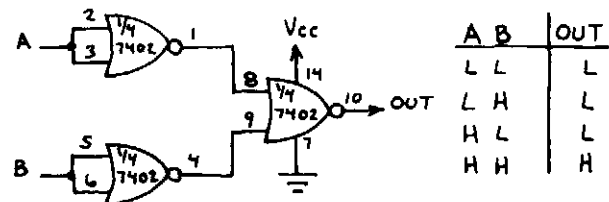


ONE-SHOT

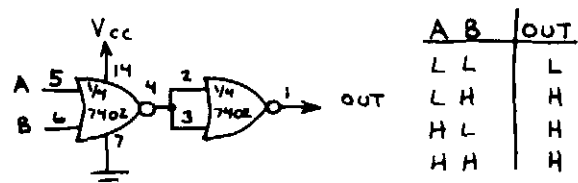


THIS CIRCUIT IS A MONOSTABLE MULTIVIBRATOR OR PULSE STRETCHER. AN INPUT PULSE TRIGGERS AN OUTPUT PULSE WITH A DURATION DETERMINED BY R AND C. OUTPUT PULSE WIDTH IS APPROXIMATELY 0.8RC.

AND GATE

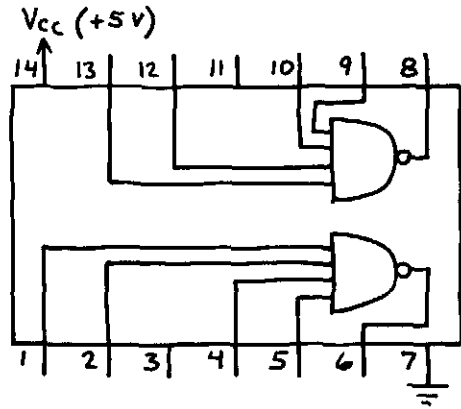


OR GATE

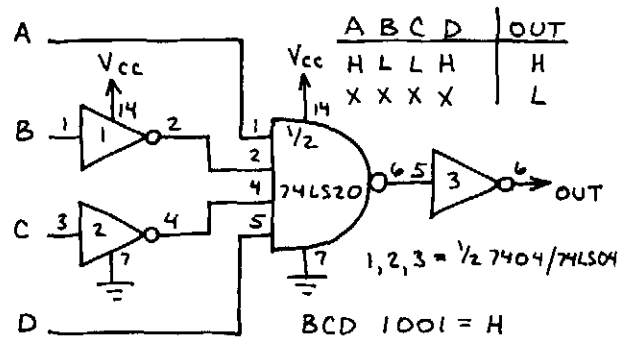
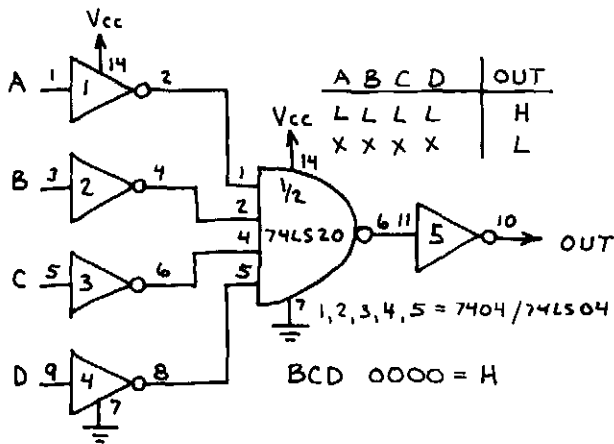


DUAL 4-INPUT NAND GATE 74LS20

MANY DECODER AND ENCODER APPLICATIONS. CAN BE USED AS DUAL 3-INPUT NAND GATE WITH ENABLE (CONTROL) INPUT FOR EACH GATE.

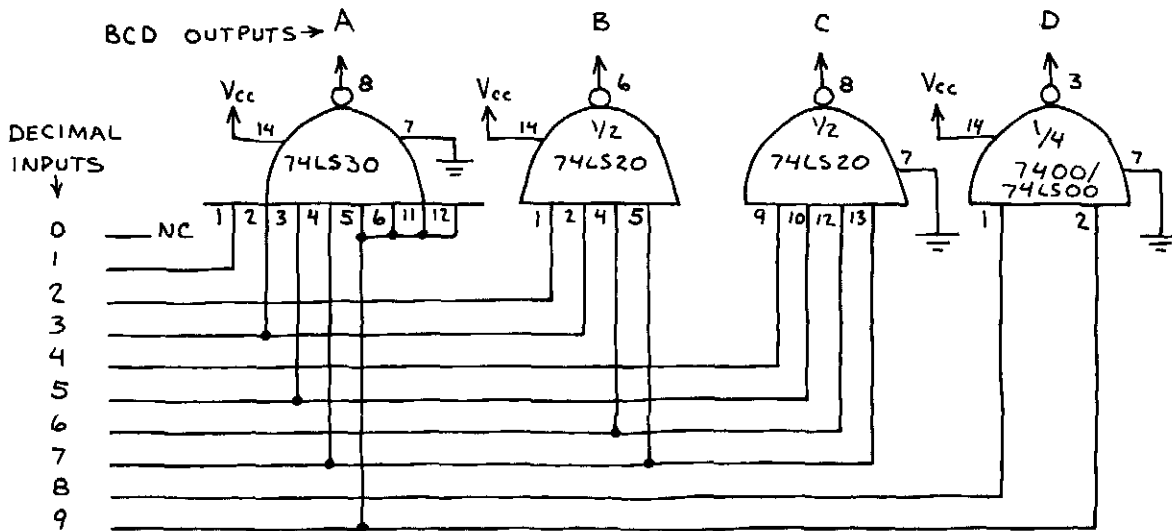


BCD DECODERS



OUTPUTS GO HIGH WHEN APPROPRIATE BCD WORD APPEARS AT INPUTS DCBA. OUTPUTS STAY LOW FOR ALL OTHER INPUTS. (OMIT FINAL INVERTER TO PROVIDE ACTIVE LOW OUTPUT.) USE THIS METHOD TO DECODE ANY 4-BIT NIBBLE.

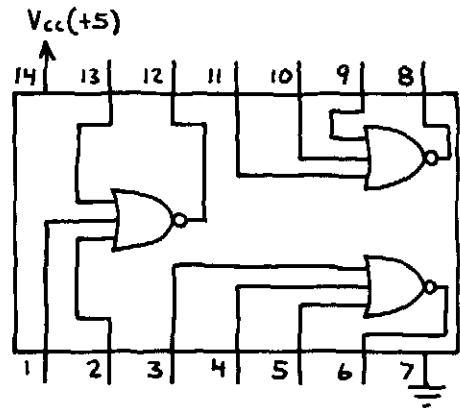
DECIMAL-TO-BINARY CODED DECIMAL (BCD) ENCODER



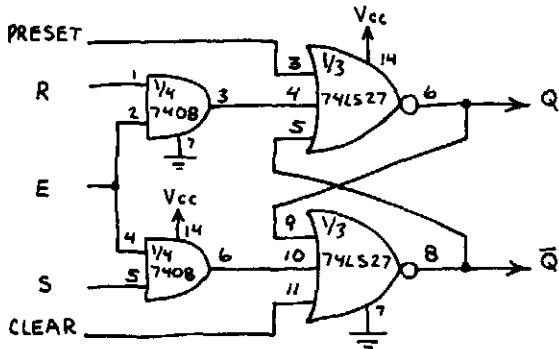
SELECTED INPUT SHOULD BE LOW AND ALL OTHER INPUTS SHOULD BE HIGH. BCD EQUIVALENT WILL APPEAR AT THE OUTPUTS.

TRIPLE 3-INPUT NOR GATE 74LS27

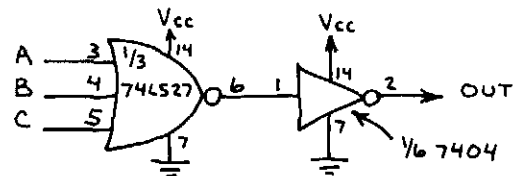
USEFUL FOR DATA SELECTORS
AND NOR GATE FLIP-FLOPS
THAT REQUIRE CLEAR AND
PRESET INPUTS.



GATED RS LATCH

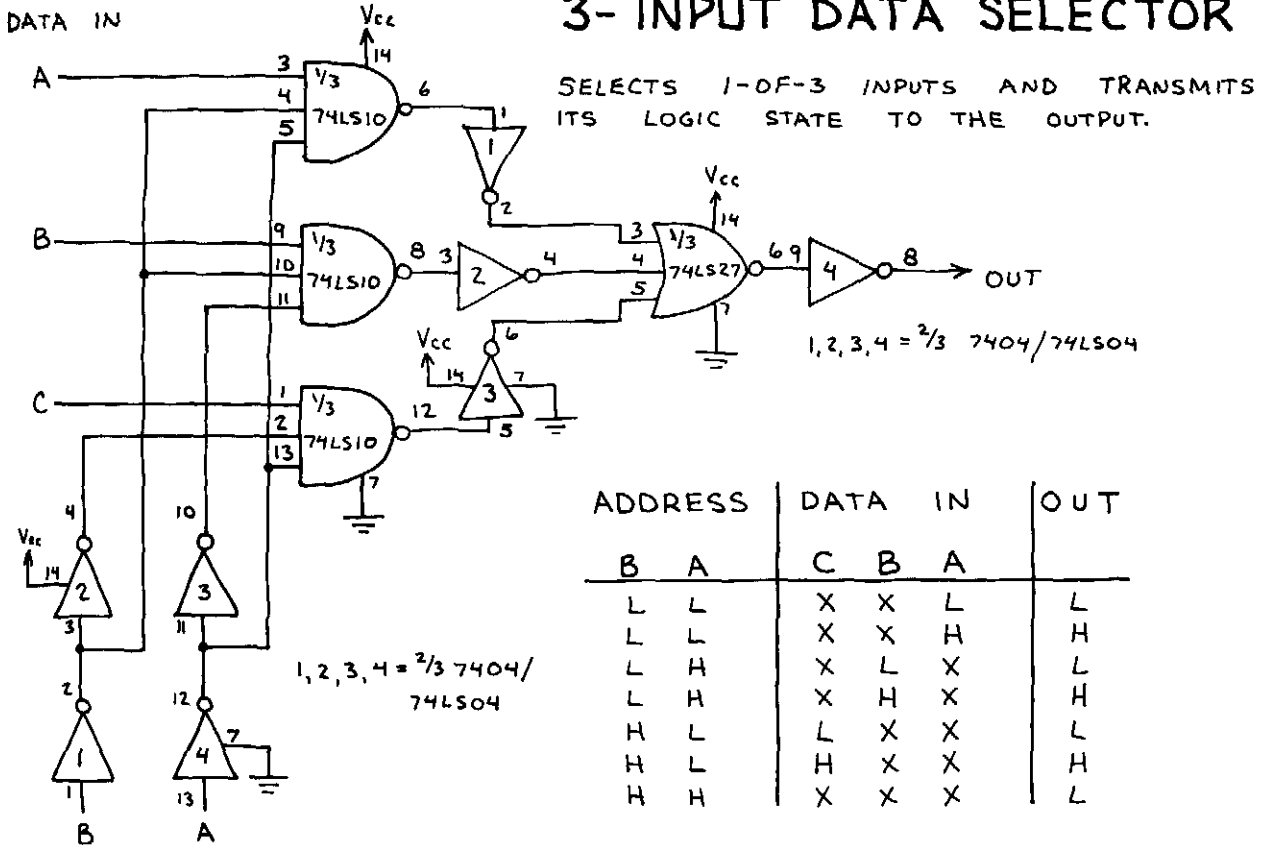


3-INPUT OR GATE



FUNCTIONS AS RS LATCH WHEN
E (ENABLE) INPUT IS HIGH. IGNORES
RS INPUTS WHEN E IS LOW.

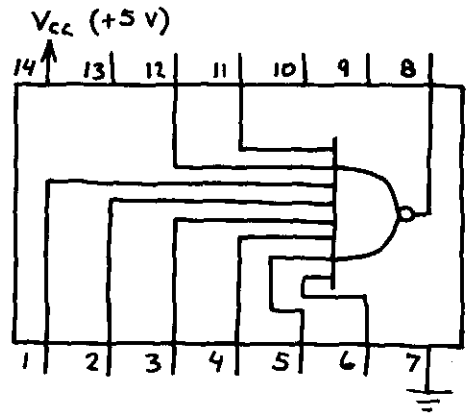
3- INPUT DATA SELECTOR



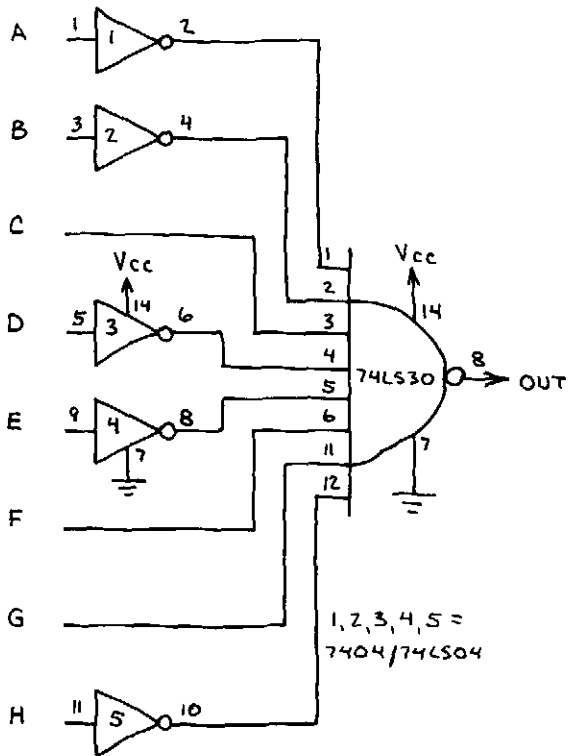
ADDRESS (DATA SELECT)

8-INPUT NAND GATE 74LS30

HANDY FOR BYTE-SIZE (8-BIT) DECODING APPLICATIONS. CAN DECODE UP TO 256 INPUT COMBINATIONS. ALSO USEFUL AS PROGRAMMABLE NAND GATE.

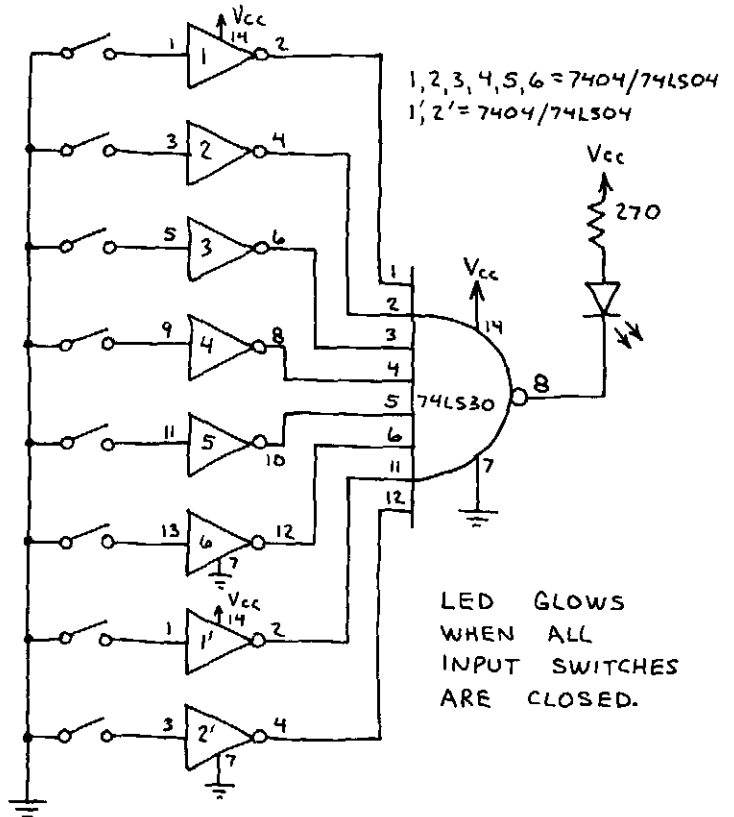


8-BIT DECODER



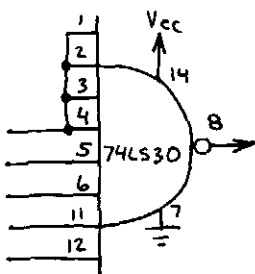
OUTPUT GOES LOW ONLY WHEN INPUT IS LHHLLHL (DECIMAL 100). UP TO 256 INPUTS CAN BE DECODED BY REARRANGING UP TO 8 INPUT INVERTERS.

UNANIMOUS VOTE DETECTOR

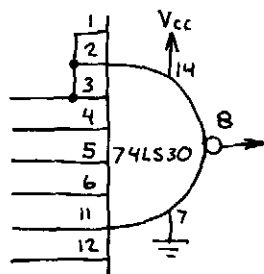


PROGRAMMABLE NAND GATES

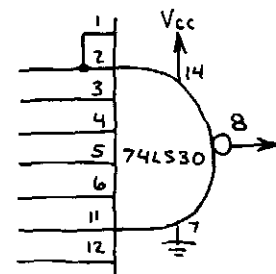
5-INPUT



6-INPUT



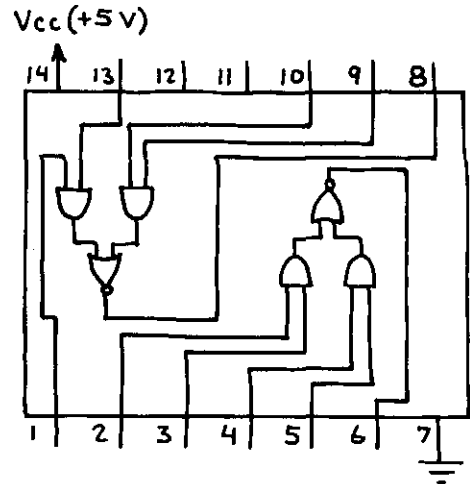
7-INPUT



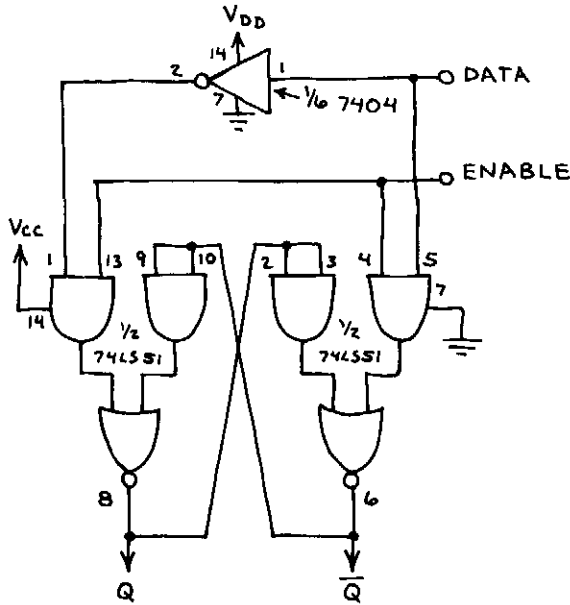
DUAL AND-OR-INVERT GATE

74LS51

VERY VERSATILE BUILDING BLOCK CHIP. IDEAL FOR CUSTOMIZED DATA SELECTORS, LATCHES AND EXPANSION OF A SINGLE INPUT TO AN AND-OR INPUT.

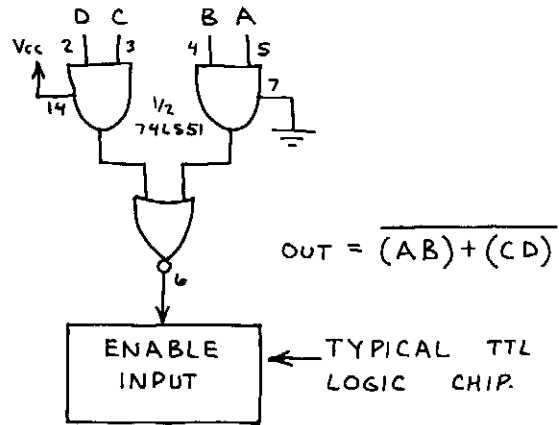


LATCH WITH ENABLE INPUT



Q OUTPUT FOLLOWS DATA INPUT WHEN ENABLE INPUT IS HIGH. NO CHANGE WHEN ENABLE IS LOW.

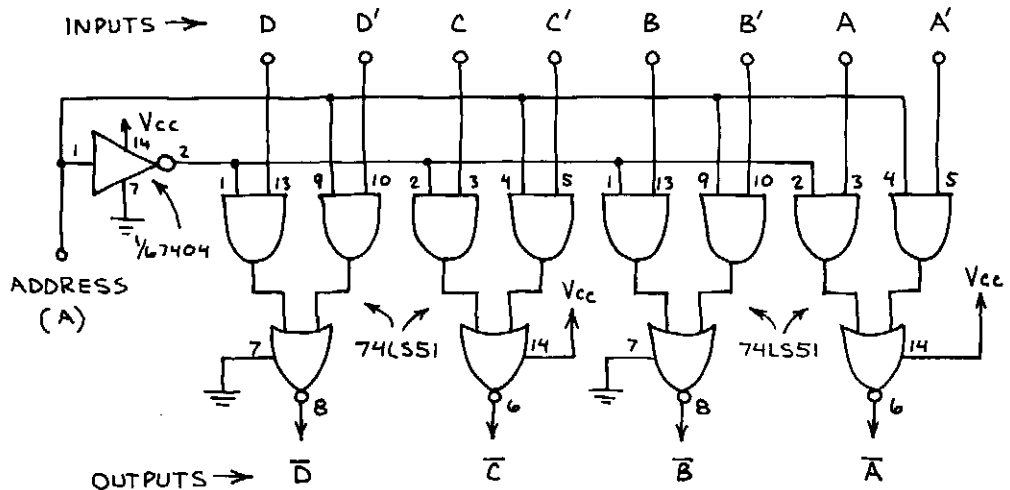
TYPICAL AND-OR INPUT



THIS CIRCUIT SELECTS 1-OF-2 4-BIT WORDS. NOTE THAT THE SELECTED WORD IS INVERTED AT THE OUTPUTS. THE CIRCUIT REQUIRES TWO 74LS51 CHIPS.

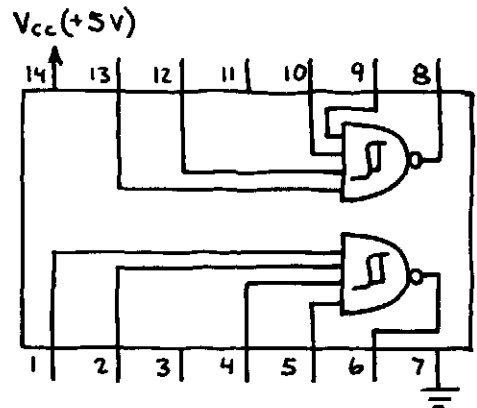
1-OF-2 DATA SELECTOR

A	INPUT		OUT
	X	X	
H	X	L	H
H	X	H	L
L	L	X	H
L	H	X	L

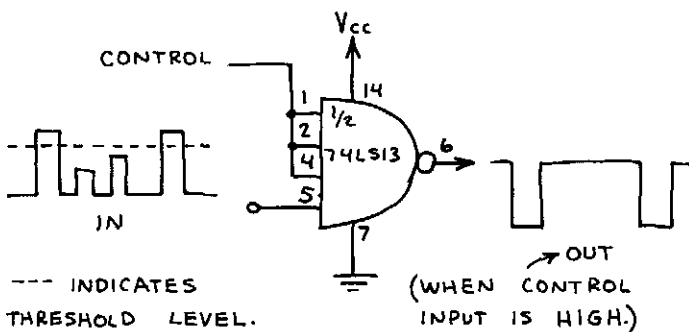


DUAL NAND SCHMITT TRIGGER 74LS13

TWO 4-INPUT NAND GATES WITH A SWITCHING THRESHOLD. OUTPUTS GO LOW WHEN INPUTS EXCEED 1.7 VOLTS. OUTPUTS GO HIGH WHEN INPUTS FALL TO 0.9 VOLT. IF ANY INPUT IS LOW, THE RESPECTIVE OUTPUT WILL STAY HIGH AND THE GATE WILL NOT TRIGGER.



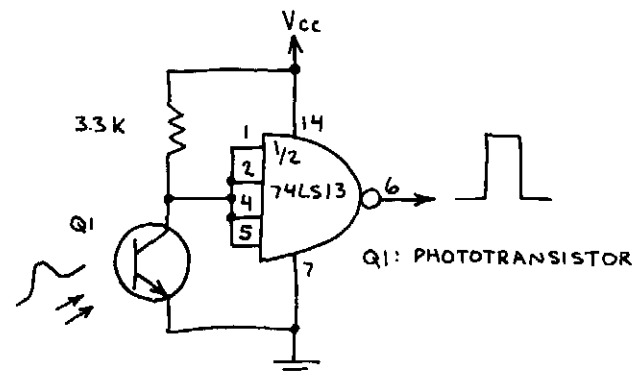
GATED THRESHOLD DETECTOR



--- INDICATES THRESHOLD LEVEL.

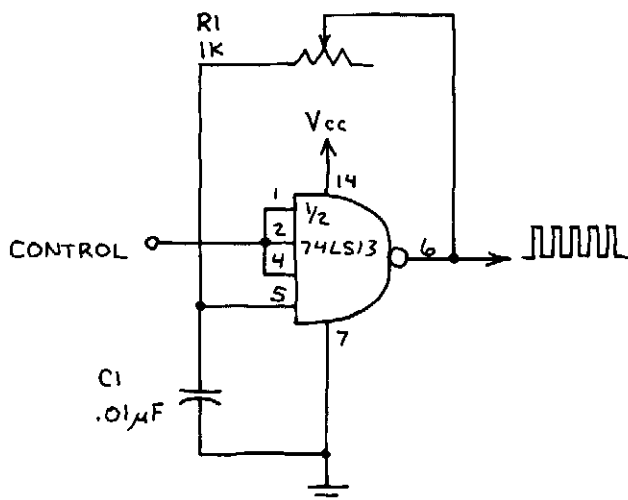
(WHEN CONTROL INPUT IS HIGH)

PHOTOTRANSISTOR RECEIVER



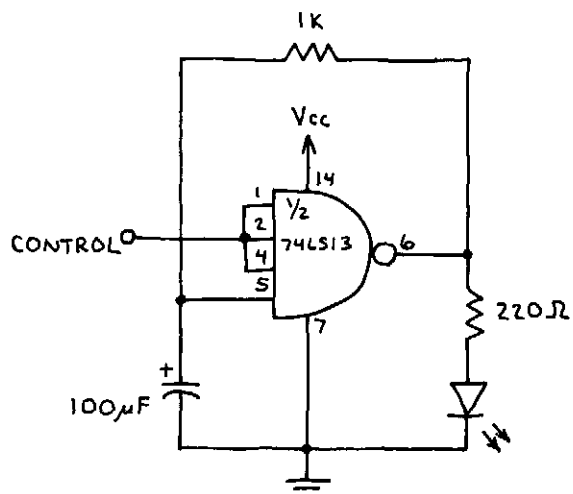
USE TO CLEAN UP INCOMING LIGHT PULSES.

GATED OSCILLATOR



OSCILLATES WHEN CONTROL IS HIGH. CHANGE R1 AND C1 TO CHANGE FREQUENCY. OK TO USE THIS CIRCUIT AS GATED CLOCK FOR LOGIC CIRCUITS.

TWO-STATE LED FLASHER



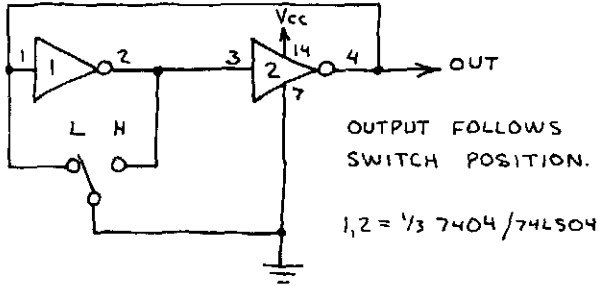
LED FLASHES TWICE EACH SECOND WHEN CONTROL INPUT IS HIGH. LED STAYS ON AND DOES NOT FLASH WHEN CONTROL IS LOW.

HEX INVERTER

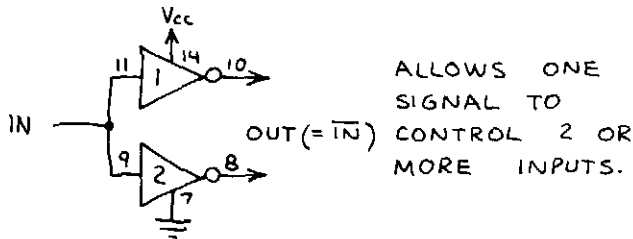
7404/74LS04

VERY IMPORTANT IN ALMOST ALL LOGIC CIRCUITS. CHANGES AN INPUT TO ITS COMPLEMENT (i.e. $H \rightarrow L$ AND $L \rightarrow H$).

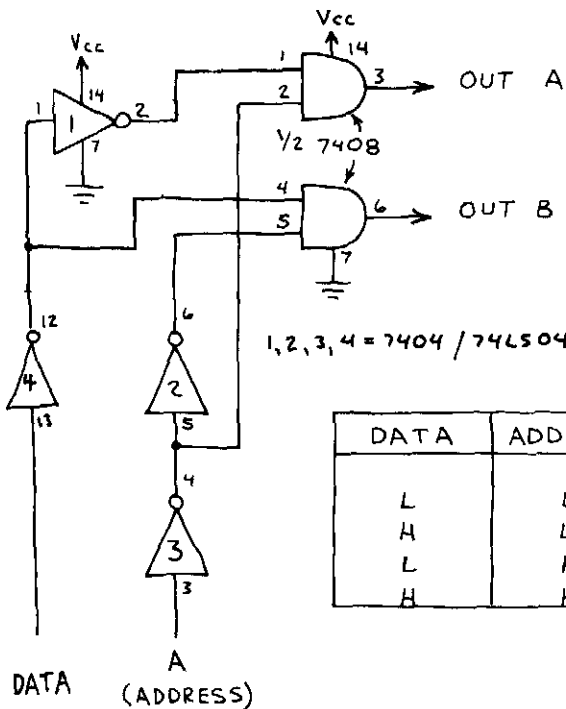
BOUNCEFREE SWITCH



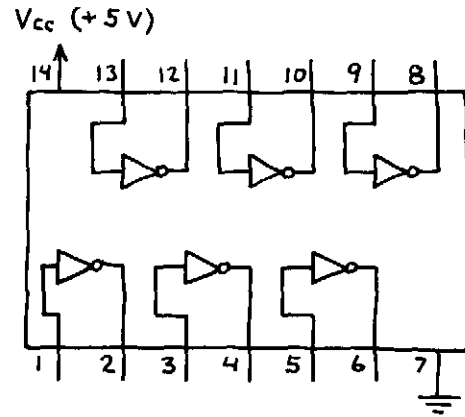
UNIVERSAL EXPANDER



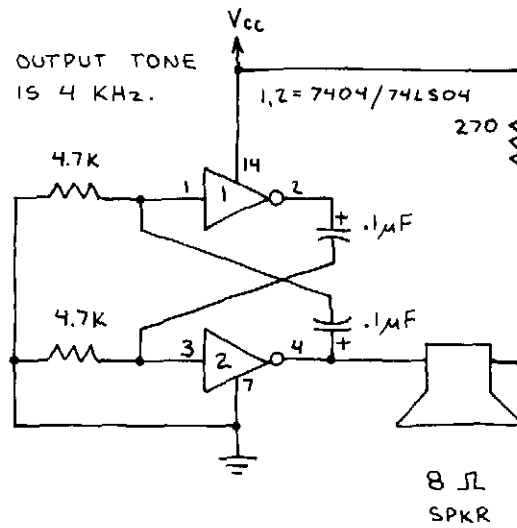
1-OF-2 DEMULTIPLEXER



DATA	ADDRESS	OUT A	OUT B
L	L	L	L
H	L	H	L
L	H	L	H
H	H	L	L



AUDIO OSCILLATOR



THIS CIRCUIT STEERS THE INPUT BIT TO THE OUTPUT SELECTED BY THE ADDRESS.

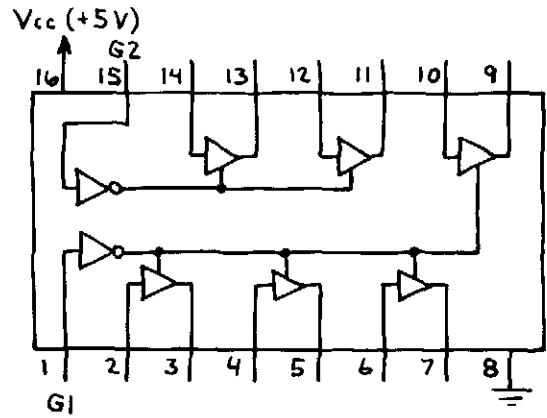
THIS TECHNIQUE CAN BE USED TO MAKE MULTIPLE OUTPUT DEMULTIPLEXERS.

HEX 3-STATE BUS DRIVER 74LS367

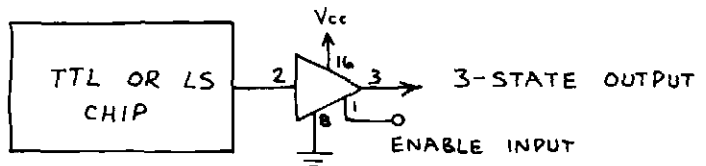
EACH GATE FUNCTIONS AS A NON-INVERTING BUFFER WHEN ITS ENABLE INPUT (G1 OR G2) IS LOW. OTHERWISE EACH GATE'S OUTPUT ENTERS THE HIGH IMPEDANCE (HI-Z) STATE.

HERE'S THE TRUTH TABLE:

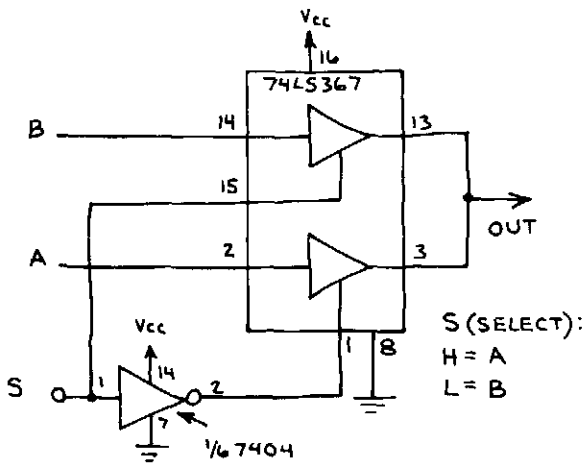
G	IN	OUT
H	X	HI-Z
L	L	L
L	H	H



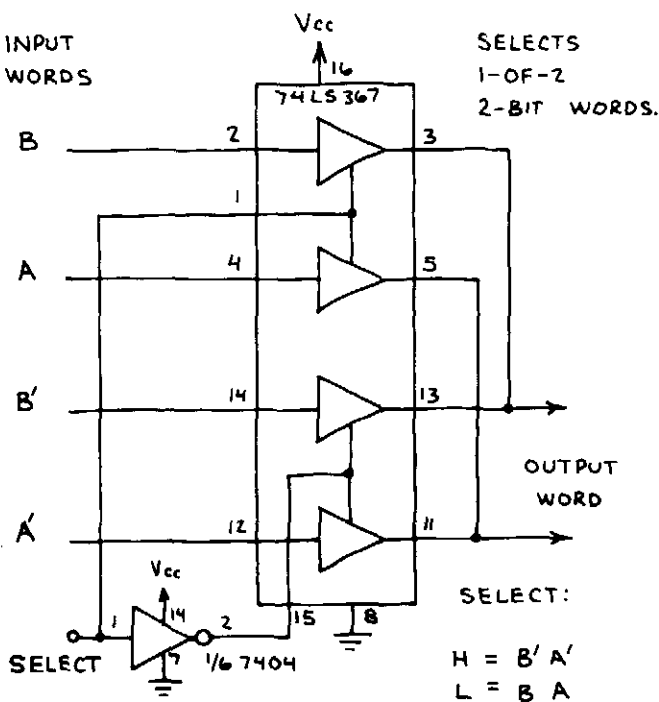
ADDING 3-STATE OUTPUT TO TTL



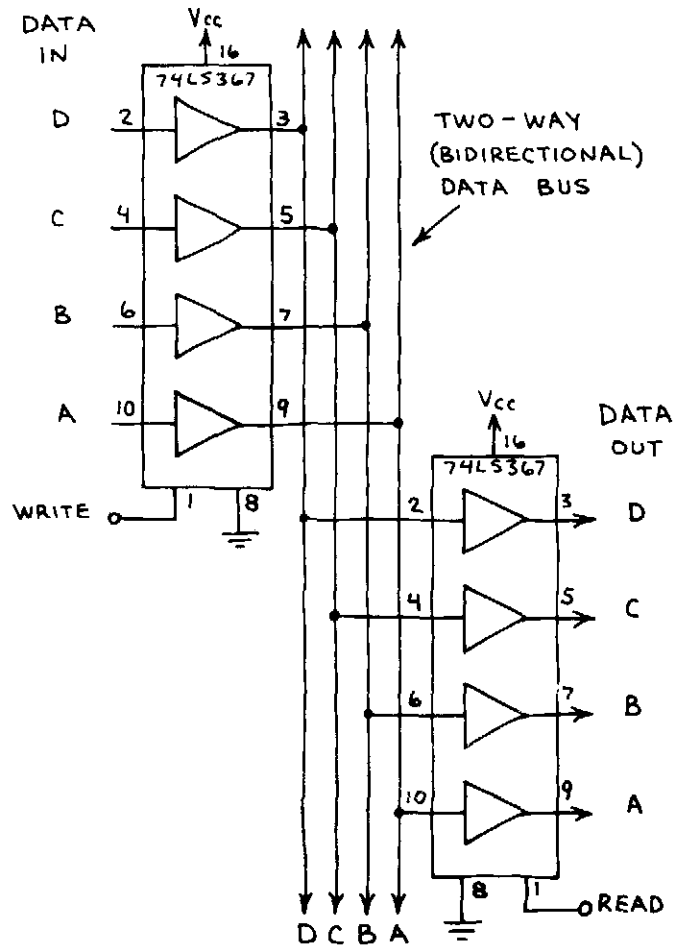
1-OF-2 DATA SELECTOR



1-OF-2 DATA SELECTOR



BIDIRECTIONAL DATA BUS

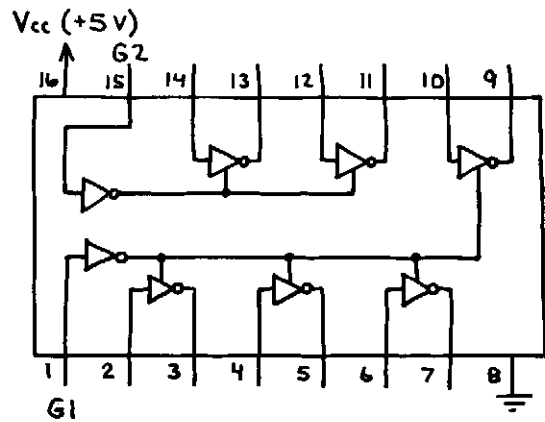


HEX 3-STATE BUS DRIVER 74LS368

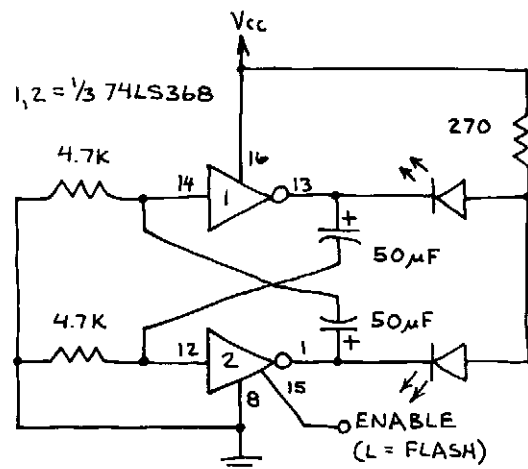
EACH GATE FUNCTIONS AS AN INVERTER WHEN ITS ENABLE INPUT (G1 OR G2) IS LOW. OTHERWISE EACH GATE'S OUTPUT ENTERS THE HIGH IMPEDANCE (HI-Z) STATE.

HERE'S THE TRUTH TABLE:

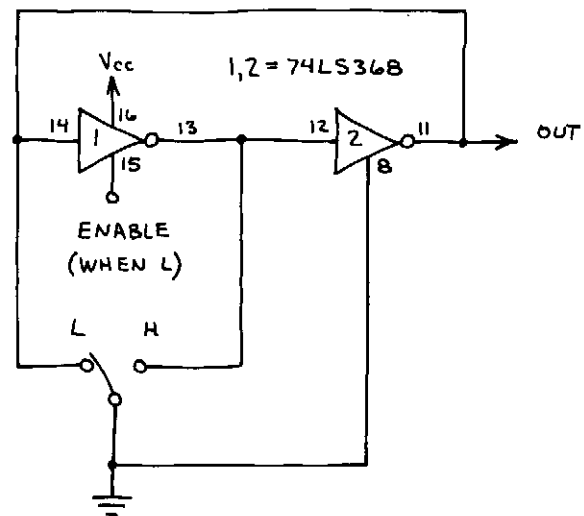
G	IN	OUT
H	X	HI-Z
L	L	H
L	H	L



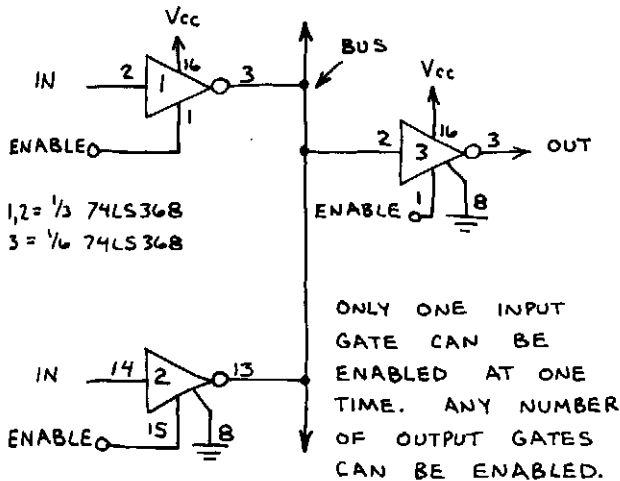
GATED LED FLASHER



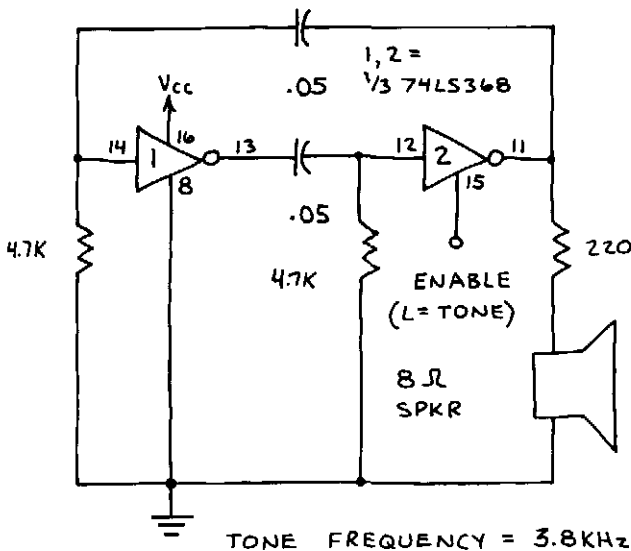
BOUNCELESS SWITCH (WITH ENABLE)



BIDIRECTIONAL DATA BUS

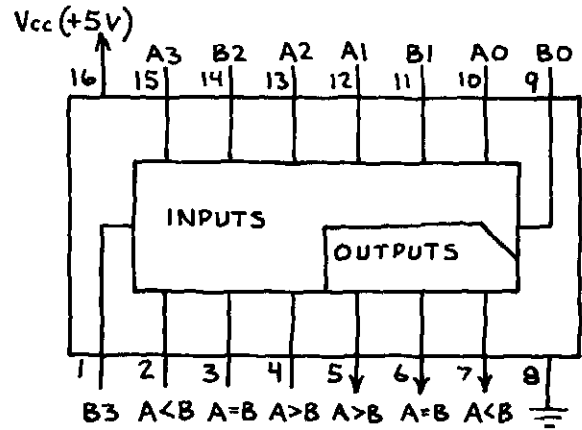


GATED TONE SOURCE

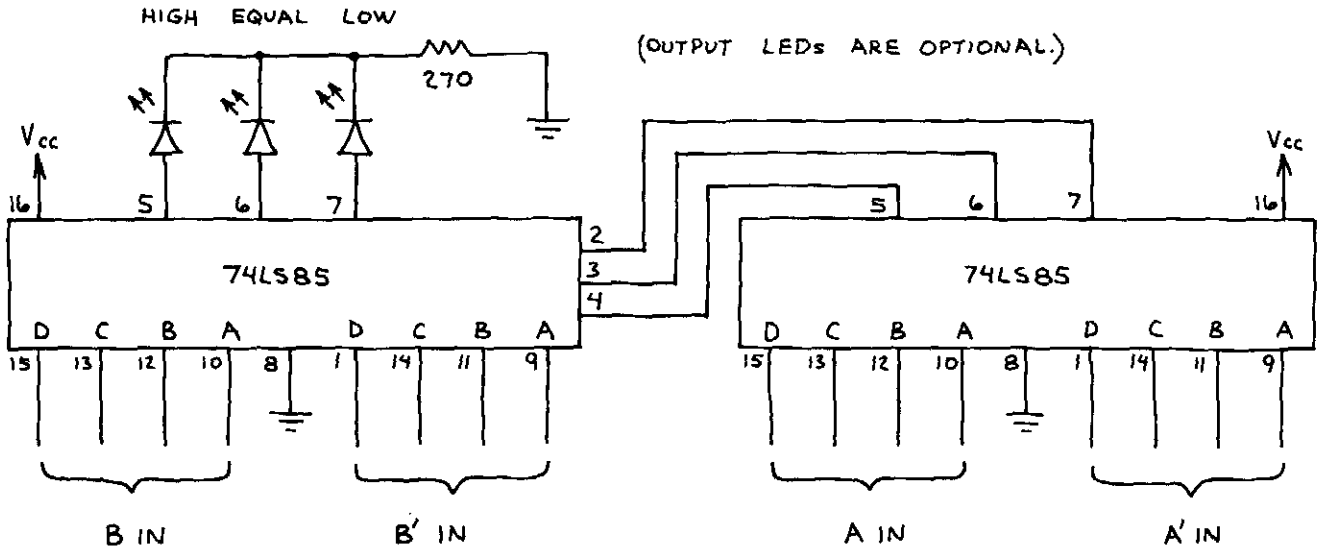


4-BIT MAGNITUDE COMPARATOR 74LS85

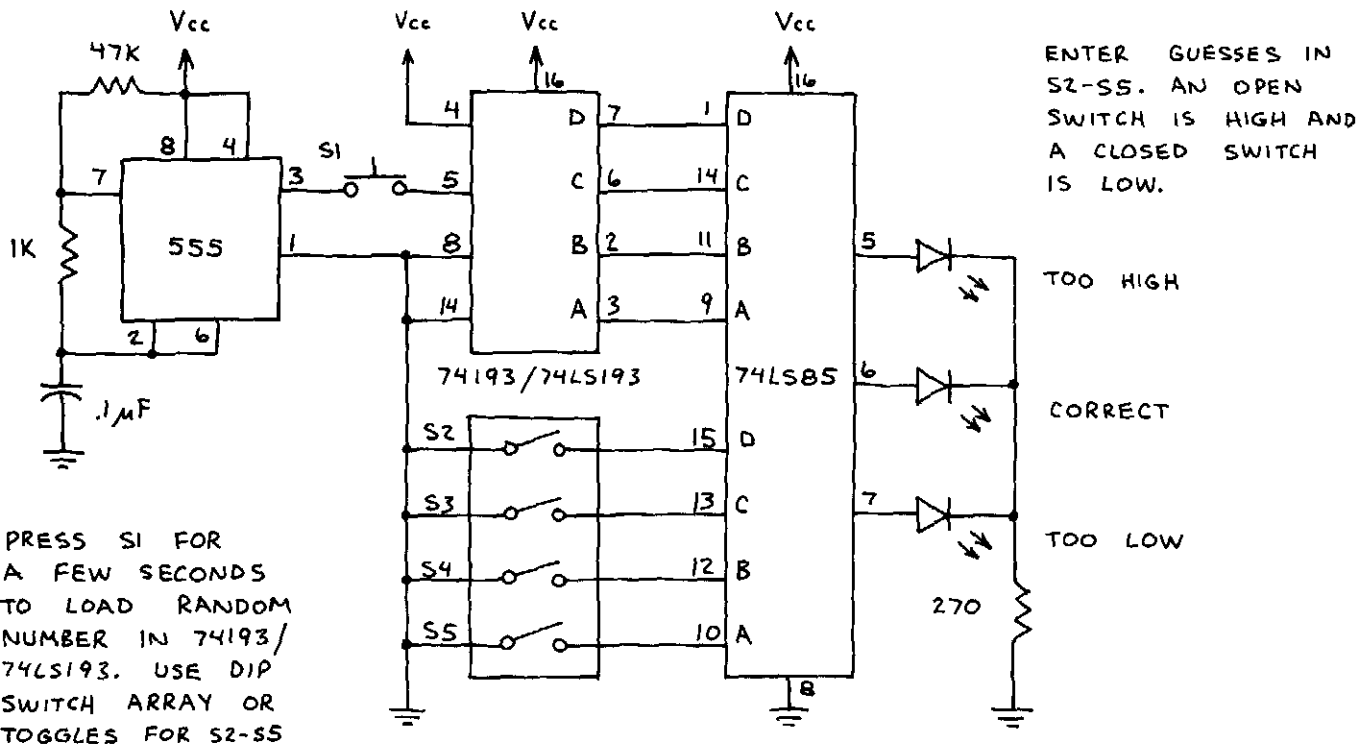
COMPARES TWO 4-BIT WORDS. INDICATES WHICH IS LARGER OR IF THEY ARE EQUAL.



8-BIT COMPARATOR



BINARY HI-LO GAME



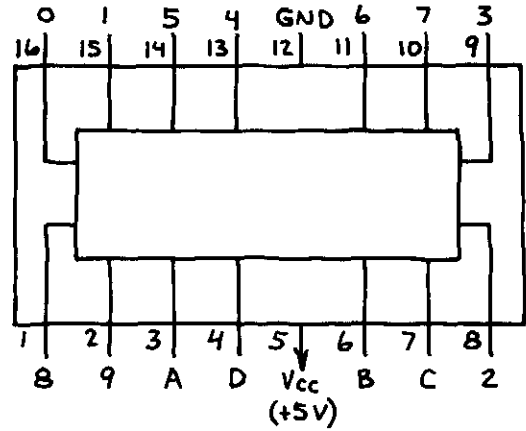
PRESS S1 FOR A FEW SECONDS TO LOAD RANDOM NUMBER IN 74193/74LS193. USE DIP SWITCH ARRAY OR TOGGLES FOR S2-S5

ENTER GUESSES IN S2-S5. AN OPEN SWITCH IS HIGH AND A CLOSED SWITCH IS LOW.

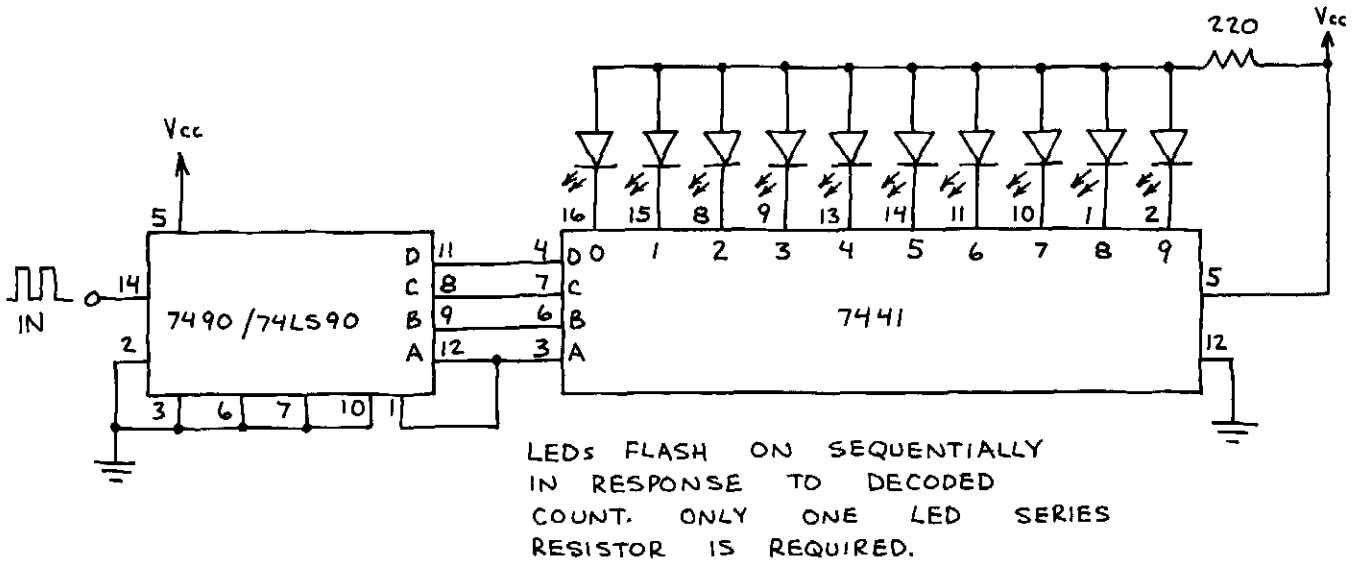
BCD-TO-DECIMAL DECODER

7441

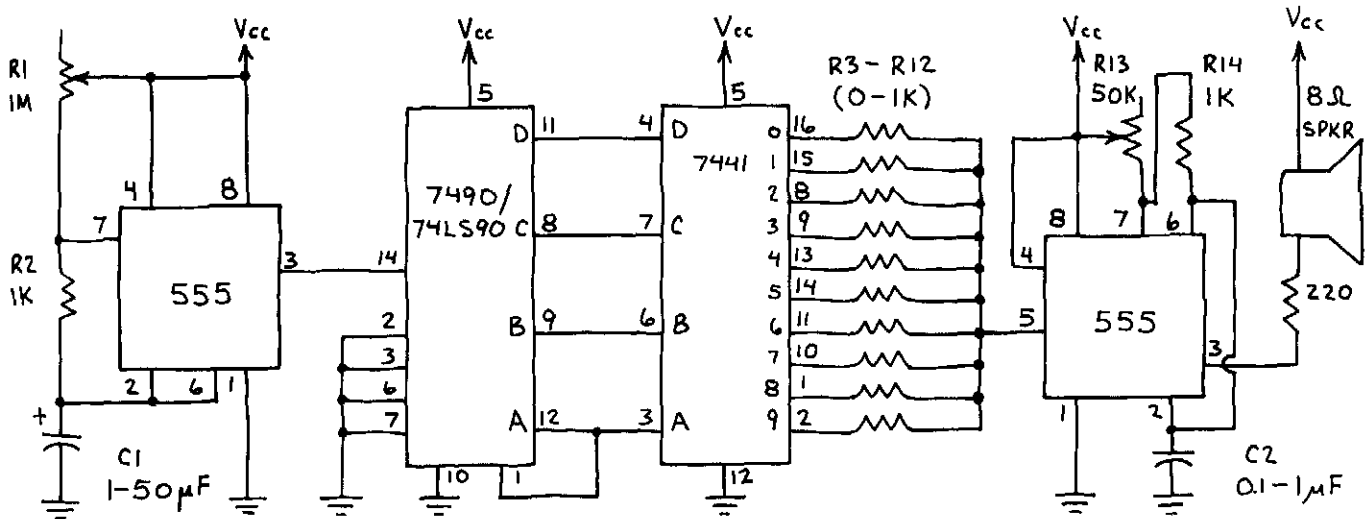
DECODES 4-BIT BCD INPUT INTO 1-OF-10 OUTPUTS. SELECTED OUTPUT GOES LOW; ALL OTHERS STAY HIGH. ORIGINALLY DESIGNED TO DRIVE GASEOUS GLOW DISCHARGE TUBES. ALL OUTPUTS GO HIGH FOR BINARY INPUTS EXCEEDING HLLH (1001).



1-OF-10 DECODED COUNTER



10-NOTE TONE SEQUENCER

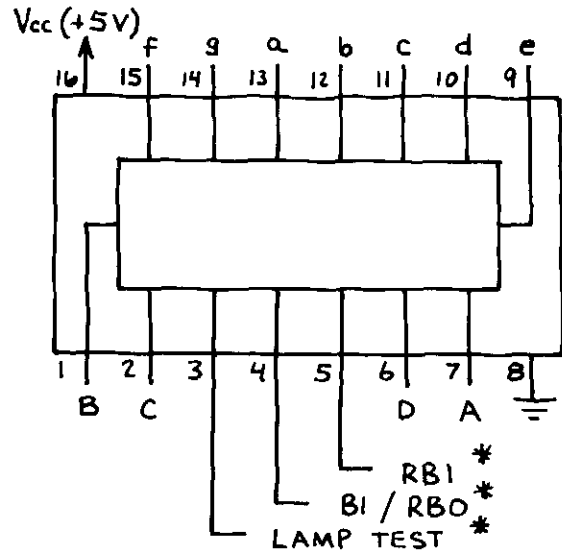
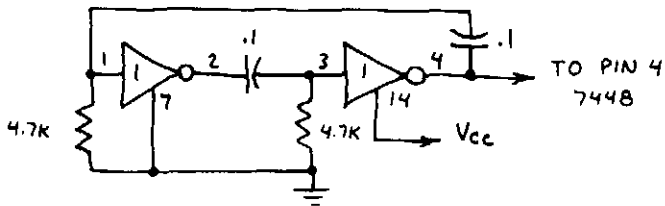


INCREASE C1 TO DECREASE TEMPO. INCREASE C2 TO INCREASE TONE FREQUENCIES. TONES ARE DETERMINED BY R3-R12.

BCD-TO-7-SEGMENT DECODER / DRIVER 7448

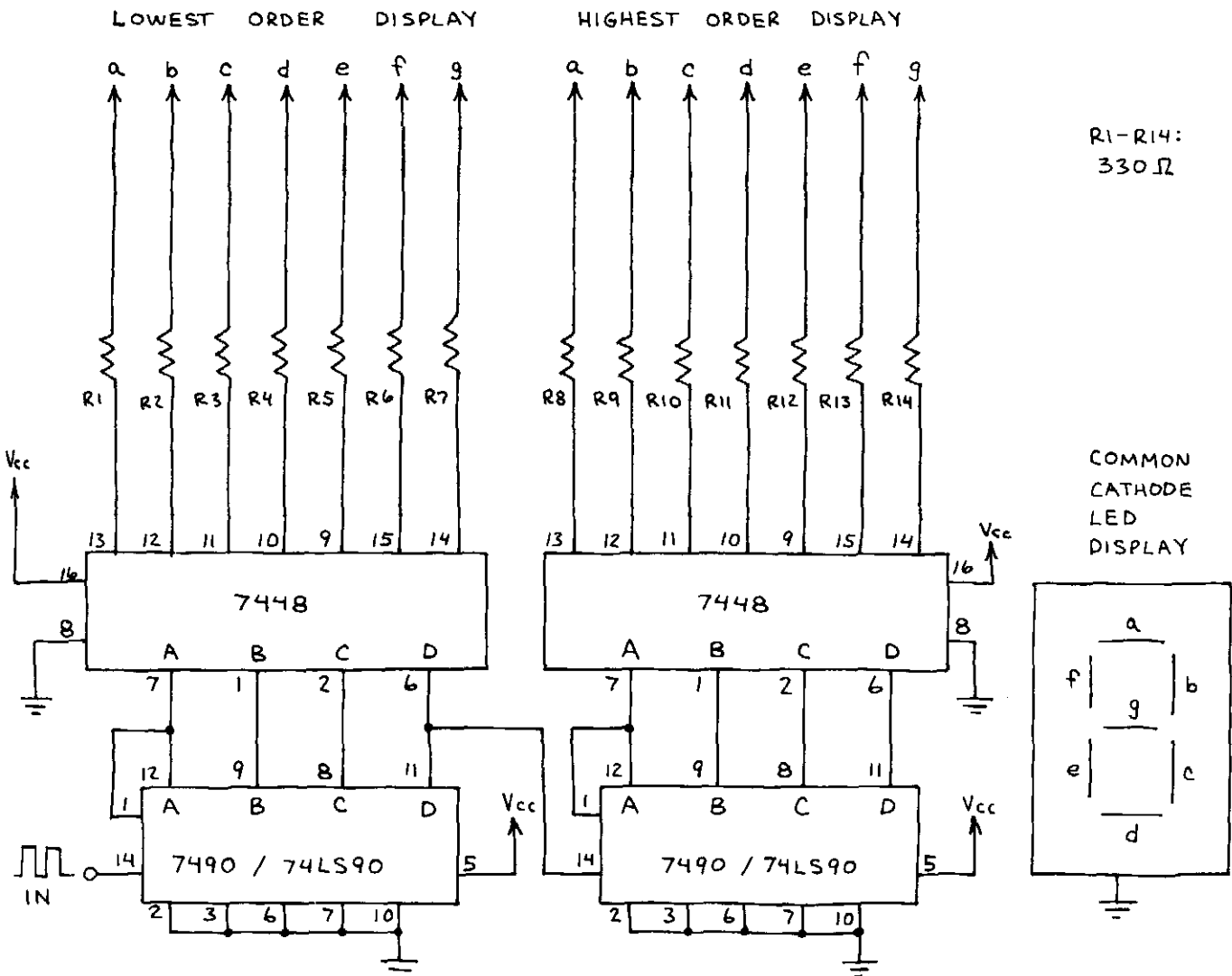
CONVERTS BCD DATA INTO
FORMAT SUITABLE FOR PRODUCING
DECIMAL DIGITS ON COMMON
CATHODE LED 7-SEGMENT DISPLAY.

DISPLAY DIMMER



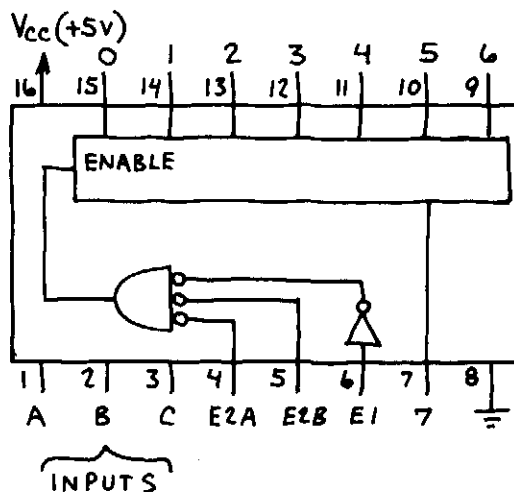
*SEE 7447 FOR
EXPLANATIONS.

0-99 TWO DIGIT COUNTER

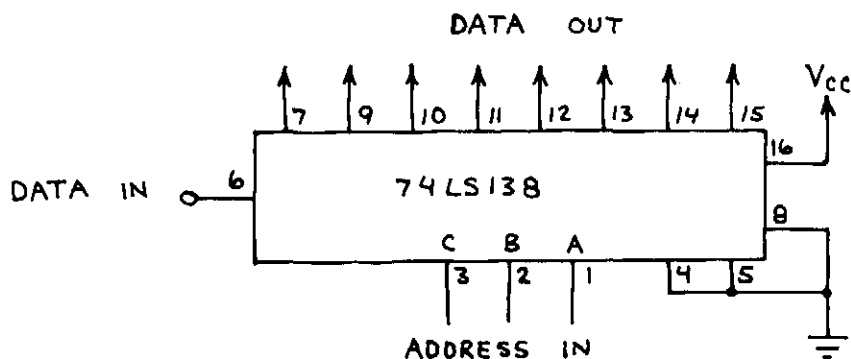


3-LINE TO 8-LINE DECODER 74LS138

EACH 3-BIT ADDRESS DRIVES ONE OUTPUT LOW. ALL OTHERS STAY HIGH. THIS CHIP HAS THREE ENABLE INPUTS. WHEN E2 IS HIGH, ALL OUTPUTS ARE HIGH. WHEN E1 IS LOW, ALL OUTPUTS ARE HIGH. TO ENABLE CHIP, MAKE E1 HIGH AND E2 LOW. (NOTE: E2 = E2A + E2B.)

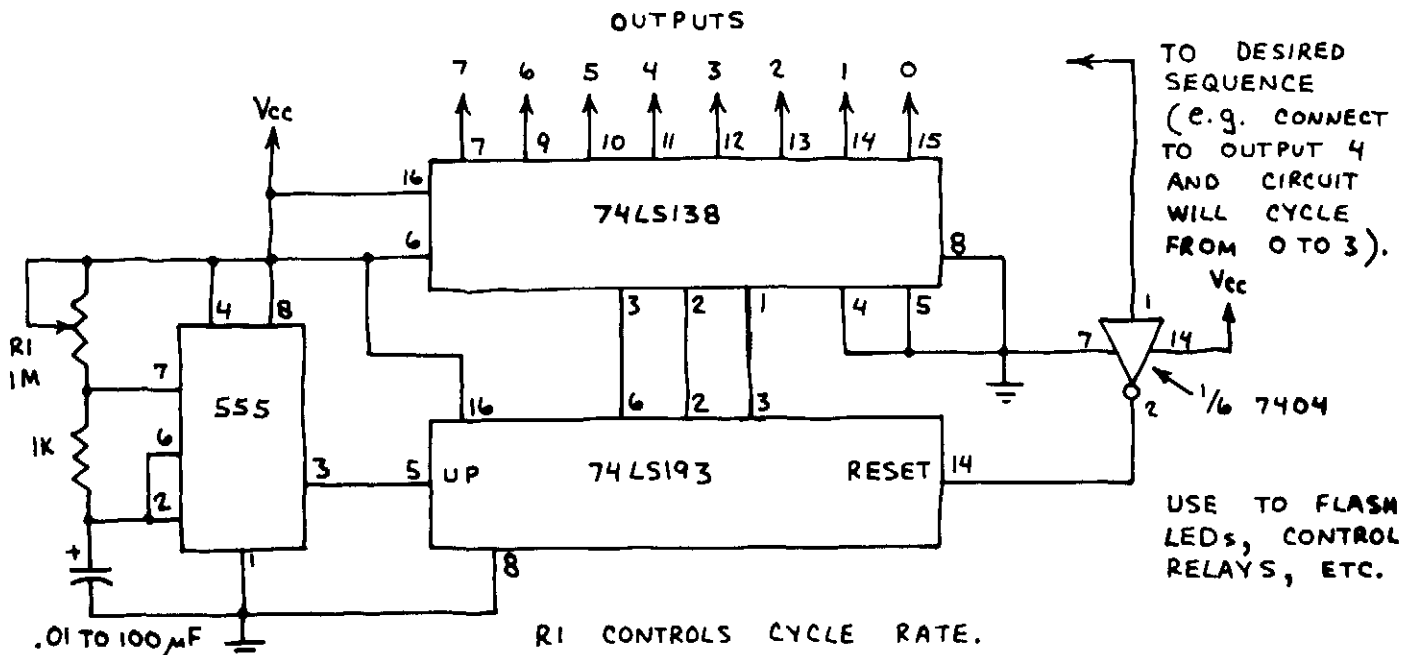


1-TO-8 DEMULTIPLEXER



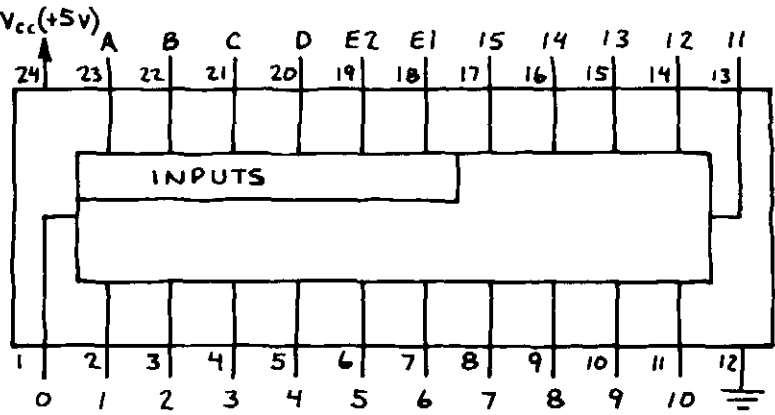
INPUT DATA (H OR L) IS PASSED TO SELECTED OUTPUT.

2-TO-8 STEP SEQUENCER

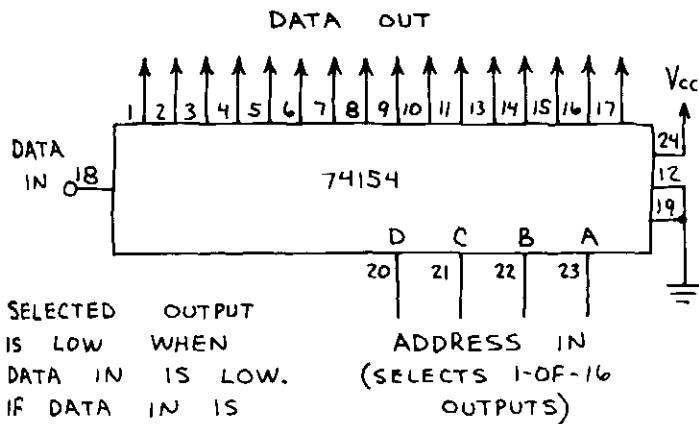


4-LINE TO 16-LINE DECODER 74154

EACH 4-BIT ADDRESS
DRIVES ONE OUTPUT LOW.
ALL OTHERS STAY HIGH.
ENABLE INPUTS (E1 AND E2)
MUST BE LOW. IF ONE OR
BOTH ARE HIGH, ALL
OUTPUTS GO LOW.



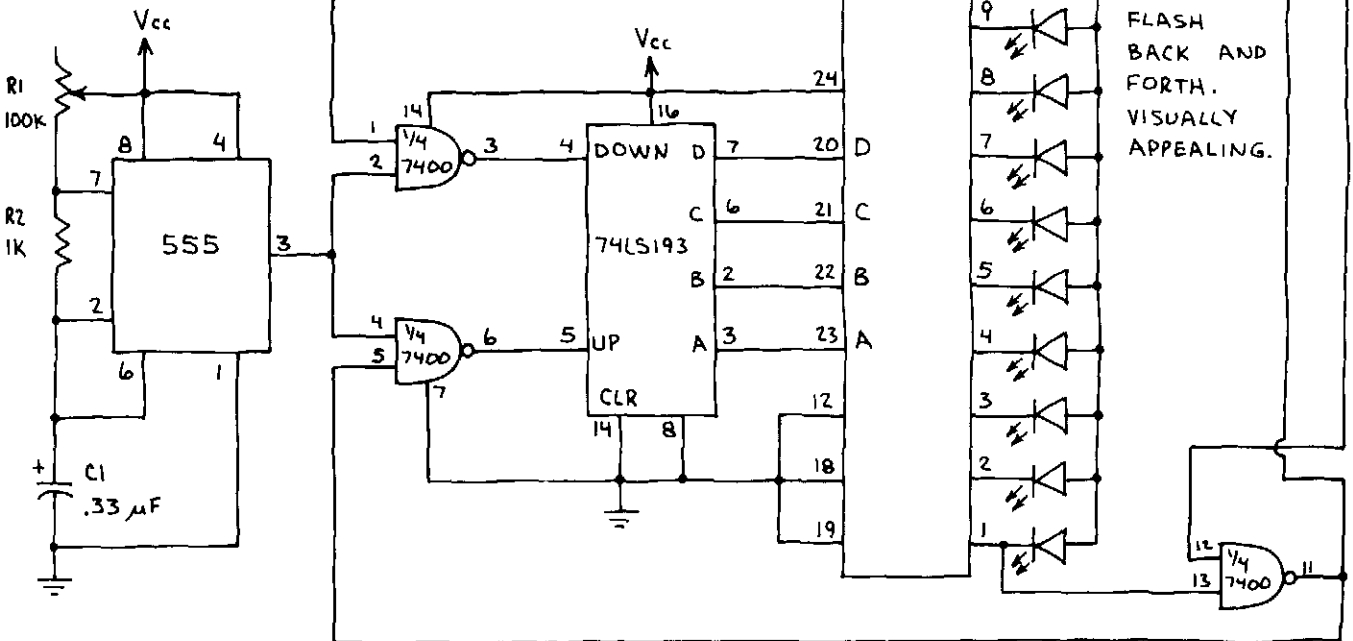
1-TO-16 DEMULTIPLEXER



SELECTED OUTPUT
IS LOW WHEN
DATA IN IS LOW.
IF DATA IN IS
HIGH, SELECTED
OUTPUT IS HIGH.

ADDRESS IN
(SELECTS 1-OF-16
OUTPUTS)

BACK AND FORTH FLASHER

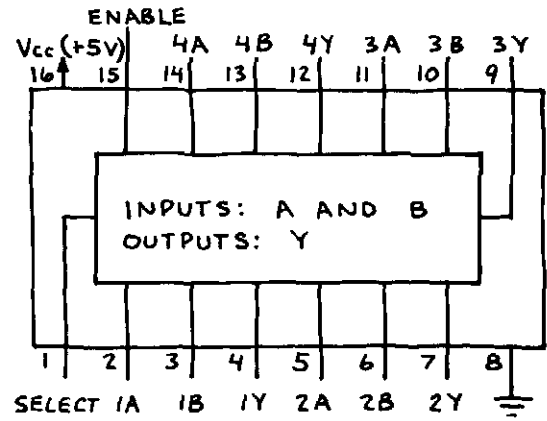


THESE
LEDS
FLASH
BACK AND
FORTH.
VISUALLY
APPEALING.

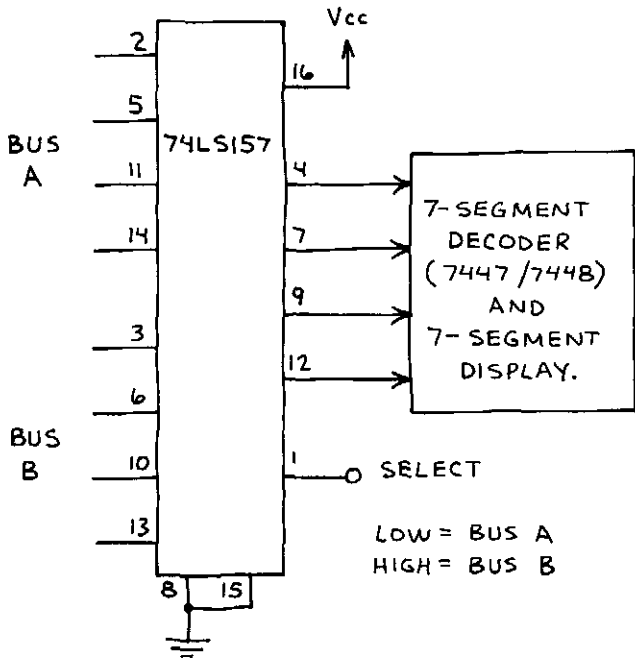
INCREASE R1 TO SLOW FLASH RATE.

QUAD 1-OF-2 DATA SELECTOR 74LS157

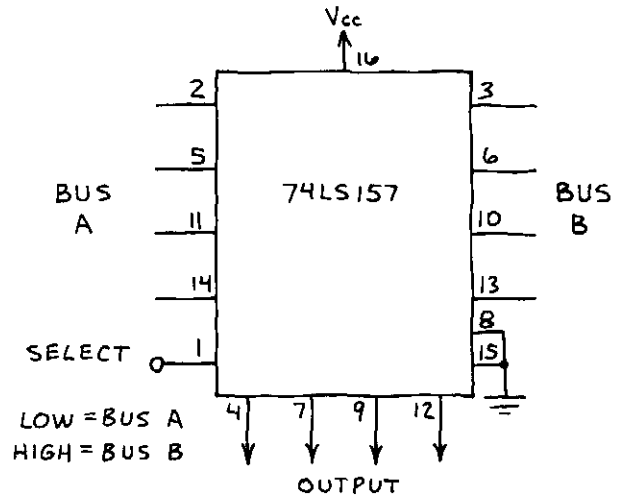
FOUR 2-LINE TO 1-LINE MULTIPLEXERS.
MANY USES IN ROUTING DATA. ALL
4 DATA SELECTORS ARE ENABLED
WHEN PIN 15 IS LOW.



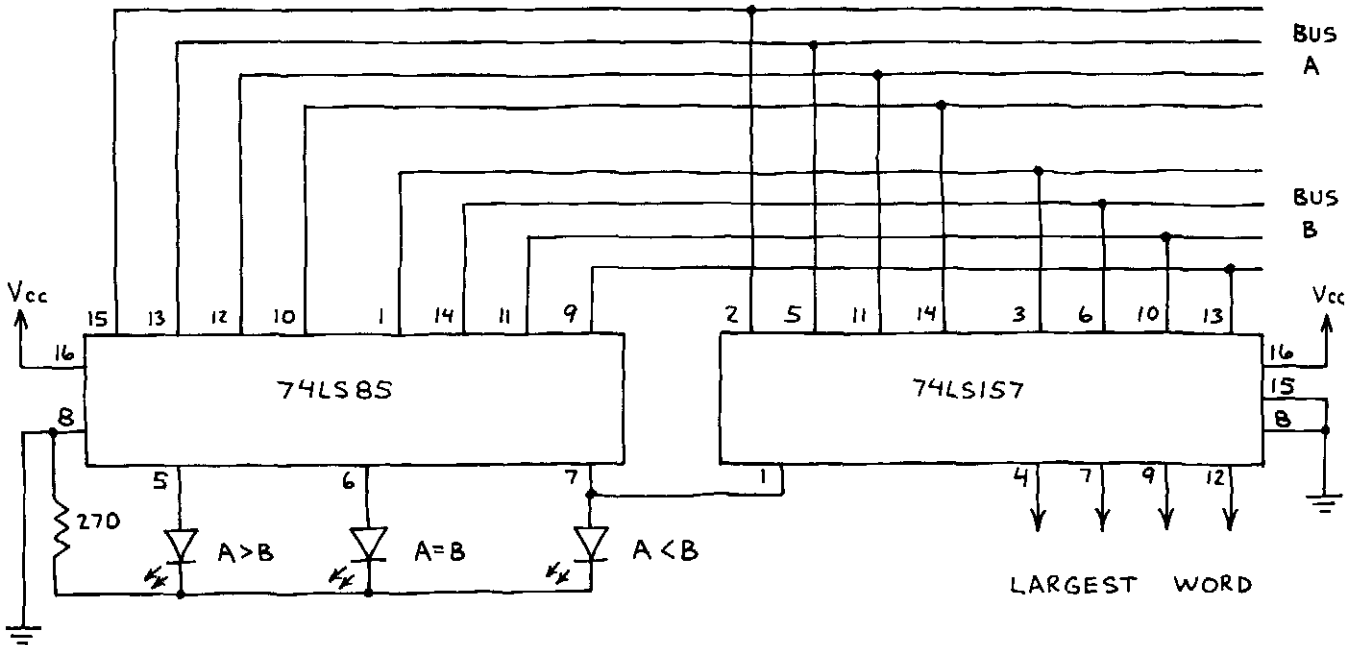
DOUBLE DUTY DISPLAY



BUS SELECTOR



WORD SORTER



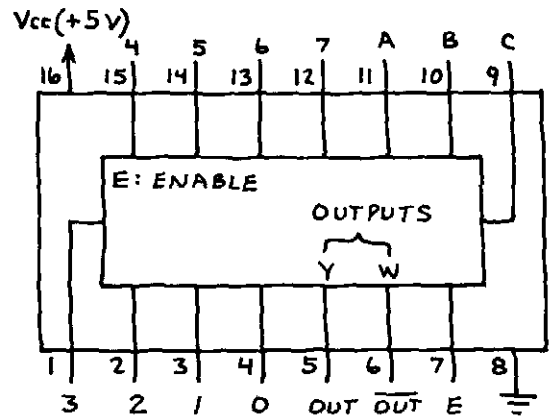
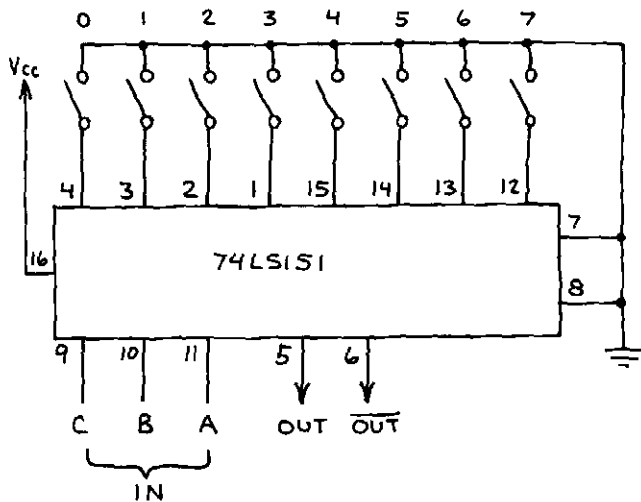
THIS CIRCUIT CONTINUALLY MONITORS TWO DATA BUSES. BUS WITH
HIGHEST MAGNITUDE DATA WORD IS ROUTED AUTOMATICALLY TO OUTPUT.

1-OF-8 DATA SELECTOR 74LS151

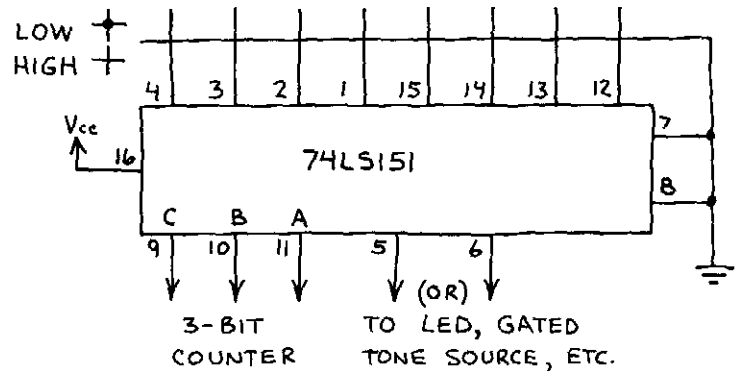
EQUIVALENT TO 8-LINE TO 1-LINE MULTIPLEXER.

PROGRAMMABLE GATE

3-BIT ADDRESS SELECTS ONE SWITCH AND APPLIES ITS STATUS (OPEN = HIGH AND CLOSED = LOW) TO THE OUTPUT. ANY 3-INPUT LOGIC FUNCTION CAN BE PROGRAMMED IN SECONDS.

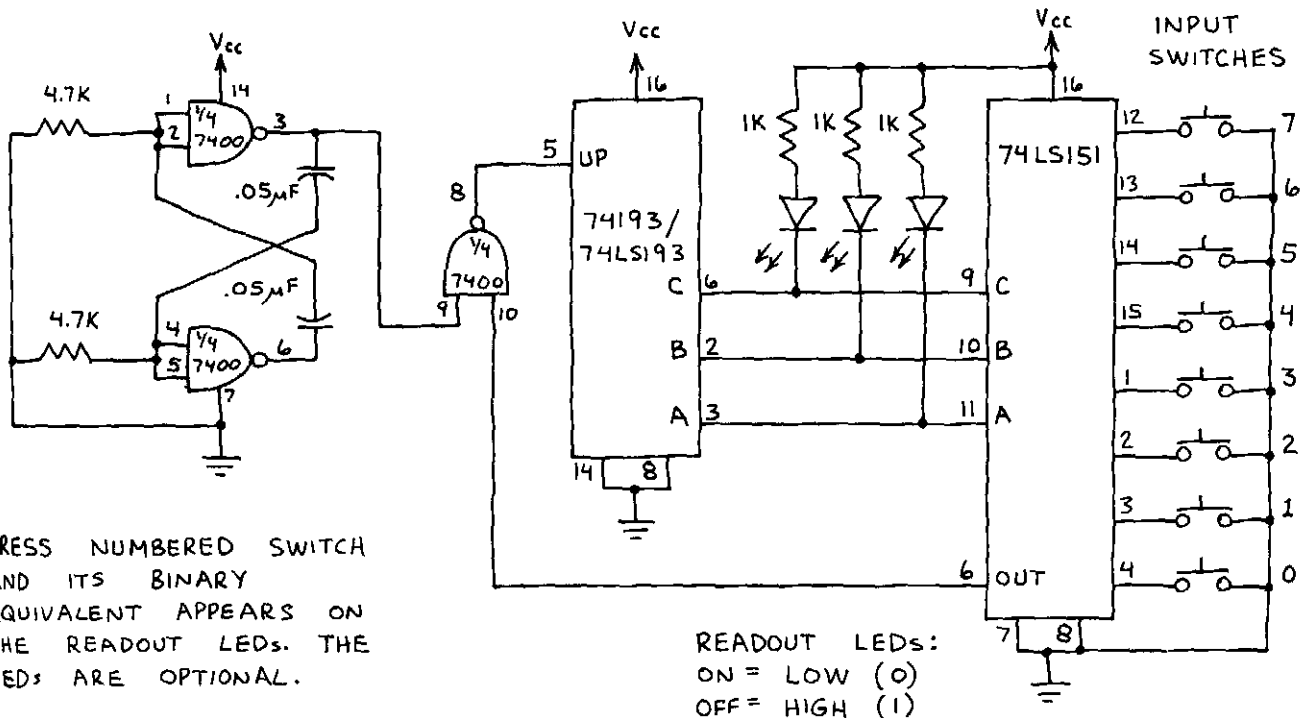


PATTERN GENERATOR



PROGRAM ANY DESIRED LOW-HIGH BIT PATTERN. THEN PLAY IT BACK.

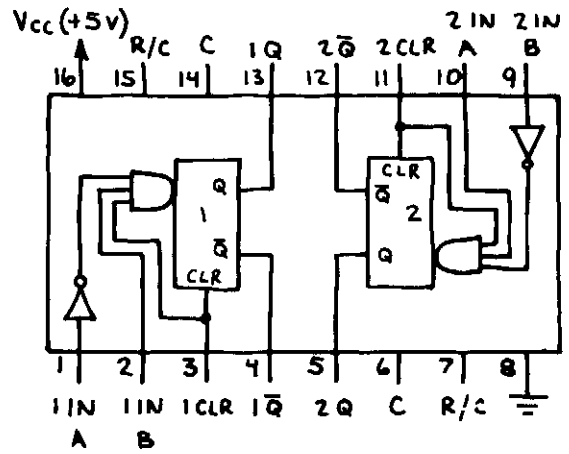
OCTAL KEYBOARD ENCODER



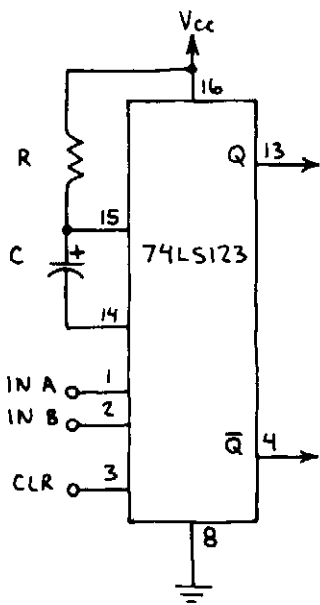
PRESS NUMBERED SWITCH AND ITS BINARY EQUIVALENT APPEARS ON THE READOUT LEDs. THE LEDs ARE OPTIONAL.

DUAL ONE-SHOT 74LS123

TWO FULLY INDEPENDENT MONOSTABLE MULTIVIBRATORS. BOTH ARE RETRIGGERABLE. PINS DESIGNATED R AND R/C ARE FOR EXTERNAL TIMING RESISTOR AND CAPACITOR.



BASIC ONE-SHOT



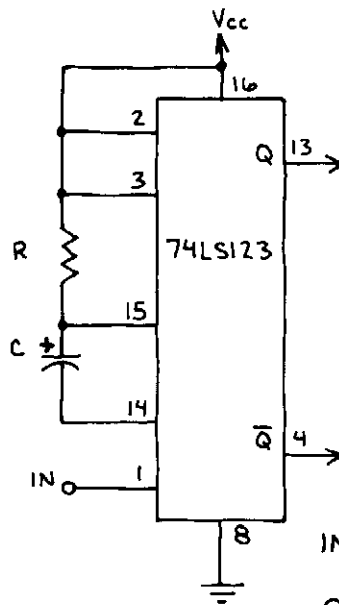
TWO WAYS TO TRIGGER:

1. KEEP INPUTS A AND B LOW; THEN MAKE B HIGH.
2. KEEP INPUTS A AND B HIGH; THEN MAKE A LOW.

TO CLEAR:

MAKE PIN 3 LOW. THIS ALSO INHIBITS TRIGGERING.

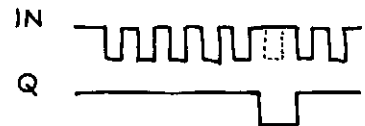
MISSING PULSE DETECTOR



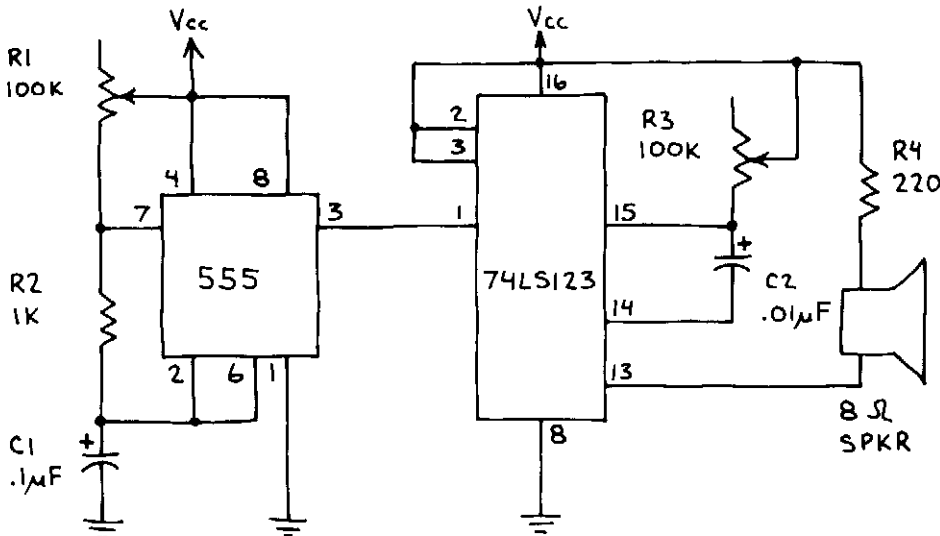
Q OUTPUT STAYS HIGH SO LONG AS INCOMING PULSES ARRIVE BEFORE ONE-SHOT TIMING PERIOD RUNS OUT.

ADJUST R AND C TO GIVE TIMING PERIOD ABOUT 1/3 LONGER THAN THE INTERVAL BETWEEN INCOMING PULSES.

OPERATION:



TONE STEPPER



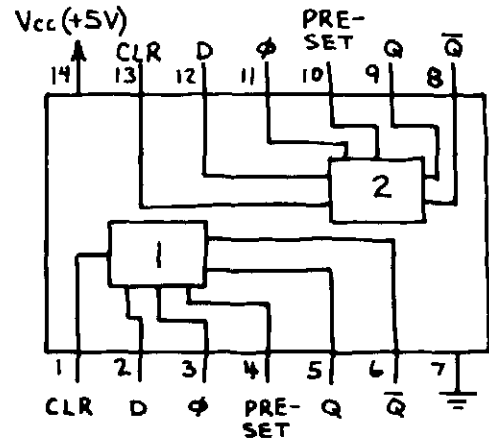
THIS CIRCUIT STEPS ACROSS A RANGE OF TONES WHEN R1 AND/OR R3 ARE ADJUSTED. VERY UNUSUAL SOUND EFFECTS.

CHANGE C1 AND C2 FOR OTHER TONE RANGES. ALSO, TRY PHOTOSENSORS FOR R1 AND R3.

DUAL D FLIP-FLOP 7474 / 74LS74

TWO D (DATA) FLIP-FLOPS IN A SINGLE PACKAGE. DATA AT D INPUT IS STORED AND MADE AVAILABLE AT Q OUTPUT WHEN CLOCK PULSE (ϕ) GOES HIGH. HERE'S THE TRUTH TABLE:

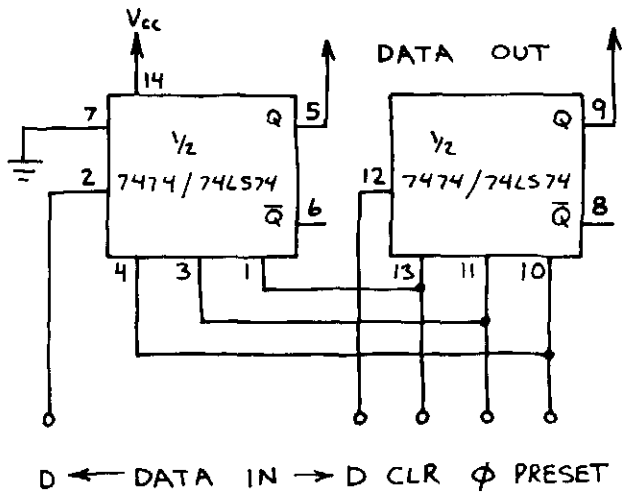
PRESET	CLEAR	CLOCK	D	Q	\bar{Q}
L	H	X	X	H	L
H	L	X	X	L	H
H	H	\uparrow	H	H	L
H	H	\uparrow	L	L	H



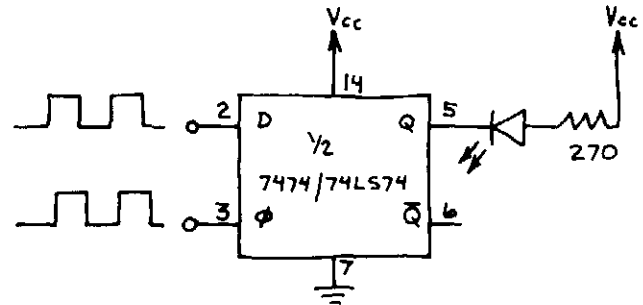
ϕ IS CLOCK INPUT.

\uparrow IS RISING EDGE OF CLOCK PULSE.

2-BIT STORAGE REGISTER

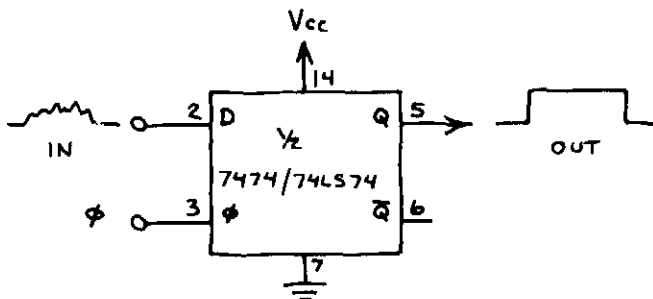


PHASE DETECTOR

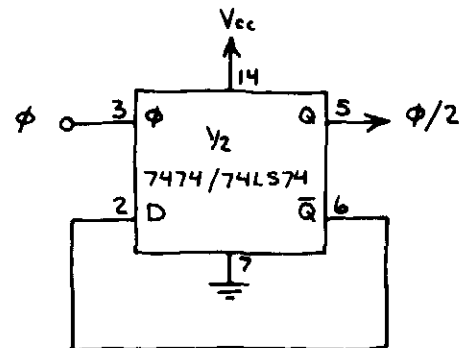


THE LED GLOWS WHEN INPUT FREQUENCIES F_1 AND F_2 ARE UNEQUAL OR OUT OF PHASE. F_1 AND F_2 SHOULD BE SQUARE WAVES.

WAVE SHAPER



DIVIDE-BY-TWO COUNTER

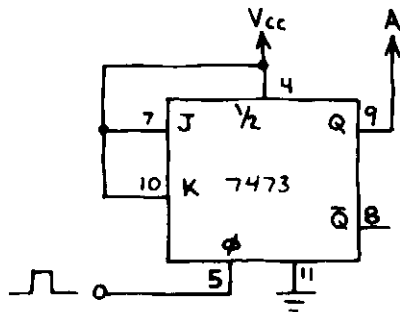


DUAL J-K FLIP-FLOP 7473

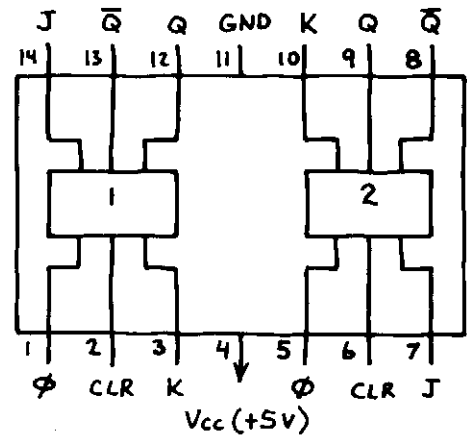
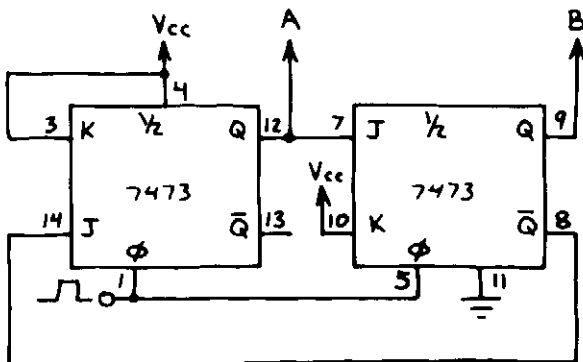
TWO JK FLIP-FLOPS IN A SINGLE PACKAGE. NOTE THE CLEAR INPUTS. THESE FLIP-FLOPS WILL TOGGLE (SWITCH OUTPUT STATES) IN RESPONSE TO INCOMING CLOCK PULSES WHEN BOTH J AND K INPUTS ARE HIGH. HERE'S THE TRUTH TABLE:

CLEAR	CLOCK	J	K	Q	\bar{Q}
L	X	X	X	L	H
H	\bar{L}	H	L	H	L
H	\bar{L}	L	H	L	H
H	\bar{L}	H	H	TOGGLE	

DIVIDE-BY-TWO



DIVIDE-BY-THREE



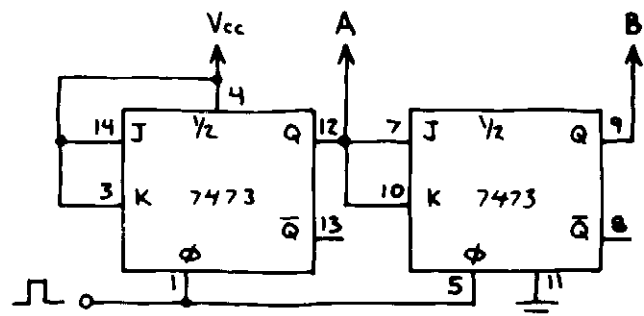
ϕ IS CLOCK INPUT.

BINARY COUNTERS

THE THREE CIRCUITS ON THIS PAGE ARE BINARY COUNTERS THAT COUNT UP TO THE MAXIMUM COUNT AND AUTOMATICALLY RECYCLE. CONNECT A DECODER TO OUTPUT OF DIVIDE-BY-THREE AND DIVIDE-BY-FOUR COUNTERS TO OBTAIN ONE-OF-THREE AND ONE-OF-FOUR OPERATION. THIS TRUTH TABLE SUMMARIZES OPERATION OF THESE COUNTERS:

DIVIDE-BY:	TWO		THREE		FOUR	
	A	B	A	B	A	B
OUTPUTS:	L	L	L	L	L	L
	H	L	L	H	L	H
		H	L	L	H	L
			H	L	H	H

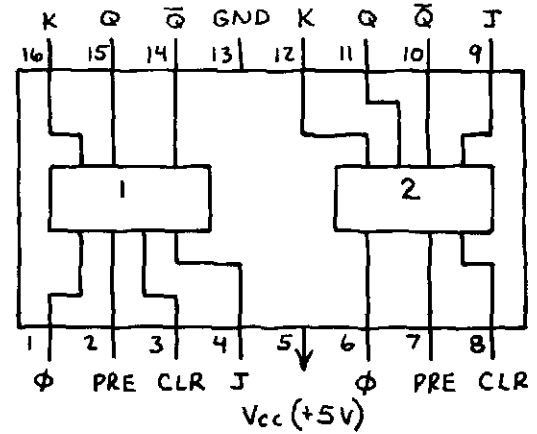
DIVIDE-BY-FOUR



DUAL J-K FLIP-FLOP 7476

TWO JK FLIP-FLOPS IN A SINGLE PACKAGE. SIMILAR TO 7473/74LS73 BUT HAS BOTH PRESET AND CLEAR INPUTS. FLIP-FLOPS WILL TOGGLE (SWITCH OUTPUT STATES) IN RESPONSE TO INCOMING CLOCK PULSES WHEN BOTH J AND K INPUTS ARE HIGH. HERE'S THE TRUTH TABLE:

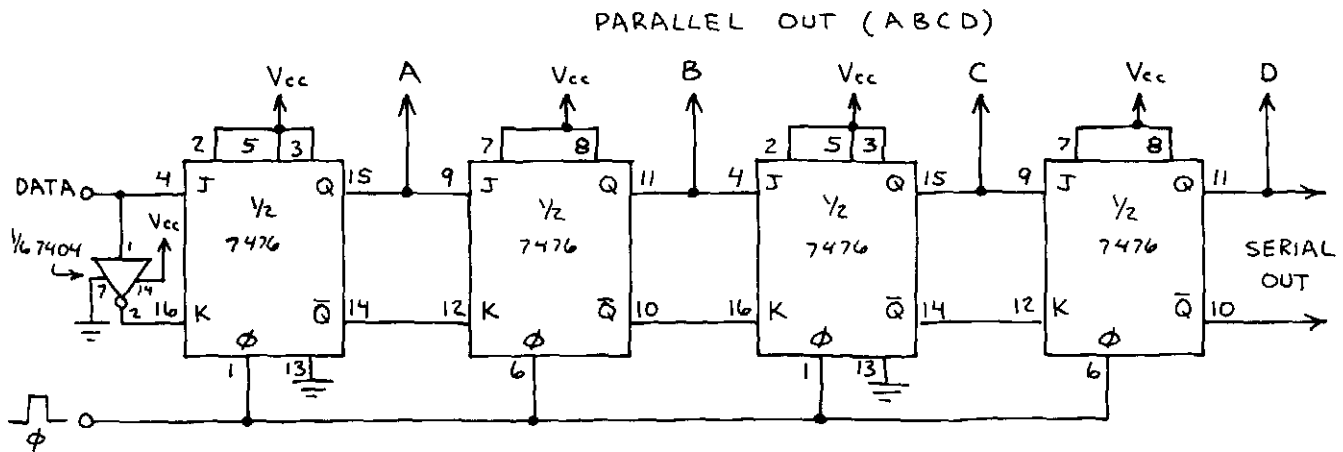
PRE	CLR	CLK	J	K	Q	\bar{Q}
L	H	X	X	X	H	L
H	L	X	X	X	L	H
H	H	\downarrow	H	L	H	L
H	H	\uparrow	L	H	L	H
H	H	\downarrow	H	H	TOGGLE	TOGGLE



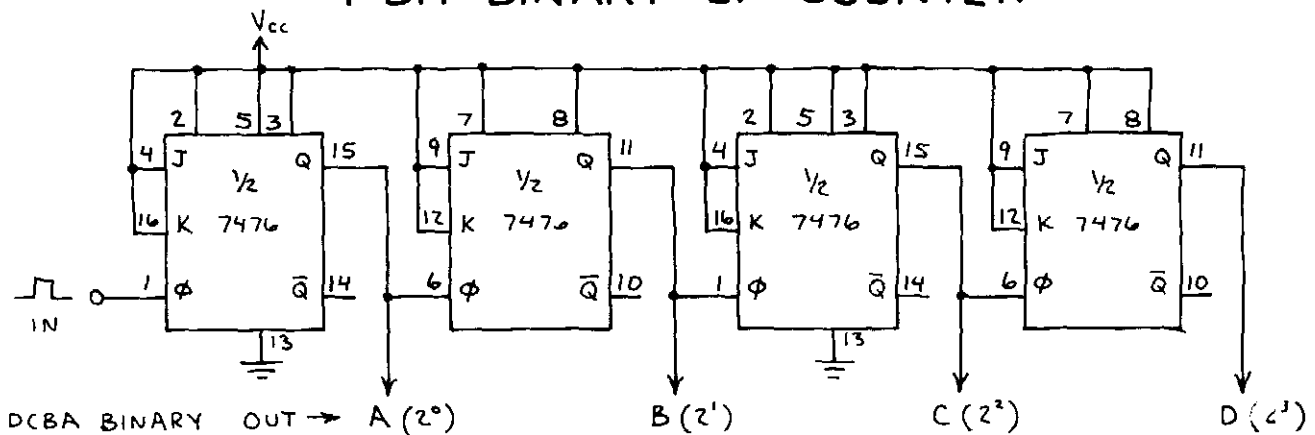
PRE = PRESET
CLR = CLEAR
 ϕ = CLOCK (OR CLK)

TOGGLE = FLIP-FLOP SWITCHES OUTPUT STATES IN RESPONSE TO CLOCK PULSES.

4-BIT SERIAL SHIFT REGISTER

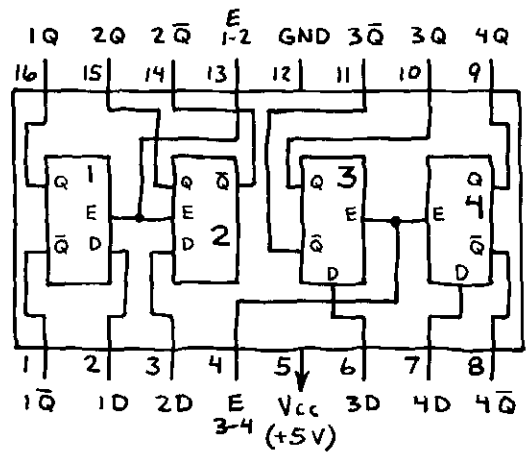


4-BIT BINARY UP COUNTER



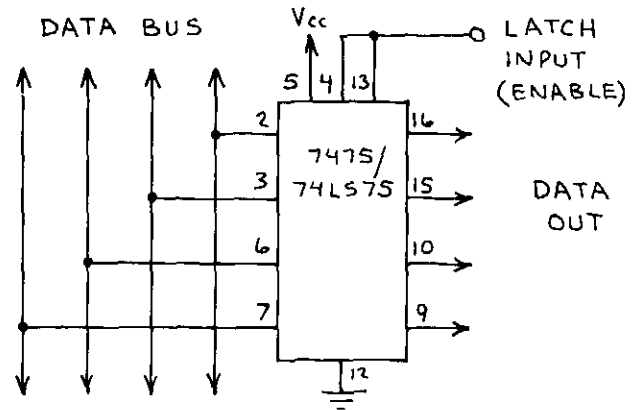
QUAD LATCH 7475/74LS75

A 4-BIT BISTABLE LATCH. PRIMARILY USED TO STORE THE COUNT IN DECIMAL COUNTING UNITS. NOTE THAT BOTH Q AND \bar{Q} OUTPUTS ARE PROVIDED. ALSO NOTE THE E (ENABLE) INPUTS. WHEN E IS HIGH, Q FOLLOWS D.

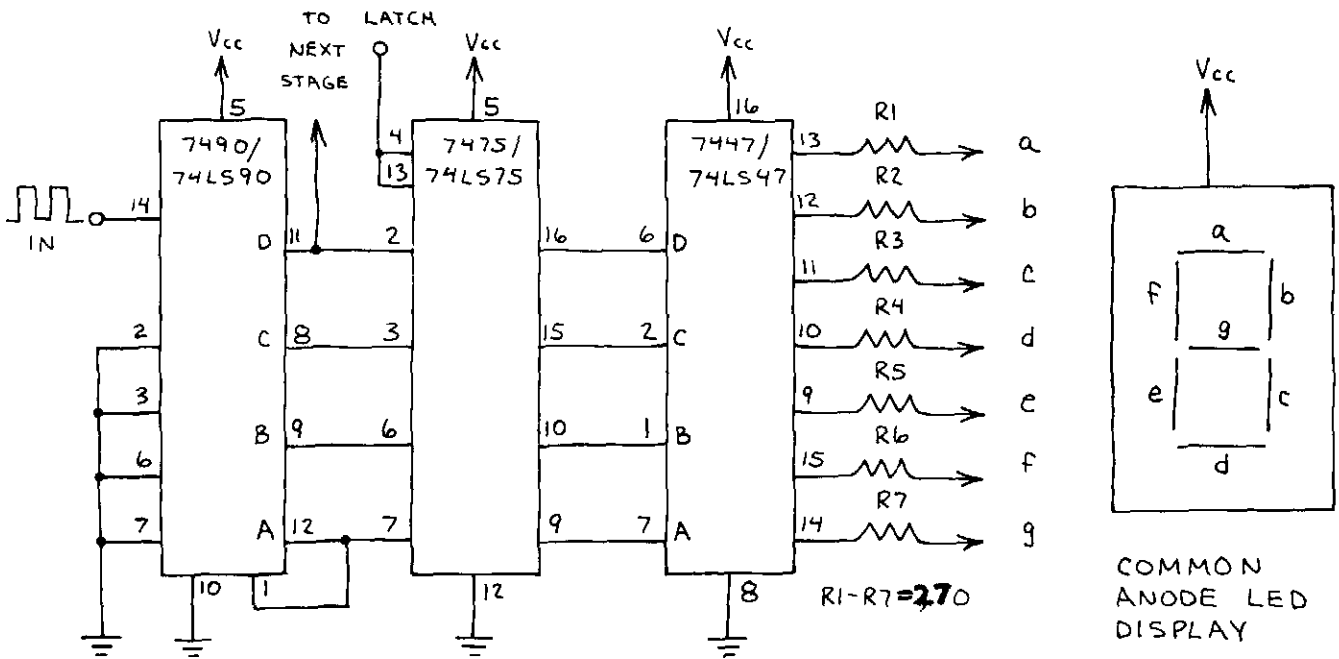


4-BIT DATA LATCH

DATA ON BUS APPEARS AT OUTPUTS WHEN LATCH INPUT IS HIGH. DATA ON BUS WHEN LATCH INPUT GOES LOW IS STORED UNTIL LATCH INPUT GOES HIGH. (LATCH INPUT CONTROLS BOTH ENABLE INPUTS.) TWO QUAD LATCHES CAN BE USED AS AN 8-BIT DATA LATCH.



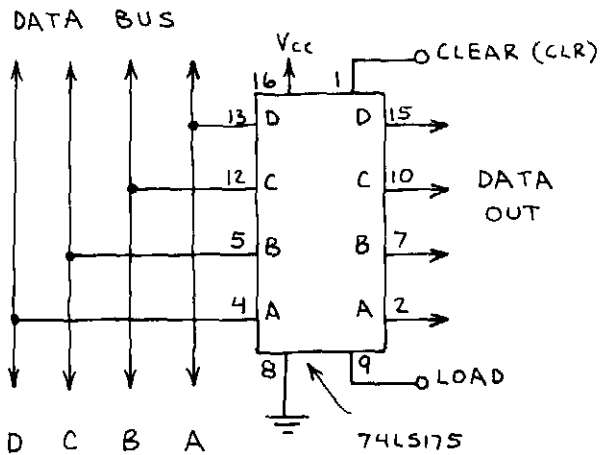
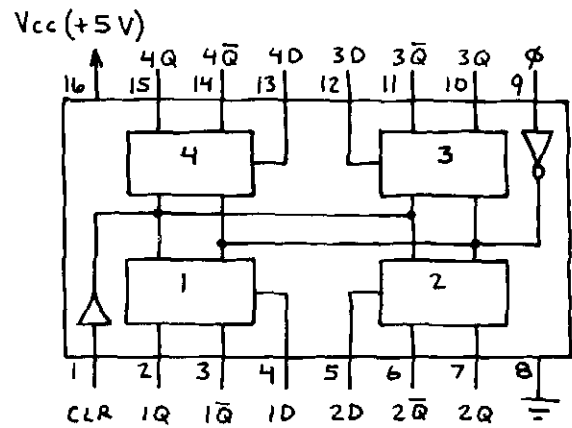
DECIMAL COUNTING UNIT



EXPANDABLE DECADE COUNTER. FOR TWO DIGIT COUNT, CONNECT PIN 11 OF 7490/74LS90 OF FIRST UNIT TO INPUT OF SECOND UNIT. A LOW AT THE LATCH INPUT FREEZES THE DATA BEING DISPLAYED.

QUAD D FLIP-FLOP 74LS175

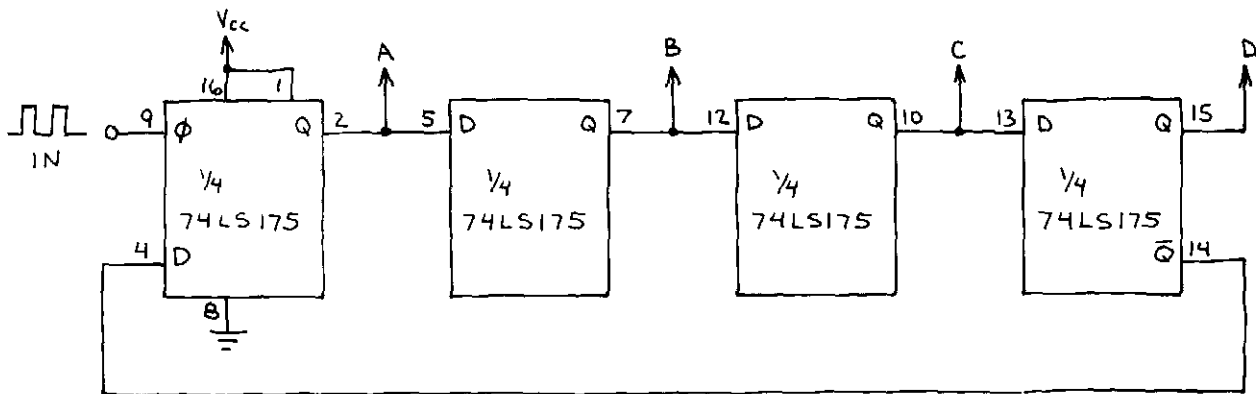
HANDY PACKAGE OF FOUR D-TYPE FLIP-FLOPS. DATA AT D-INPUTS IS LOADED WHEN CLOCK GOES HIGH. MAKING CLEAR INPUT LOW MAKES ALL Q OUTPUTS LOW AND \bar{Q} OUTPUTS HIGH.



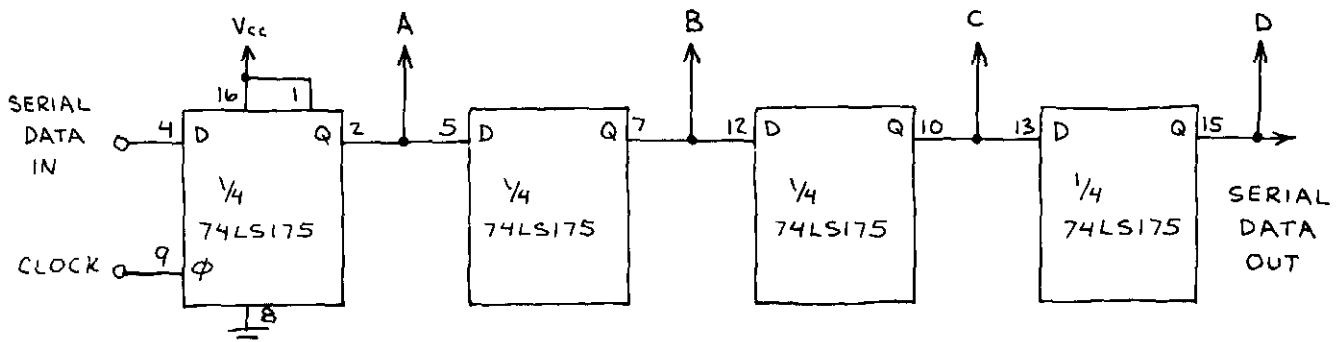
4-BIT DATA REGISTER

DATA ON BUS IS LOADED INTO 74LS175 WHEN LOAD INPUT GOES HIGH. DATA IS THEN STORED AND MADE AVAILABLE AT OUTPUTS UNTIL NEW LOAD PULSE ARRIVES.

MODULO-8 COUNTER

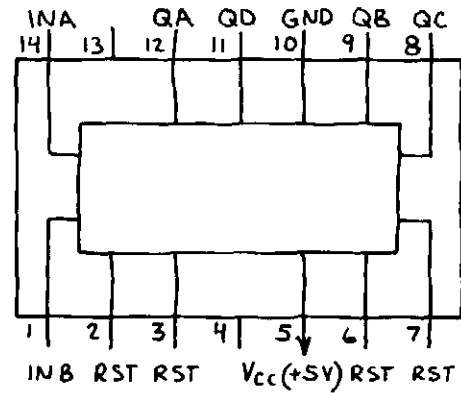


SERIAL IN/OUT, PARALLEL OUT SHIFT REGISTER

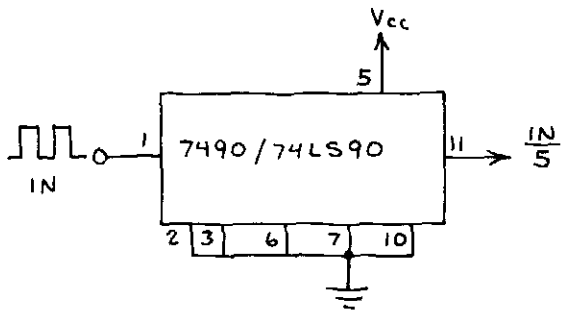


BCD (DECADE) COUNTER 7490/74LS90

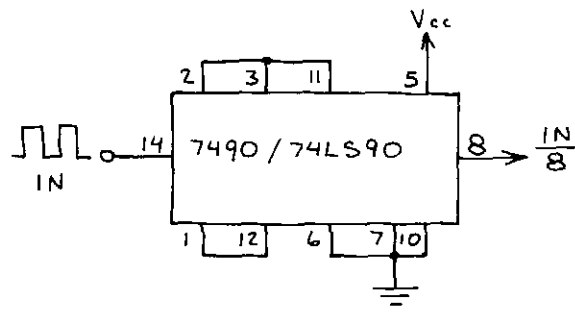
ONE OF THE MOST POPULAR DECADE COUNTERS. EASILY USED FOR DIVIDE-BY-N COUNTERS. LESS EXPENSIVE THAN MORE SOPHISTICATED COUNTERS. RST INDICATES RESET PINS. THIS CHIP IS USUALLY USED IN DECIMAL COUNTING UNITS, BUT CIRCUITS ON THIS PAGE SHOW MANY OTHER POSSIBILITIES.



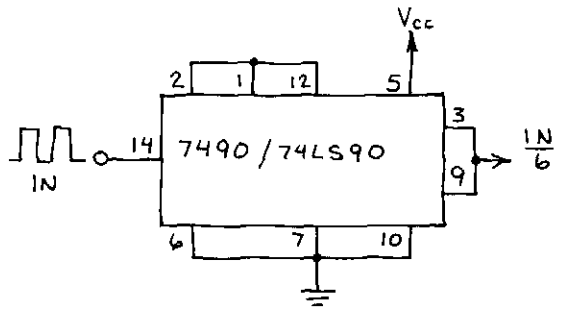
DIVIDE-BY-5 COUNTER



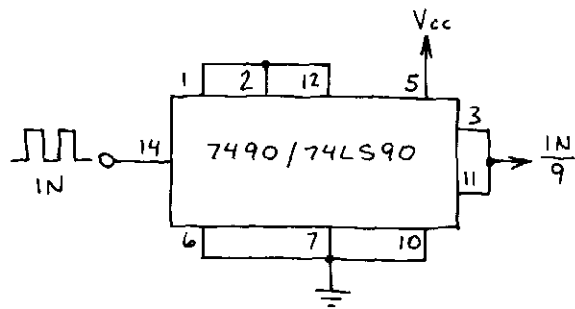
DIVIDE-BY-8 COUNTER



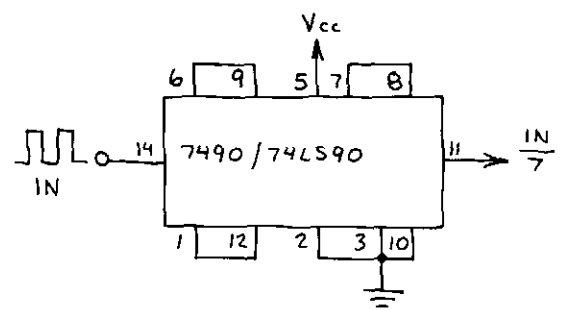
DIVIDE-BY-6 COUNTER



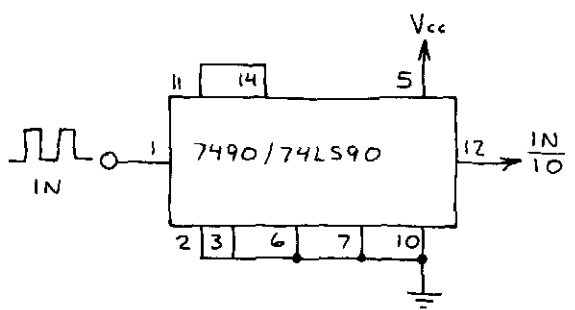
DIVIDE-BY-9 COUNTER



DIVIDE-BY-7 COUNTER

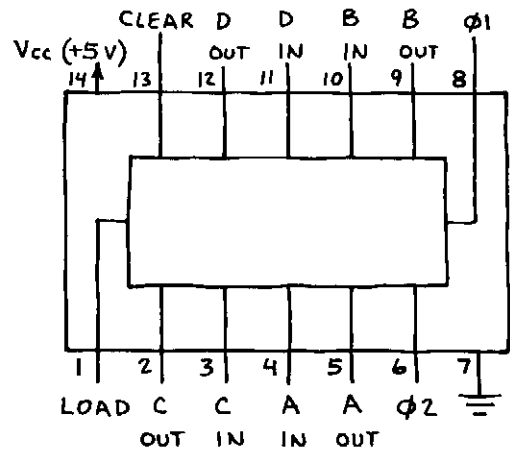


DIVIDE-BY-10 COUNTER



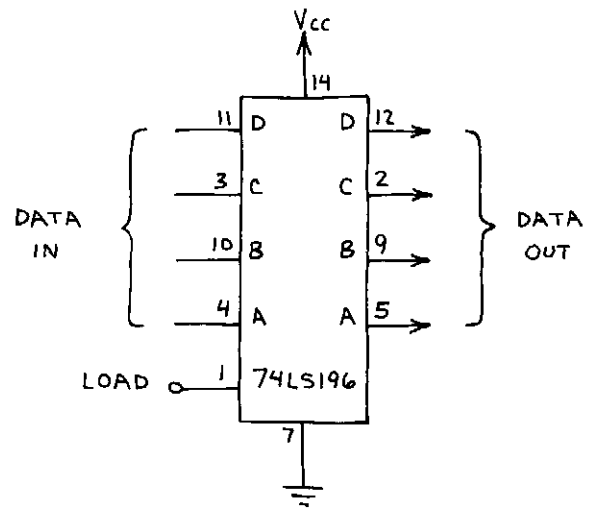
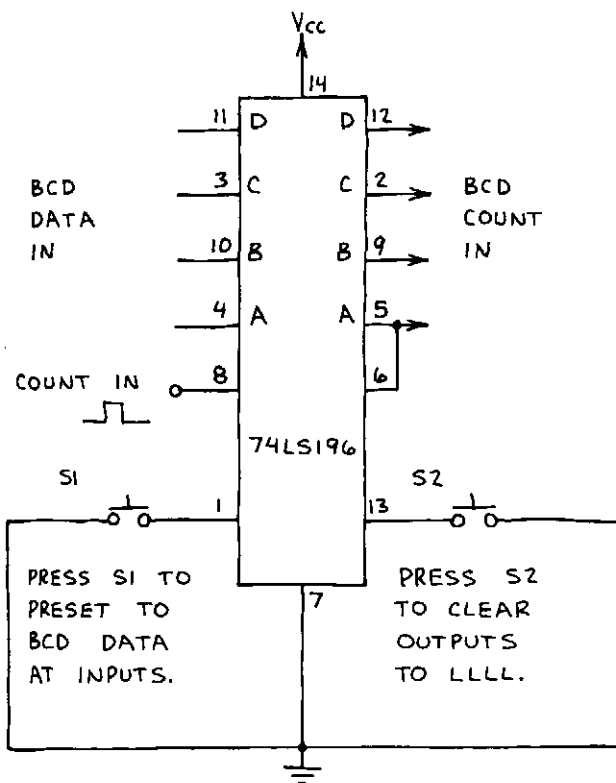
BCD (DECADE) COUNTER 74LS196

MORE SOPHISTICATED VERSION OF THE POPULAR 7490/74LS90 BCD COUNTER. INCLUDES 4-PRESET INPUTS WHICH PERMIT ANY BCD NUMBER TO BE LOADED WHEN PIN 1 IS MADE LOW. THE COUNTER IS CLEARED TO LLLL WHEN PIN 13 IS MADE LOW. ϕ INDICATES CLOCK INPUT.



DECADE COUNTER

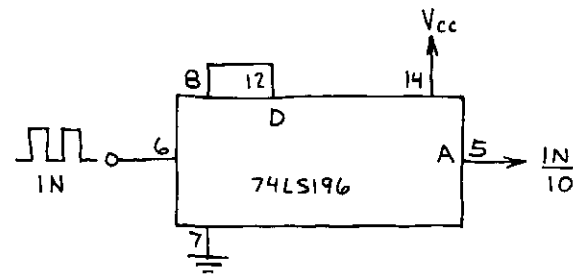
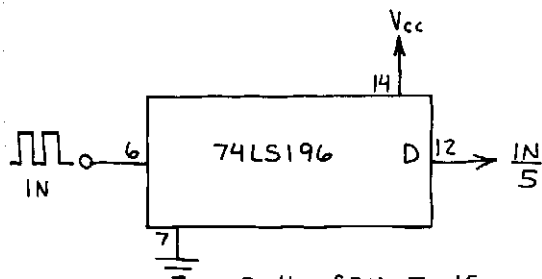
4-BIT LATCH



WHEN LOAD INPUT IS LOW, OUTPUTS FOLLOW INPUTS. NO CHANGE WHEN LOAD INPUT IS HIGH. NOTE THAT A PAIR OF 74LS196'S CAN BE USED IN A DECIMAL COUNTING UNIT (COUNTER PLUS REGISTER).

DIVIDE-BY-5 COUNTER

DIVIDE-BY-10 COUNTER

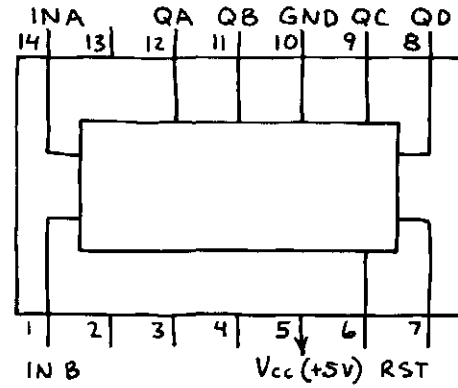


0-4 COUNT IS AVAILABLE AT DCBA OUTPUTS.

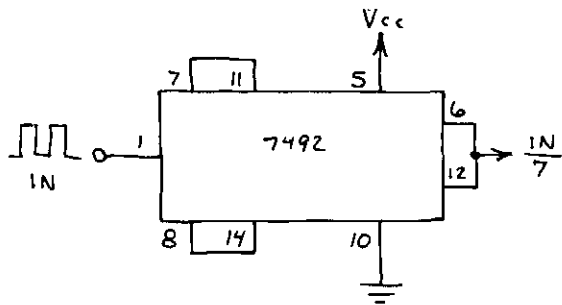
DIVIDE-BY-12 BINARY COUNTER

7492

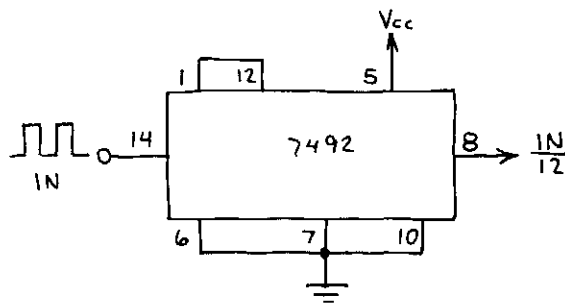
OFTEN USED TO DIVIDE CONDITIONED 60 HZ PULSES FROM AC POWER LINE INTO 10 HZ PULSES. OTHER DIVIDER APPLICATIONS ALSO. RST INDICATES RESET PINS.



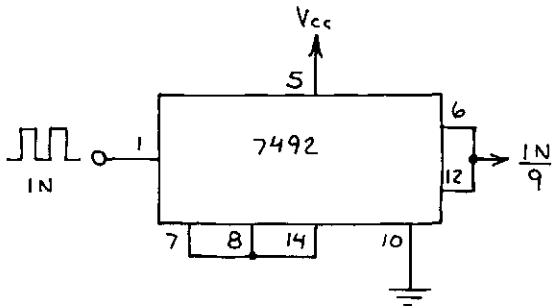
DIVIDE-BY-7 COUNTER



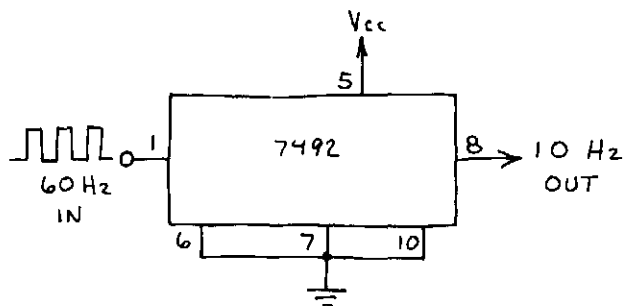
DIVIDE-BY-12 COUNTER



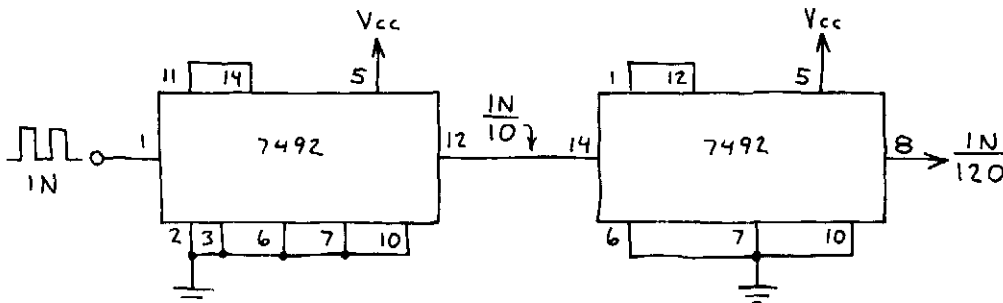
DIVIDE-BY-9 COUNTER



10-HZ PULSE SOURCE



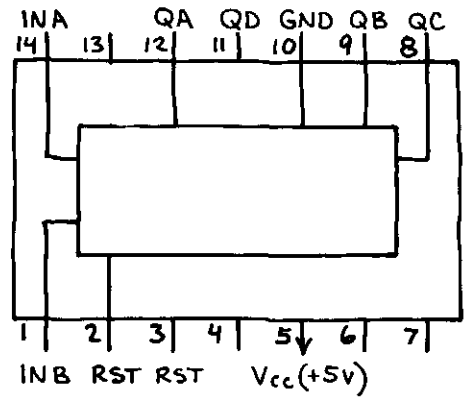
DIVIDE-BY-120 COUNTER



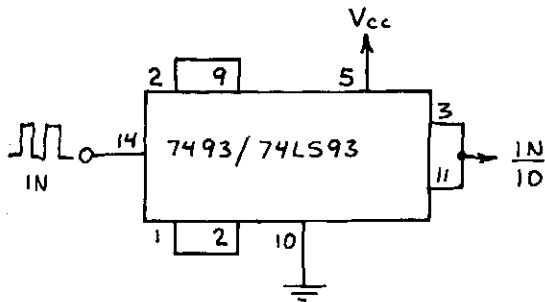
THIS METHOD OF CASCADING COUNTERS CAN BE USED TO CREATE ANY DIVIDE-BY-N COUNTER.

4-BIT (BINARY) COUNTER 7493 / 74LS93

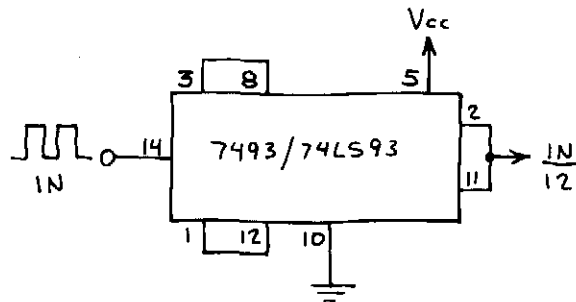
EASY TO USE 4-BIT BINARY COUNTER. LESS EXPENSIVE THAN MORE SOPHISTICATED COUNTERS. RST INDICATES RESET PINS. NOTE UNUSUAL LOCATION OF POWER SUPPLY PINS.



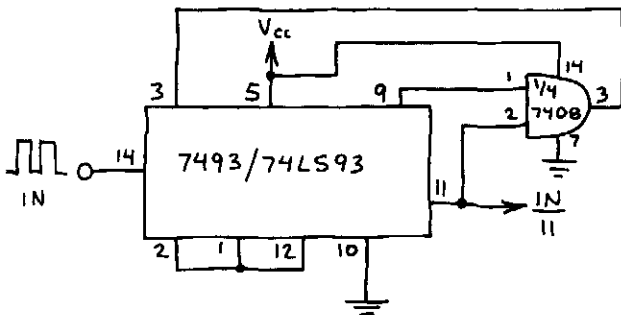
DIVIDE-BY-10 COUNTER



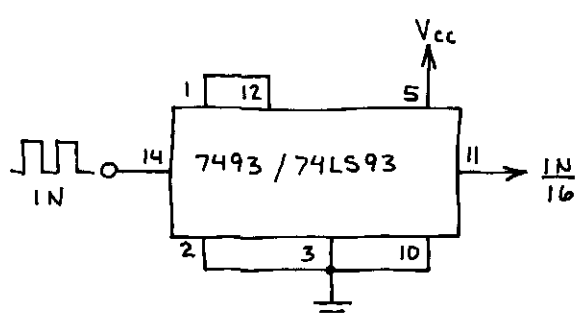
DIVIDE-BY-12 COUNTER



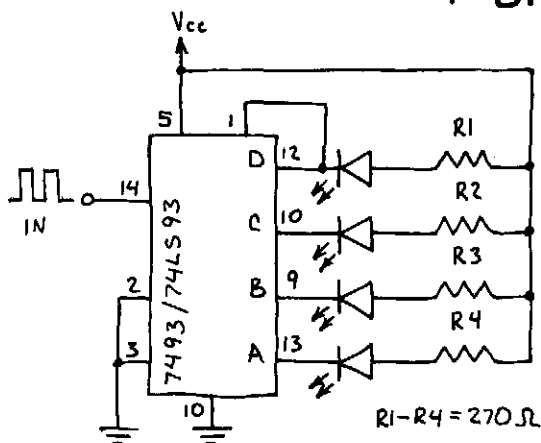
DIVIDE-BY-11 COUNTER



DIVIDE-BY-16 COUNTER



4-BIT BINARY COUNTER

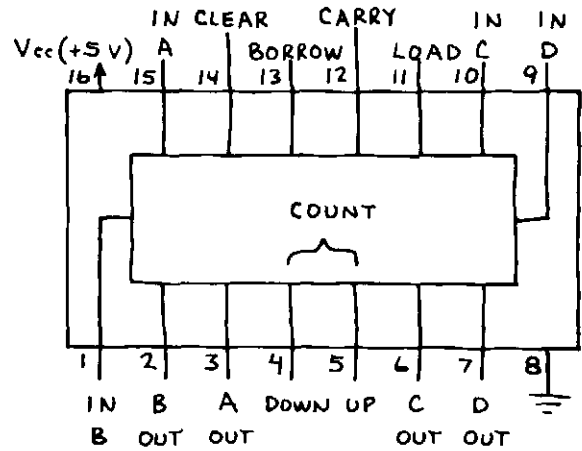


COUNTS FROM 0-15 IN BINARY AND RECYCLES. GLOWING LED = L (0); OFF LED = H (1). 555 TIMER IC MAKES GOOD INPUT CLOCK.

TRUTH TABLE			
D	C	B	A
L	L	L	L
L	L	L	H
L	L	H	L
L	L	H	H
L	H	L	L
L	H	L	H
L	H	H	L
L	H	H	H
H	L	L	L
H	L	L	H
H	L	H	L
H	L	H	H
H	H	L	L
H	H	L	H
H	H	H	L
H	H	H	H

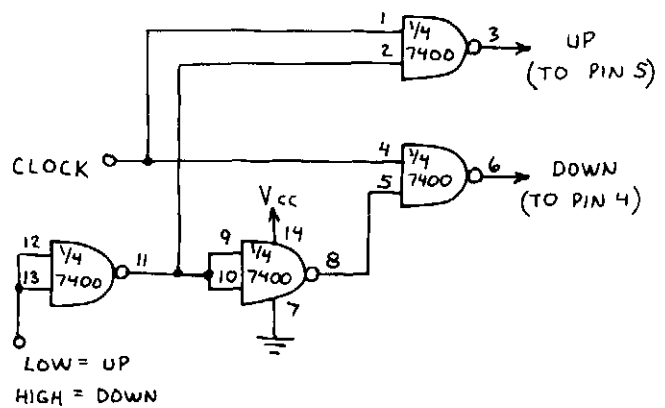
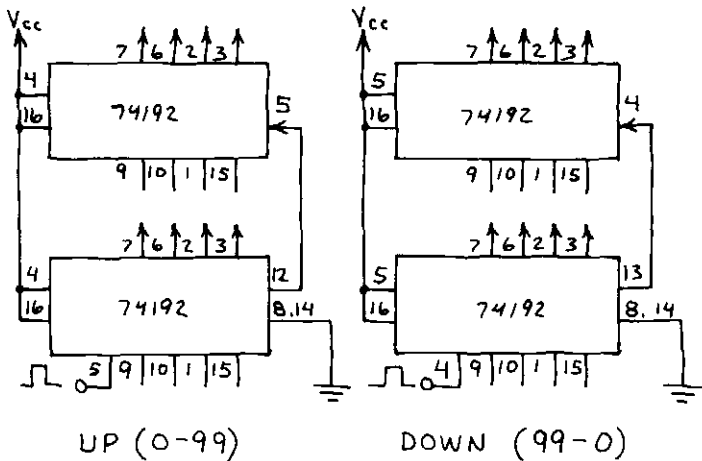
BCD UP-DOWN COUNTER 74192

FULLY PROGRAMMABLE BCD COUNTER. OPERATION IS IDENTICAL TO 74193/74LS193 EXCEPT COUNT IS 10-STEP BCD (LLLL-HLLH) INSTEAD OF 16-STEP BINARY. MANY APPLICATIONS FOR 74192/74LS192 AND 74193/74LS193 ARE INTERCHANGEABLE.

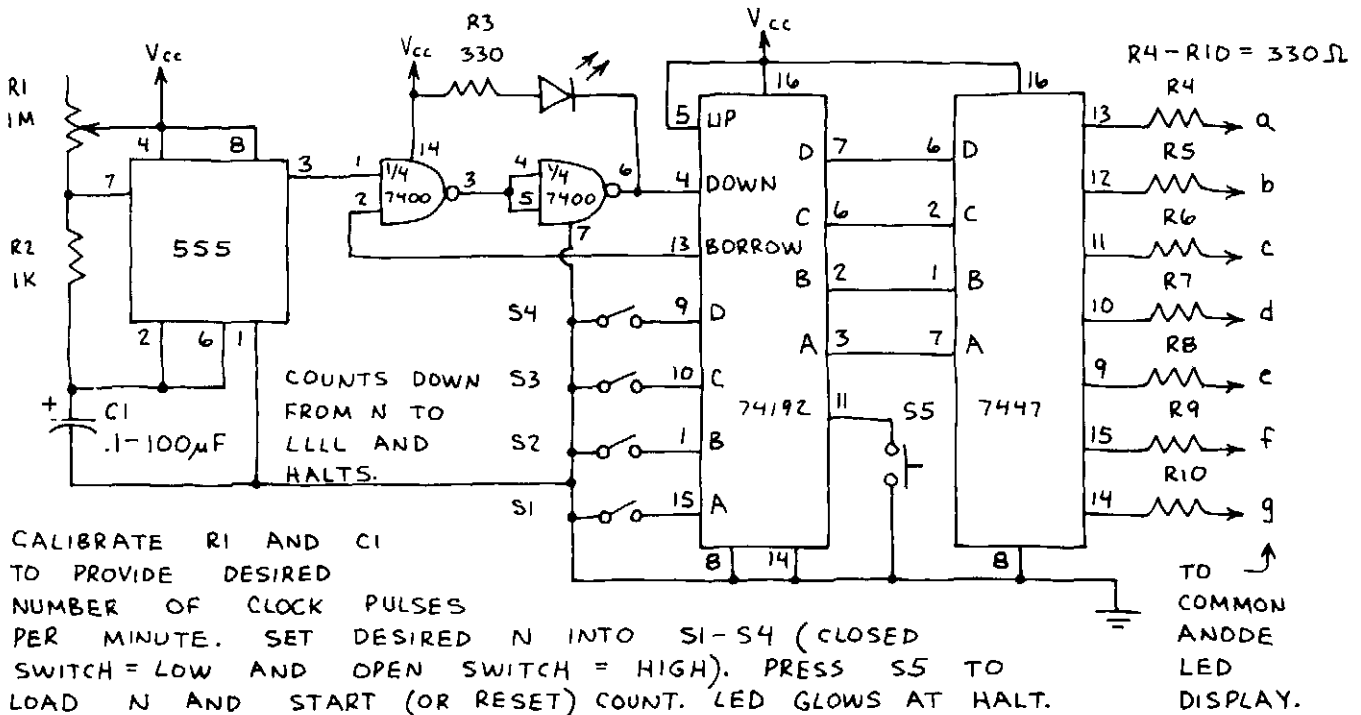


CASCADED COUNTERS

SINGLE UP-DOWN INPUT



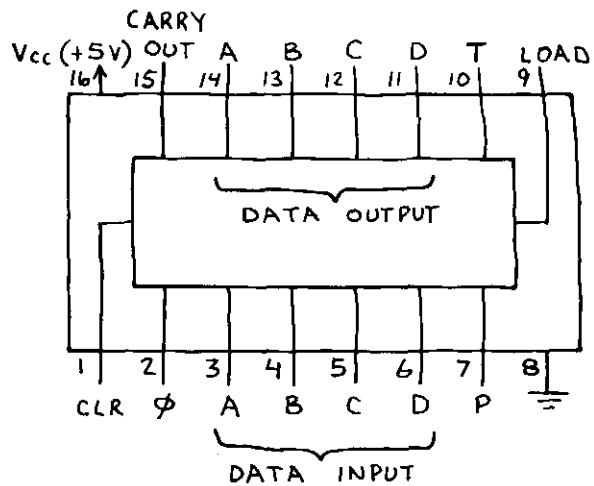
PROGRAMMABLE COUNT DOWN TIMER



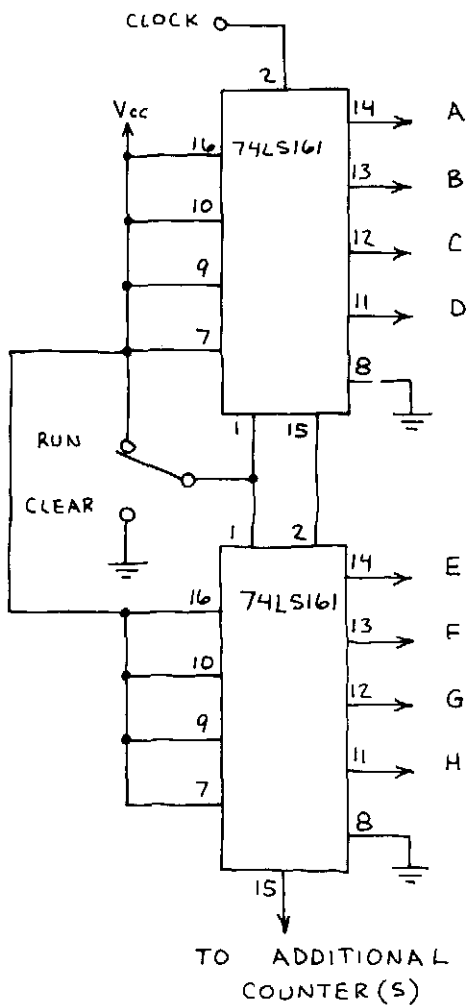
4-BIT UP COUNTER

74LS161

GENERAL PURPOSE BINARY COUNTER WITH PROGRAMMABLE INPUTS. COUNTER ACCEPTS DATA AT INPUTS WHEN LOAD INPUT GOES LOW. A LOW AT THE CLEAR INPUT RESETS THE COUNTER TO LLLL UPON THE NEXT CLOCK PULSE. P AND T ARE COUNT ENABLE INPUTS. BOTH P AND T MUST BE HIGH TO COUNT. THESE ENABLE INPUTS ARE NOT AVAILABLE WITH THE OTHERWISE MORE ADVANCED 74LS193.

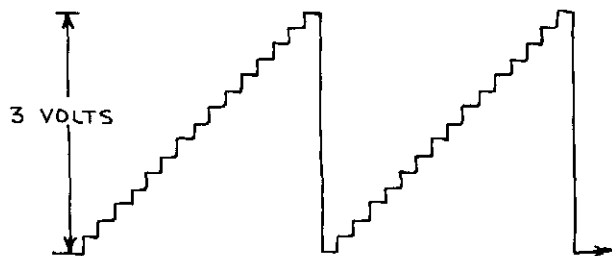
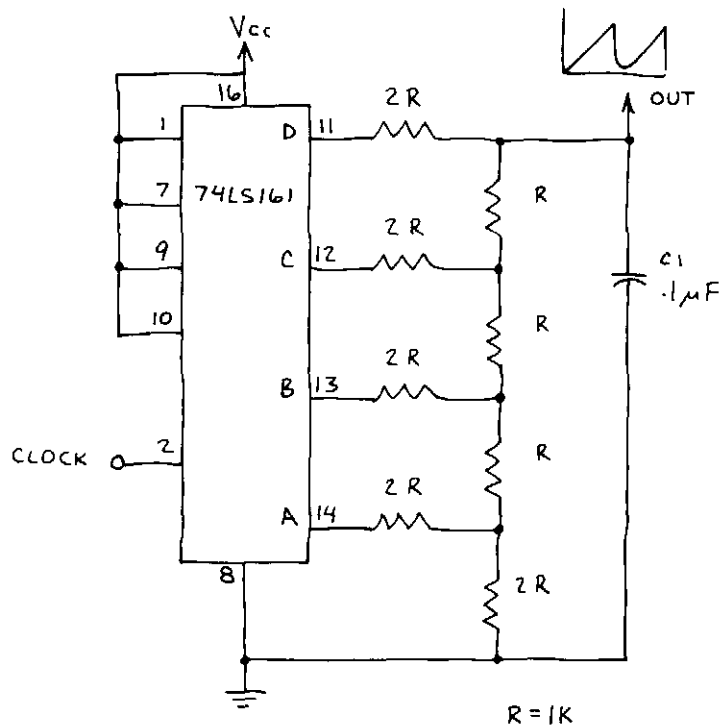


8-BIT COUNTER



OUTPUT A IS LOWEST ORDER BIT.

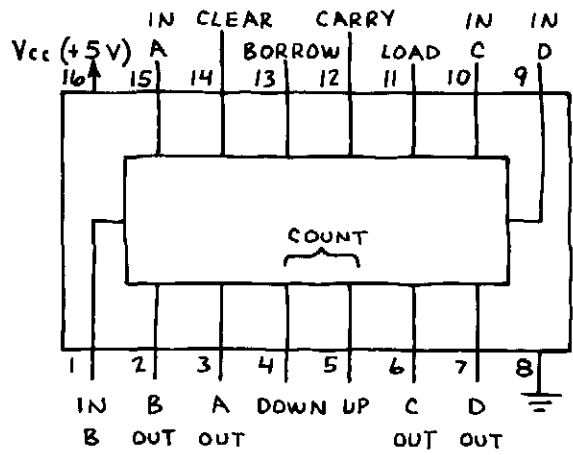
RAMP SYNTHESIZER



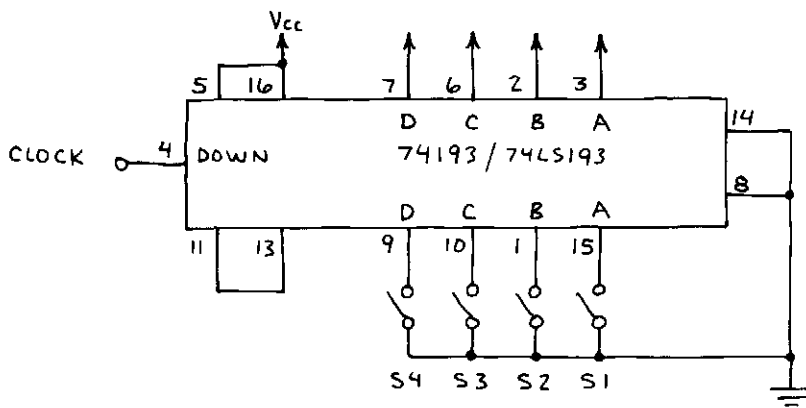
REMOVE C1 TO OBTAIN THIS STAIRCASE. FREQUENCY OF RAMP AND STAIRCASE IS 1/16 CLOCK FREQUENCY.

4-BIT UP-DOWN COUNTER 74193/74LS193

VERY VERSATILE 4-BIT COUNTER WITH UP-DOWN CAPABILITY. ANY 4-BIT NUMBER AT THE DCBA INPUTS IS LOADED INTO THE COUNTER WHEN THE LOAD INPUT (PIN 11) IS MADE LOW. THE COUNTER IS CLEARED TO LLLL WHEN THE CLEAR INPUT (PIN 14) IS MADE HIGH. THE BORROW AND CARRY OUTPUTS INDICATE UNDERFLOW OR OVERFLOW BY GOING LOW.



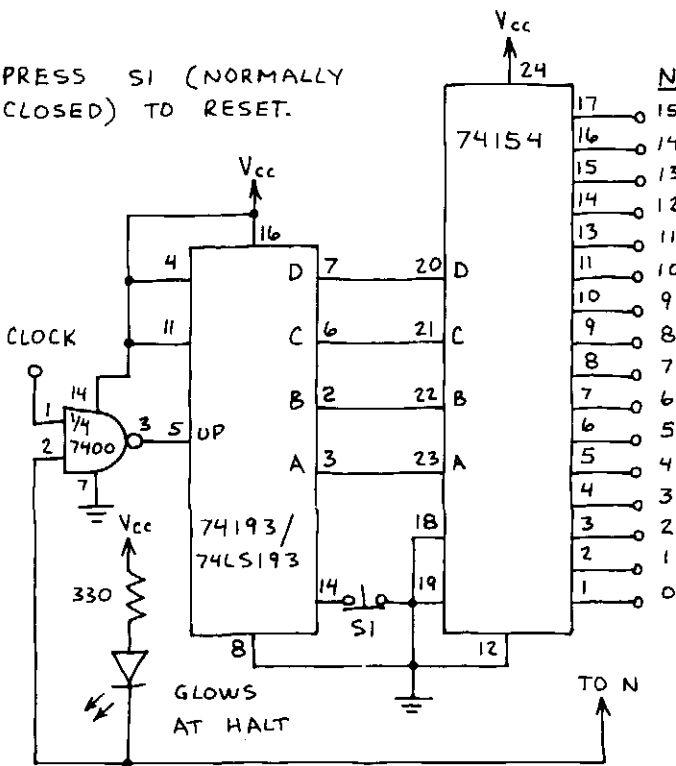
COUNT DOWN FROM N AND RECYCLE



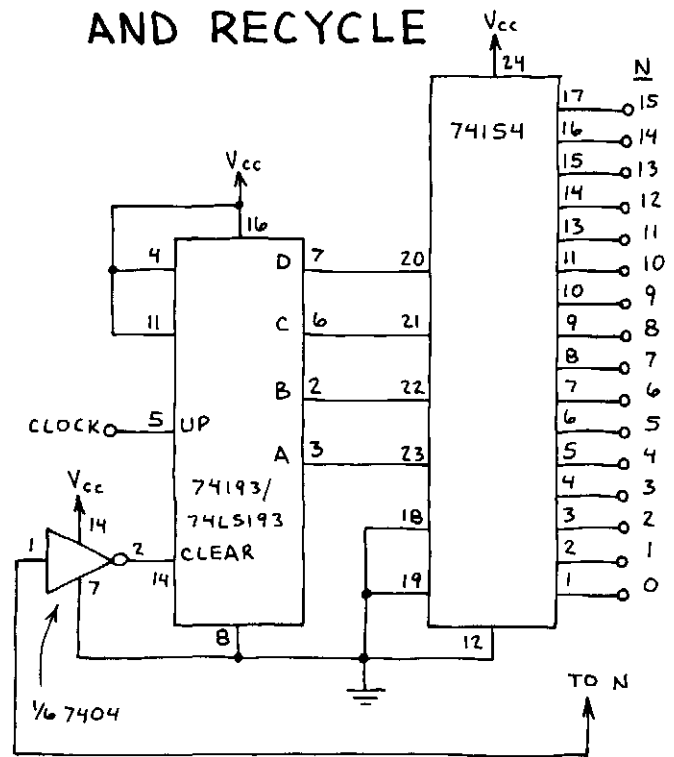
SET DESIRED N INTO S1-S4 (CLOSED SWITCH = LOW AND OPEN SWITCH = HIGH). WHEN COUNT REACHES LLLL AND THEN UNDERFLOWS, THE BORROW PULSE LOADS N AND THE COUNT RECYCLES.

COUNT UP TO N AND HALT

PRESS S1 (NORMALLY CLOSED) TO RESET.



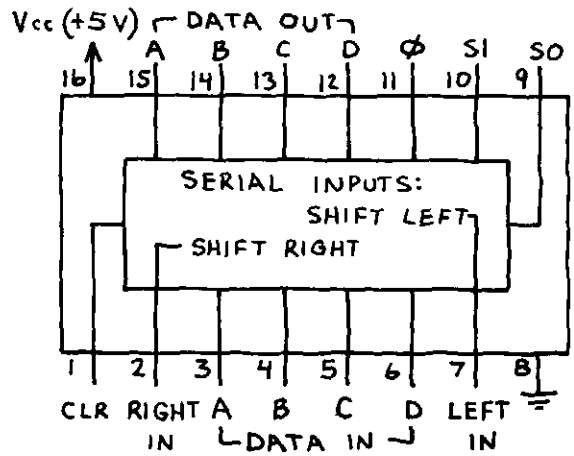
COUNT UP TO N AND RECYCLE



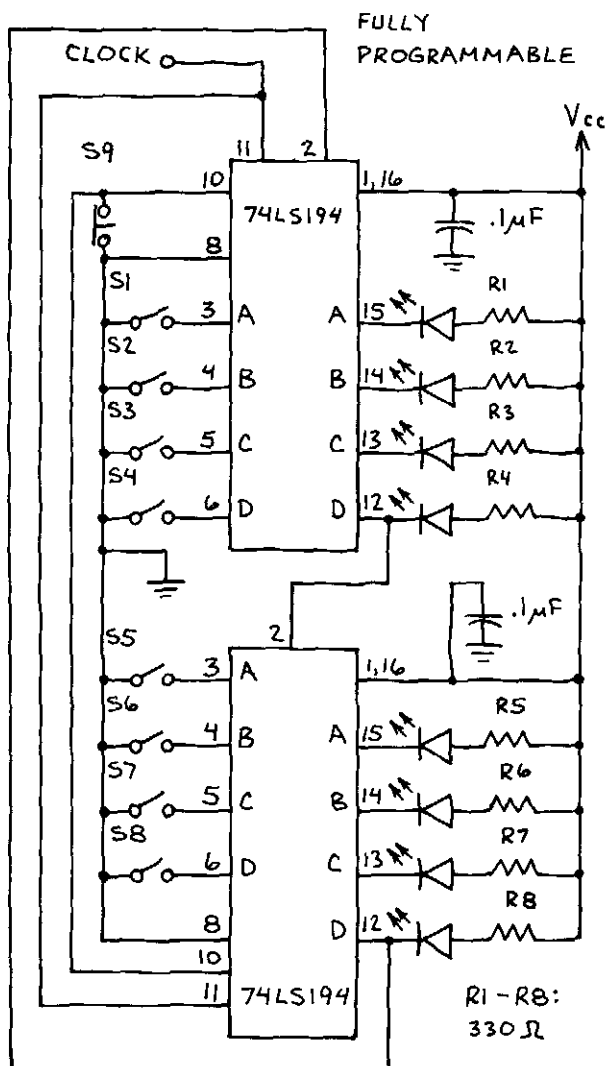
NOTES

4-BIT SHIFT REGISTER 74LS194

BIDIRECTIONAL UNIVERSAL SHIFT REGISTER. SHIFTS RIGHT WHEN SO IS HIGH AND SI IS LOW. SHIFTS LEFT WHEN SO IS LOW AND SI IS HIGH. SHIFTS ONE POSITION PER CLOCK PULSE. LOADS DATA AT INPUTS WHEN SO AND SI ARE HIGH. IMPORTANT: BYPASS POWER SUPPLY PINS WITH 0.1μF CAPACITOR!



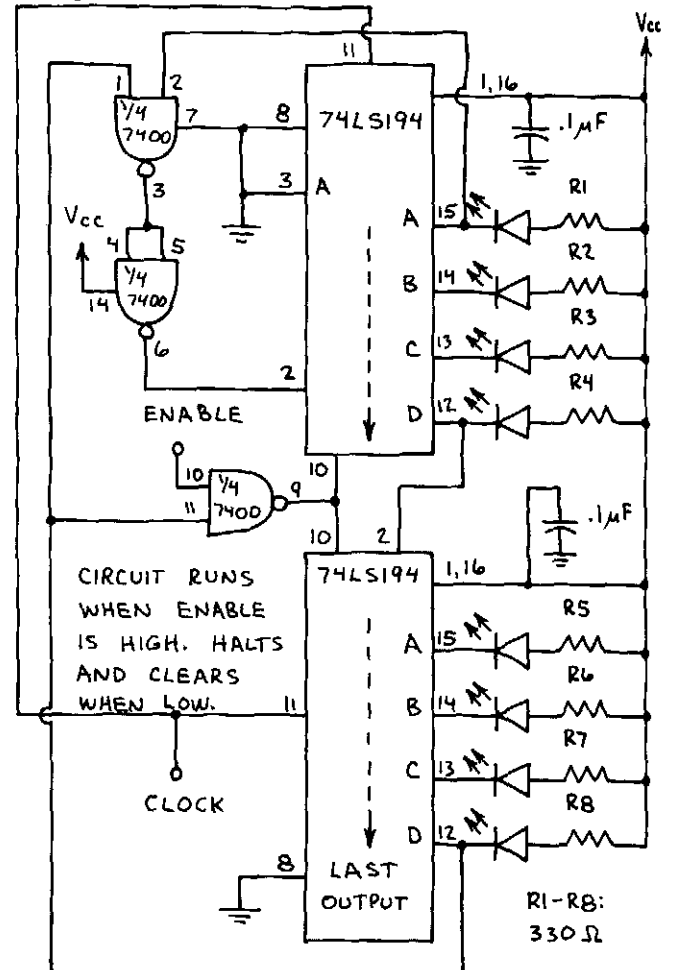
SEQUENCE GENERATOR



LOAD ANY DESIRED BIT PATTERN INTO SI-S8 (OPEN = HIGH AND CLOSED = LOW). PRESS S9 (NORMALLY CLOSED) TO LOAD. DATA WILL MOVE RIGHT ONE OUTPUT PER CLOCK PULSE. LEDs ARE OPTIONAL.

BARGRAPH GENERATOR

WHEN POWER IS FIRST APPLIED, MAKE ENABLE INPUT LOW TO START CIRCUIT.

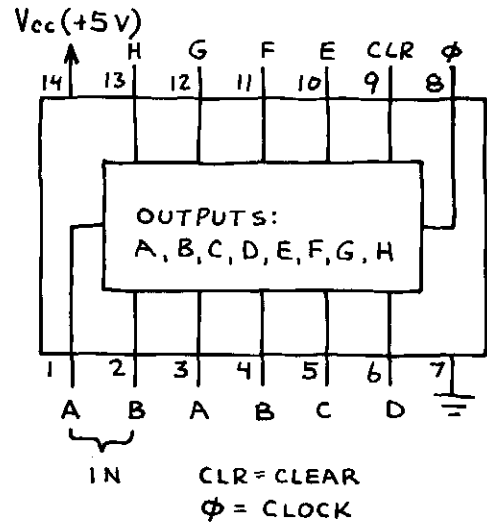


OUTPUTS GO LOW AND STAY LOW ONE AT A TIME FROM LEFT TO RIGHT (A→D) IN SEQUENCE WITH CLOCK. WHEN FINAL OUTPUT GOES LOW, ALL OUTPUTS BUT THE FIRST GO HIGH AND RECYCLE.

8-BIT SHIFT REGISTER

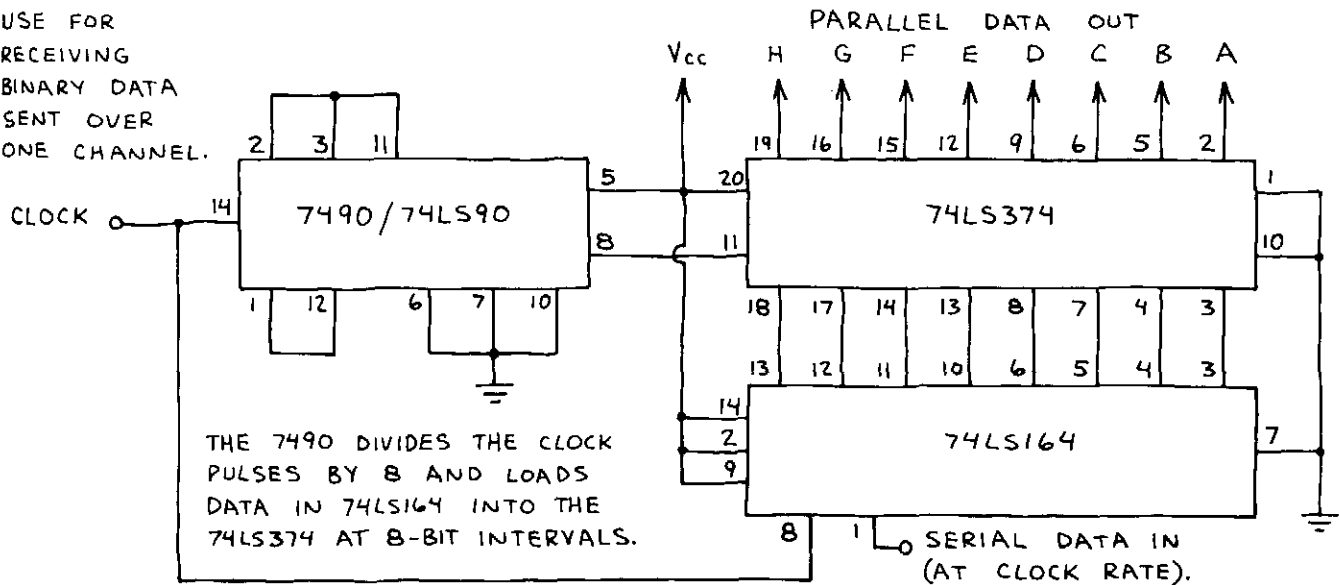
74LS164

DATA AT ONE OF THE TWO SERIAL INPUTS IS ADVANCED ONE BIT FOR EACH CLOCK PULSE. DATA CAN BE EXTRACTED FROM THE 8 PARALLEL OUTPUTS OR IN SERIAL FORM AT ANY SINGLE OUTPUT. ENTER DATA AT EITHER INPUT. THE UNUSED INPUT MUST BE HELD HIGH OR CLOCKING WILL BE INHIBITED. MAKING PIN 9 LOW CLEARS THE REGISTER TO LLLL.

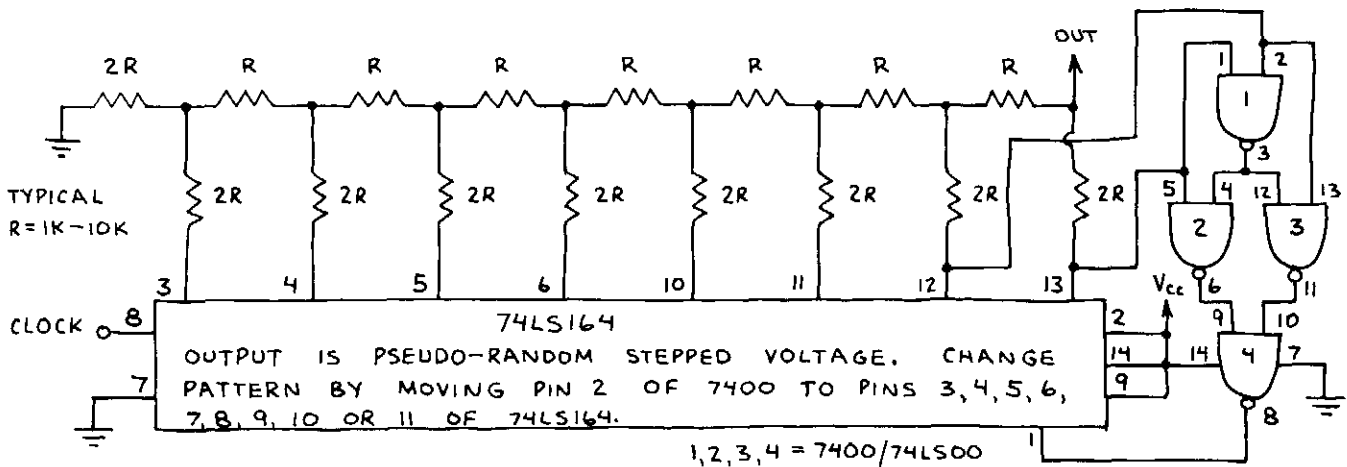


8-BIT SERIAL-TO-PARALLEL DATA CONVERTER

USE FOR RECEIVING BINARY DATA SENT OVER ONE CHANNEL.



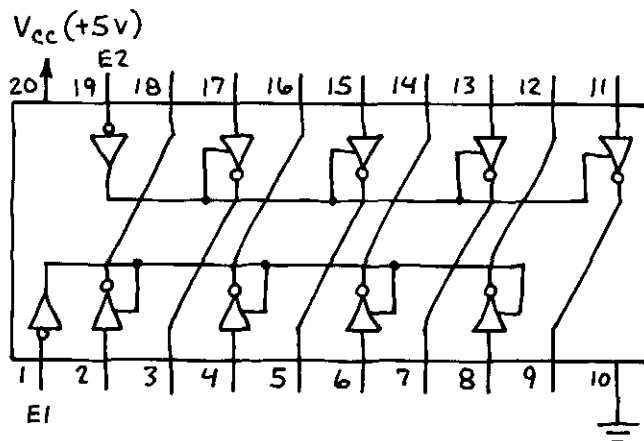
PSEUDO-RANDOM VOLTAGE GENERATOR



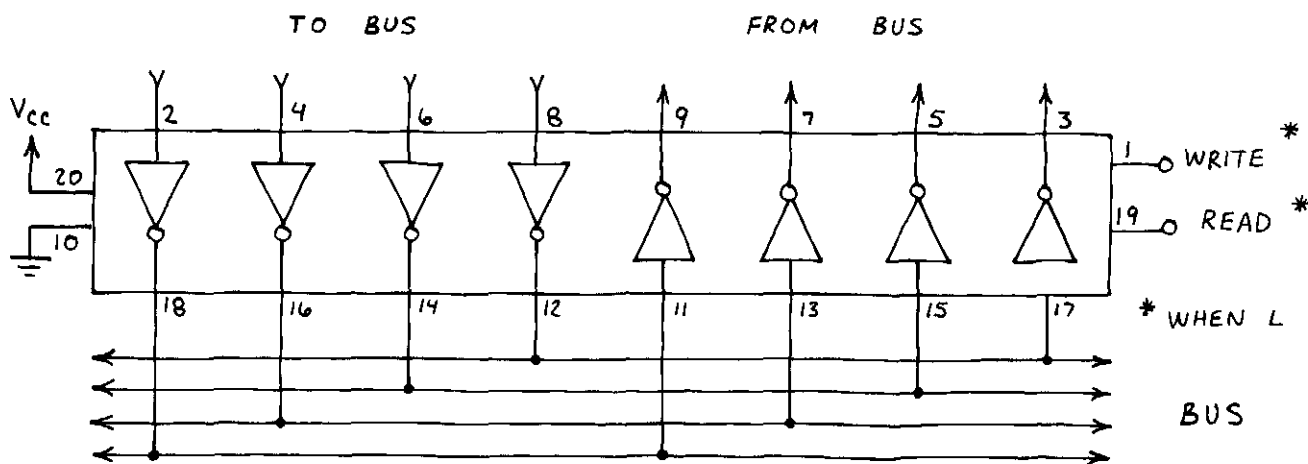
OCTAL BUFFER 74LS240

IDEAL FOR INTERFACING
EXTERNAL CIRCUITS TO
HOME COMPUTERS.
INVERTS DATA.

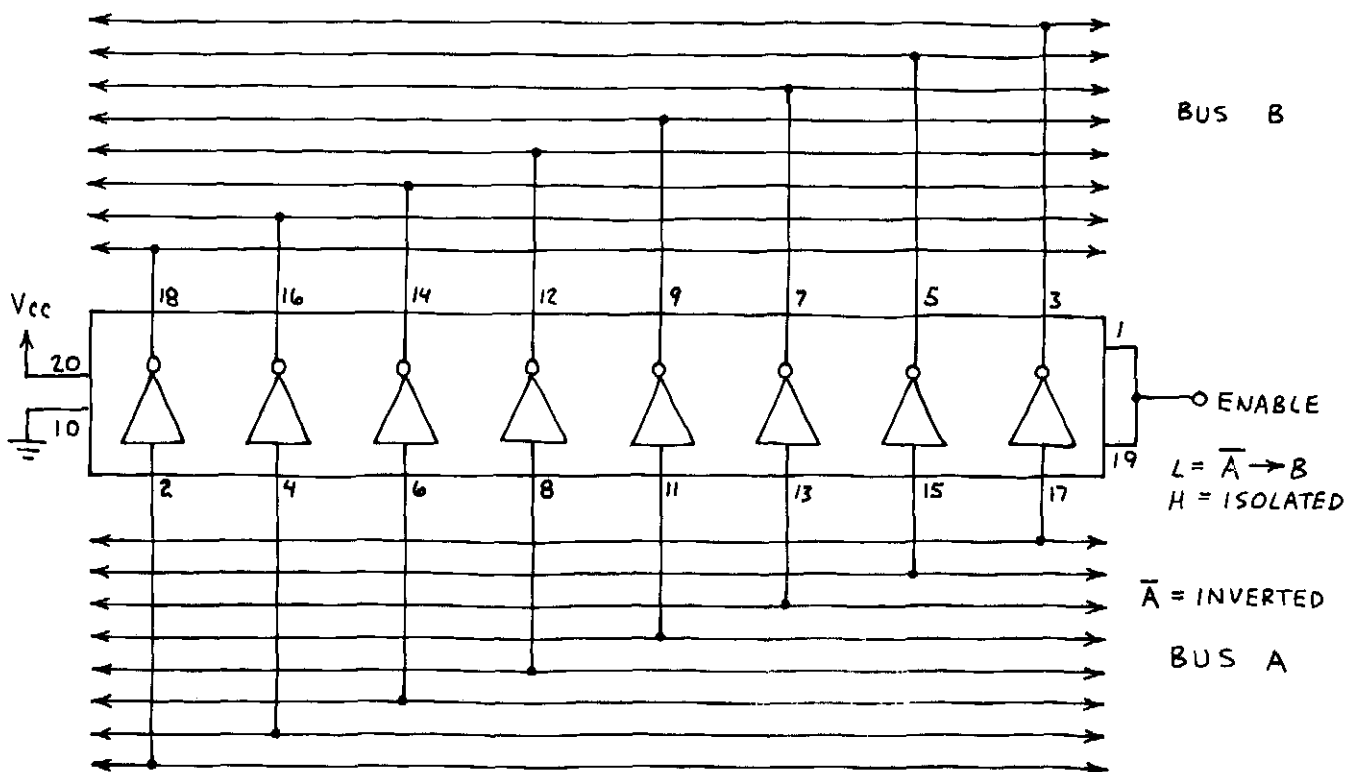
CONTROL (E1, E2)		OUT
L		$\overline{1N}$
H		HI-Z



4-BIT BUS TRANSFER



8-BIT BUS BUFFER

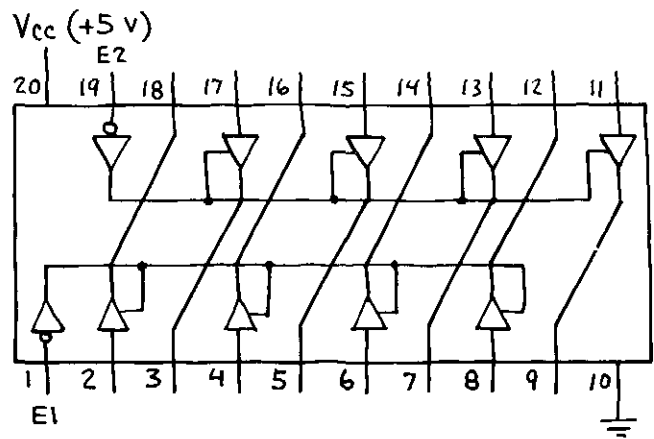


OCTAL BUFFER

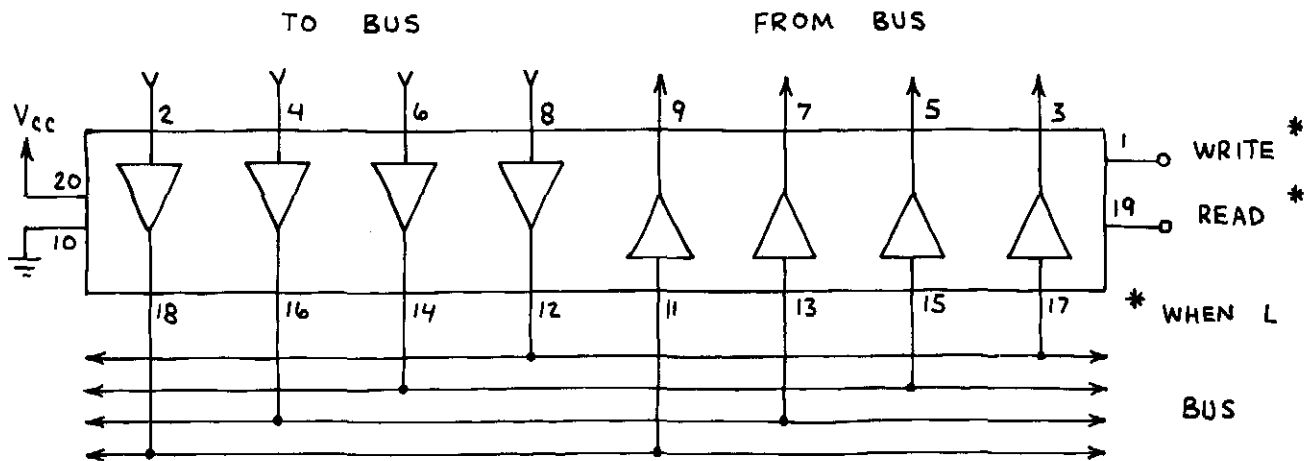
74LS244

NON-INVERTING VERSION OF 74LS240. IDEAL FOR COMPUTER INTERFACING.

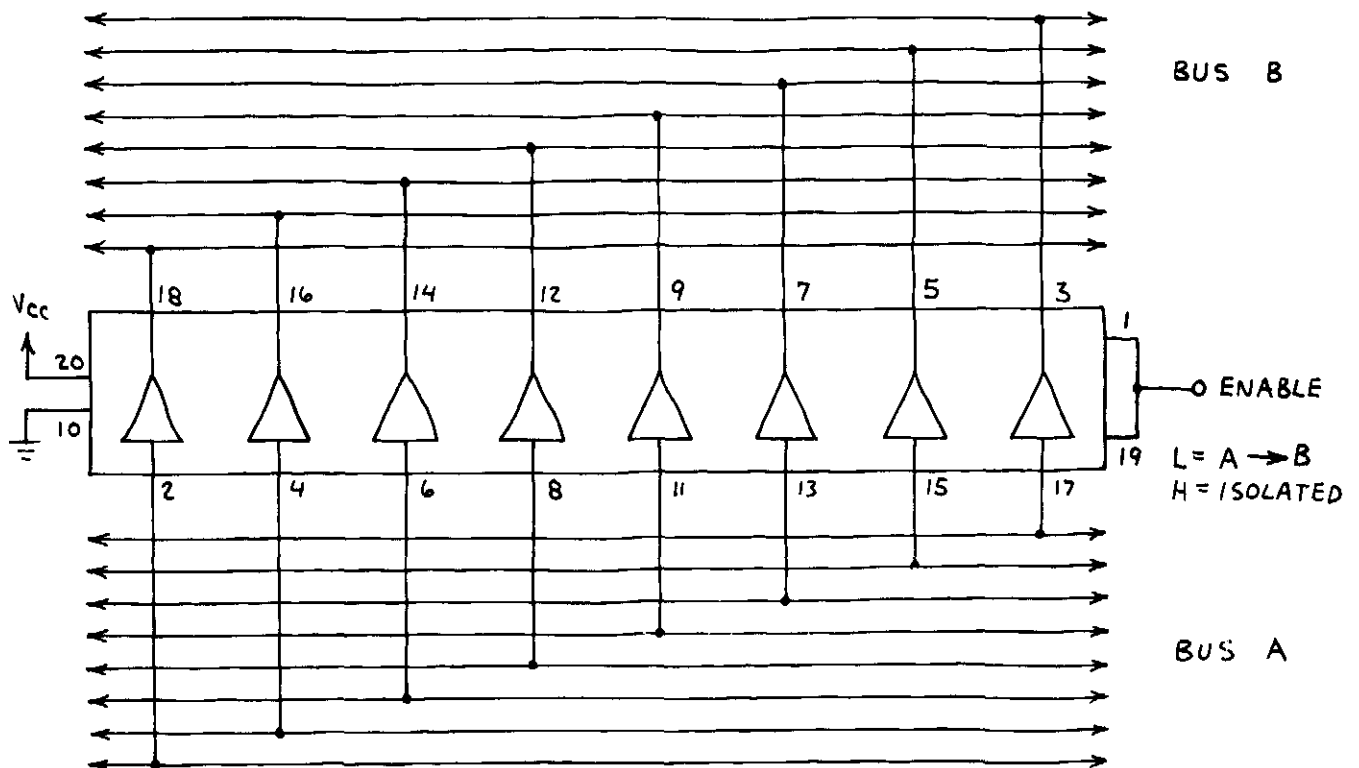
CONTROL (E1, E2)	OUT
L	\overline{IN}
H	HI-Z



4-BIT BUS TRANSFER

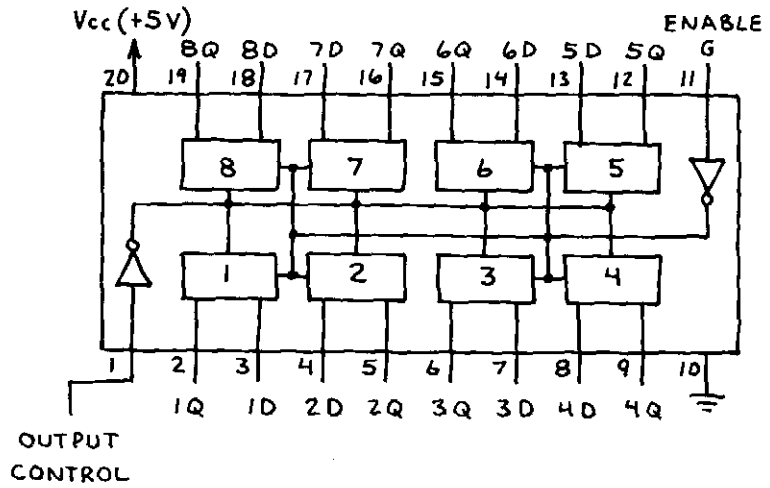


8-BIT BUS BUFFER

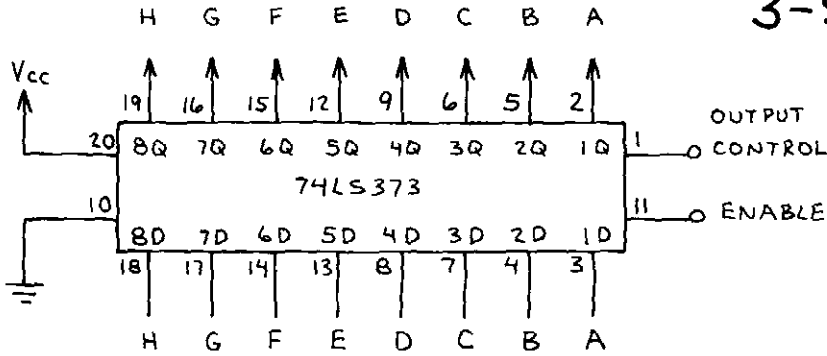


OCTAL D-TYPE LATCH 74LS373

EIGHT "TRANSPARENT" D-TYPE LATCHES. OUTPUT FOLLOWS INPUT WHEN ENABLE IS HIGH. THE DATA AT THE INPUTS IS LOADED WHEN THE ENABLE INPUT IS LOW. THIS CHIP HAS 3-STATE OUTPUTS WHICH ARE CONTROLLED BY PIN 1. SEE TRUTH TABLE BELOW.



3-STATE REGISTER



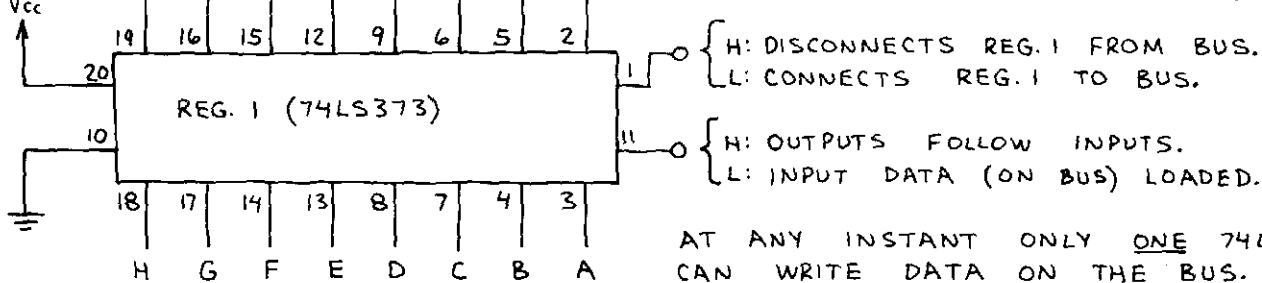
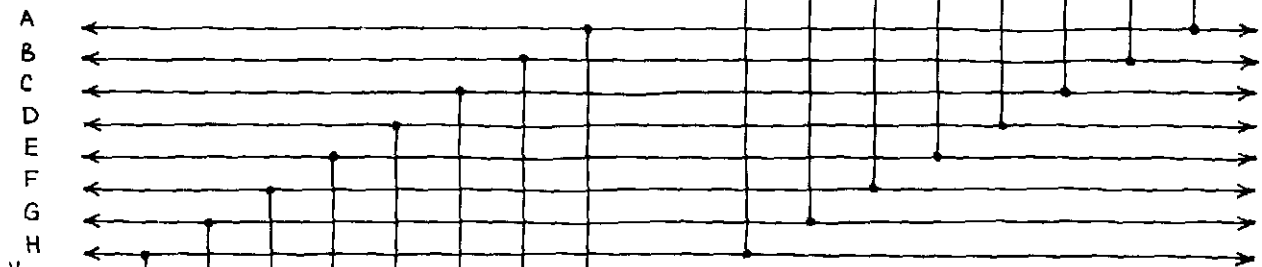
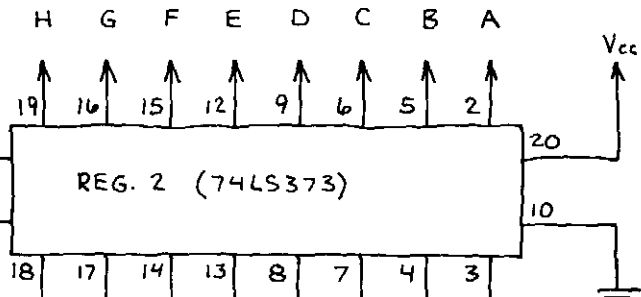
THIS IS A GENERAL PURPOSE 8-BIT STORAGE REGISTER. HERE'S THE TRUTH TABLE:

CONTROL	ENABLE	D	Q
L	H	H	H
L	H	L	L
L	L	X	Q
H	X	X	HI-Z

DATA BUS REGISTERS

H: PLACES OUTPUTS IN HI-Z MODE
L: MAKES DATA AVAILABLE

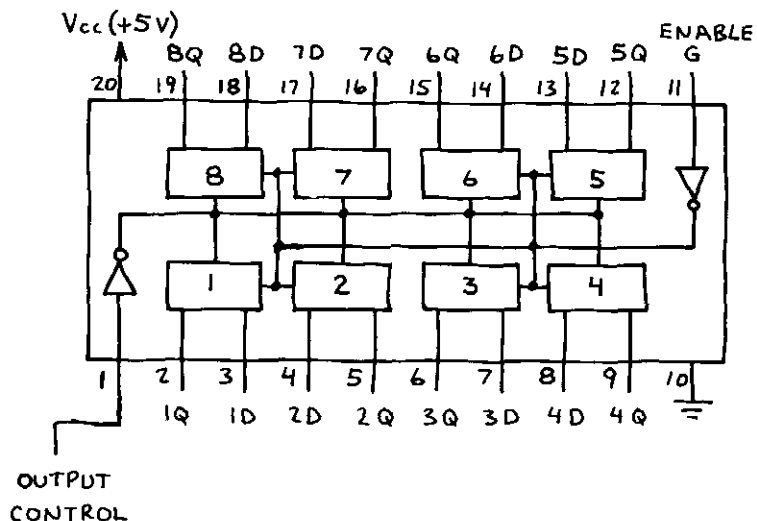
H: OUTPUTS FOLLOW DATA ON BUS
L: LOAD DATA FROM BUS



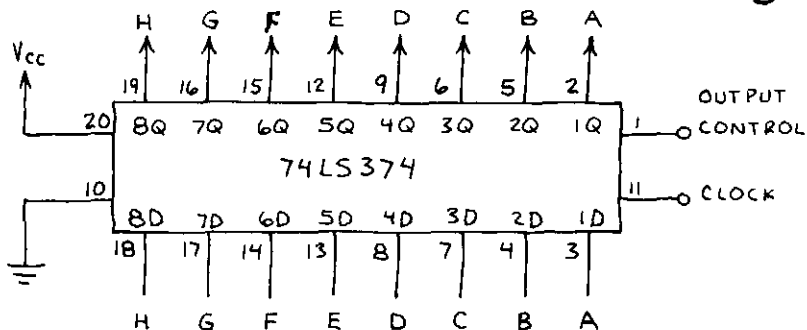
AT ANY INSTANT ONLY ONE 74LS373 CAN WRITE DATA ON THE BUS. ANY NUMBER CAN READ DATA FROM BUS.

OCTAL D FLIP-FLOP 74LS374

EIGHT D-TYPE EDGE TRIGGERED FLIP-FLOPS. UNLIKE 74LS373, OUTPUTS DO NOT FOLLOW INPUTS. INSTEAD, A RISING CLOCK PULSE AT PIN 11 LOADS DATA APPEARING AT INPUTS. THIS CHIP HAS 3-STATE OUTPUTS WHICH ARE CONTROLLED BY PIN 1.



CLOCKED 3-STATE REGISTER

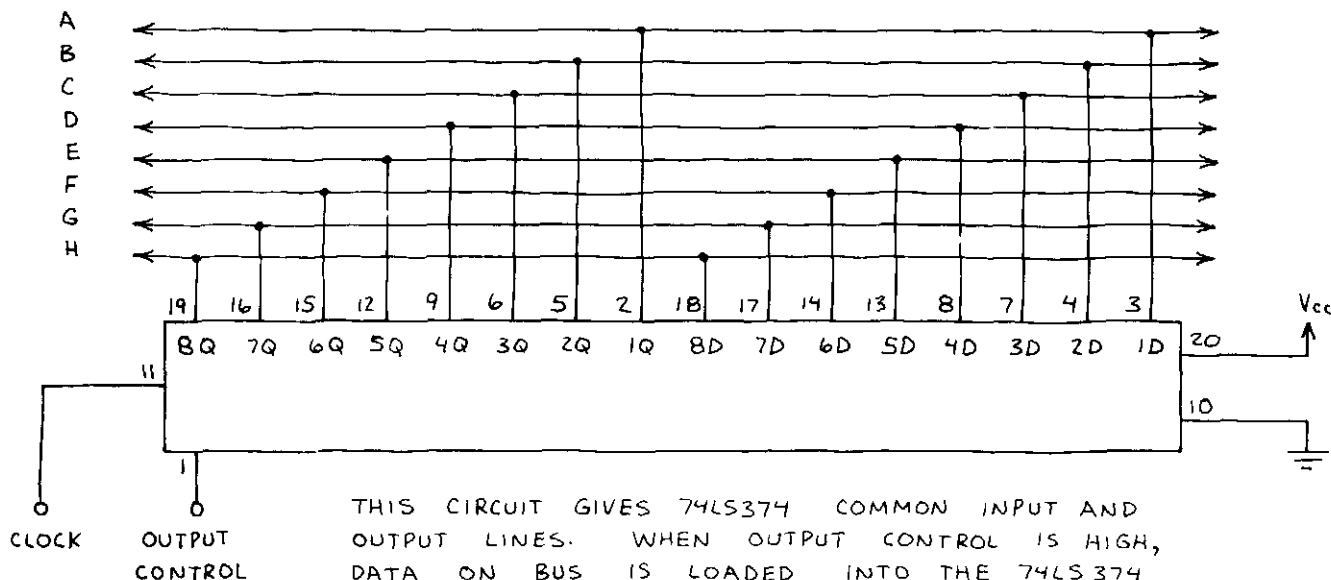


GENERAL PURPOSE
CLOCKED REGISTER.
HERE'S THE TRUTH TABLE:

OUTPUT CONTROL	CLOCK	D	Q
L	⌋	H	H
L	⌋	L	L
L	H	X	Q
H	X	X	HI-Z

COMMON INPUT/OUTPUT BUS REGISTER

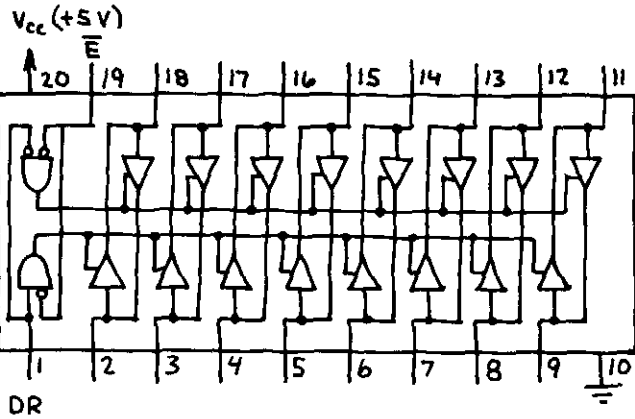
← BIDIRECTIONAL DATA BUS →



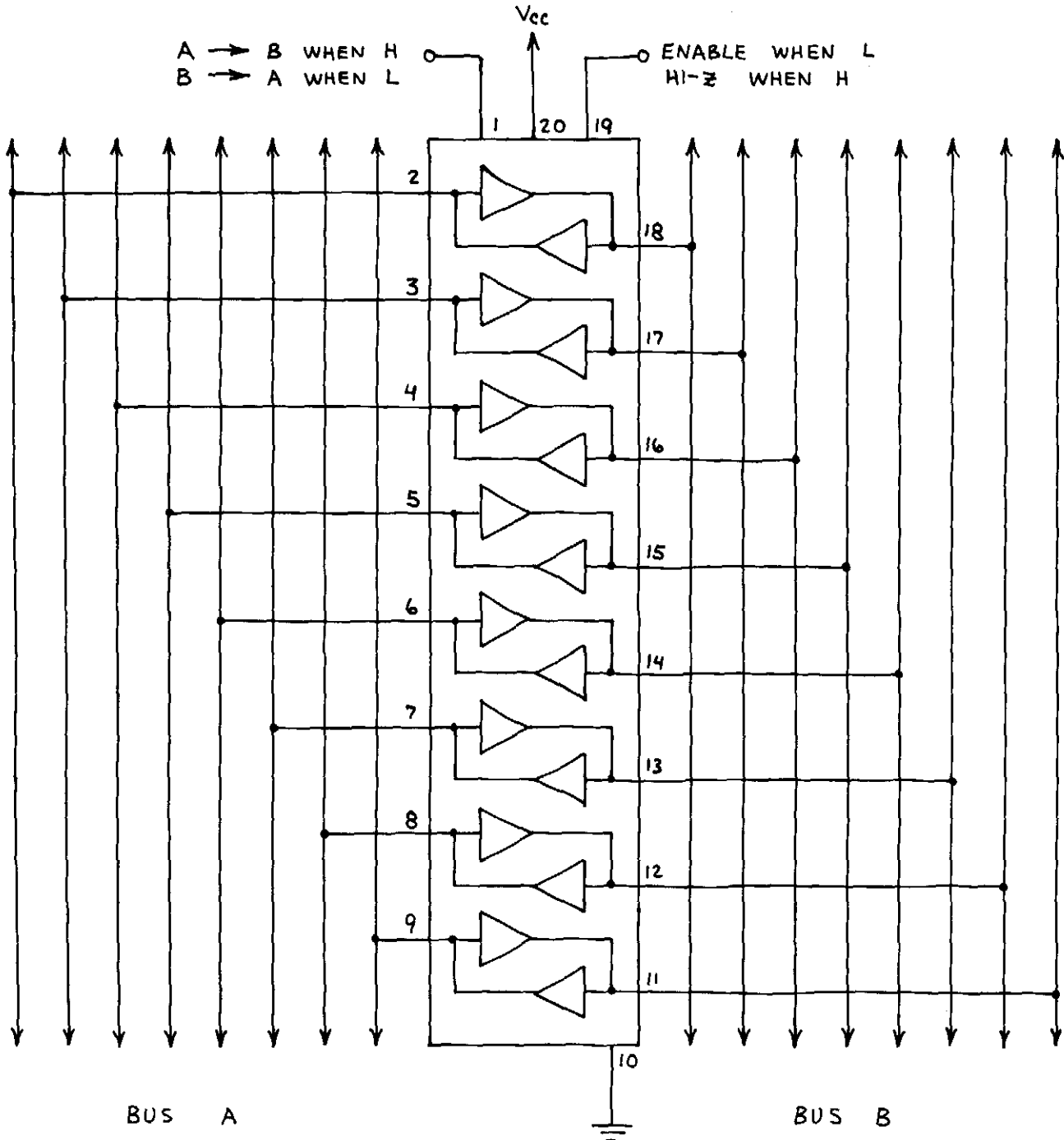
THIS CIRCUIT GIVES 74LS374 COMMON INPUT AND OUTPUT LINES. WHEN OUTPUT CONTROL IS HIGH, DATA ON BUS IS LOADED INTO THE 74LS374 ON THE RISING EDGE (⌋) OF THE CLOCK PULSE. WHEN OUTPUT CONTROL IS LOW, DATA IN THE 74LS374 IS WRITTEN ONTO THE BUS.

OCTAL BUS TRANSCEIVER 74LS245

ALLOWS DATA TO BE TRANSFERRED IN EITHER DIRECTION BETWEEN TWO BUSES. INCLUDES HIGH IMPEDANCE (HI-Z) OUTPUTS.



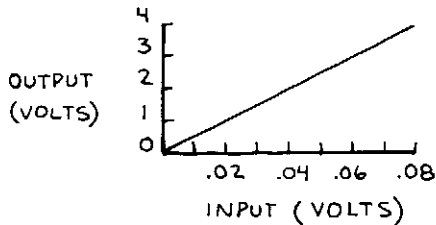
BUS TRANSCEIVER



LINEAR INTEGRATED CIRCUITS

INTRODUCTION

THE OUTPUT OF A LINEAR IC IS PROPORTIONAL TO THE SIGNAL AT ITS INPUT. THE CLASSIC LINEAR IC IS THE OPERATIONAL AMPLIFIER. THIS GRAPH SHOWS THE LINEAR INPUT-OUTPUT RELATIONSHIP OF A TYPICAL OP-AMP CIRCUIT:



MANY NON-DIGITAL ICs—INCLUDING OP-AMPS—CAN BE USED IN BOTH LINEAR AND NON-LINEAR MODES. THEY ARE SOMETIMES DESCRIBED AS ANALOG ICs.

LINEAR ICs GENERALLY REQUIRE MORE EXTERNAL COMPONENTS THAN DIGITAL ICs. THIS INCREASES THEIR SUSCEPTABILITY TO EXTERNAL NOISE AND MAKES THEM A LITTLE TRICKIER TO USE. ON THE OTHER HAND, SOME LINEAR ICs CAN DO ESSENTIALLY THE SAME THING AS A NETWORK OF DIGITAL CHIPS.

HERE'S A BRIEF DESCRIPTION OF THE LINEAR CHIPS IN THIS SECTION:

VOLTAGE REGULATORS

PROVIDE A STEADY VOLTAGE, EITHER FIXED OR ADJUSTABLE, THAT IS UNAFFECTED BY CHANGES IN THE SUPPLY VOLTAGE AS LONG AS THE SUPPLY VOLTAGE IS ABOVE THE DESIRED OUTPUT VOLTAGE.

OPERATIONAL AMPLIFIERS

THE IDEAL AMPLIFIER... ALMOST. HIGH INPUT IMPEDANCE AND GAIN. LOW OUTPUT IMPEDANCE. GAIN IS

EASILY CONTROLLED WITH A SINGLE FEEDBACK RESISTOR. FET INPUT OP-AMPS (BIFETS) HAVE A VERY HIGH FREQUENCY RESPONSE. IT'S USUALLY OK TO SUBSTITUTE OP-AMPS IF BOTH ARE NORMALLY POWERED BY A DUAL POLARITY SUPPLY ($\frac{1}{2}$ LF353 FOR 741C, ETC)... BUT PERFORMANCE WILL IMPROVE OR DECREASE ACCORDING TO THE NEW OP-AMP'S SPECIFICATIONS.

COMPARATOR

SAME AS AN OP-AMP WITHOUT A FEEDBACK RESISTOR. ULTRA-HIGH GAIN GIVES A SNAP-LIKE RESPONSE TO AN INPUT VOLTAGE AT ONE INPUT THAT EXCEEDS A REFERENCE VOLTAGE AT THE SECOND INPUT.

TIMERS

USE ALONE OR WITH OTHER ICs FOR NUMEROUS TIMING AND PULSE GENERATION APPLICATIONS.

LED CHIPS

MOST IMPORTANT ARE A FLASHER CHIP AND A DOT-BARGRAPH ANALOG-TO-DIGITAL DISPLAY. VERY EASY TO USE.

OSCILLATORS

A VOLTAGE CONTROLLED OSCILLATOR AND A COMBINED VOLTAGE-TO-FREQUENCY AND FREQUENCY-TO-VOLTAGE CONVERTER. ALSO INCLUDED IS A TONE DECODER THAT CAN BE SET TO INDICATE A SPECIFIC FREQUENCY.

AUDIO AMPLIFIERS

THIS SECTION INCLUDES SEVERAL EASY TO USE POWER AMPLIFIERS THAT ARE IDEAL FOR DO-IT-YOURSELF STEREO, PUBLIC ADDRESS SYSTEMS, INTERCOMS AND OTHER AUDIO APPLICATIONS.

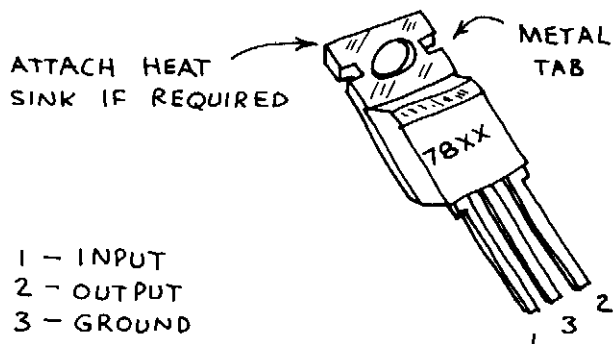
VOLTAGE REGULATORS

7805 (5-VOLTS)

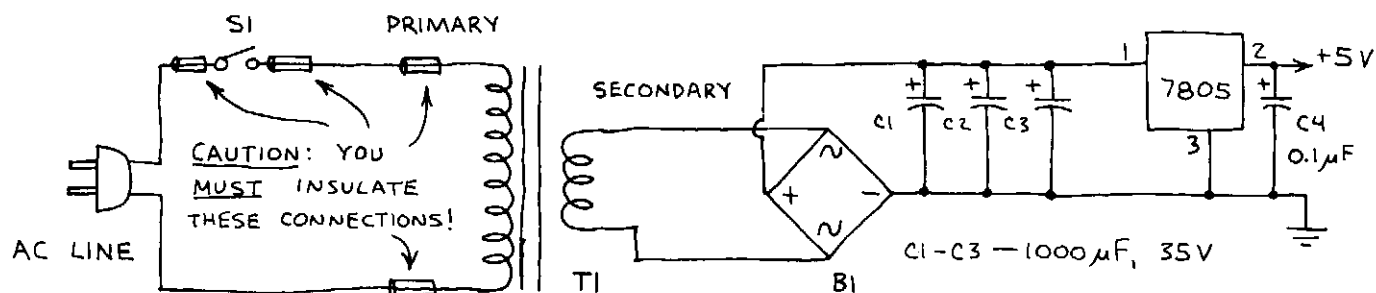
7812 (12-VOLTS)

7815 (15-VOLTS)

FIXED VOLTAGE REGULATORS. IDEAL FOR STAND-ALONE POWER SUPPLIES, ON-CARD REGULATORS, AUTOMOBILE BATTERY POWERED PROJECTS, ETC. UP TO 1.5 AMPERES OUTPUT IF PROPERLY HEAT SUNK AND SUFFICIENT INPUT CURRENT AVAILABLE. THERMAL SHUTDOWN CIRCUIT TURNS OFF REGULATOR IF HEATSINK TOO SMALL.

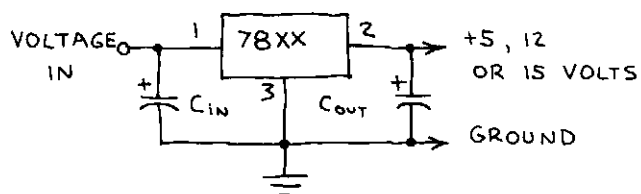


5-VOLT LINE POWERED TTL/LS POWER SUPPLY



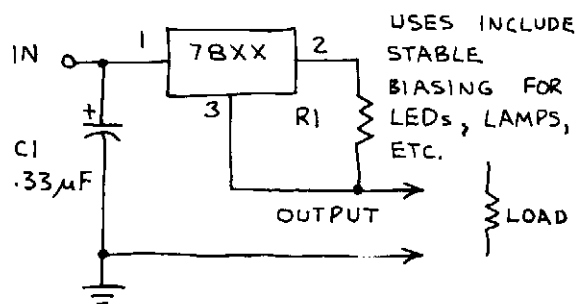
T1 - 117-12.6 V, 1.2 A OR 3 A TRANSFORMER
 B1 - 1A-4A FULL WAVE BRIDGE RECTIFIER

VOLTAGE REGULATOR



C_{IN} - OPTIONAL; USE $0.33 \mu F$ OR SO IF REGULATOR FAR FROM POWER SUPPLY.
 C_{OUT} - OPTIONAL; USE $0.1 \mu F$ OR MORE TO TRAP SPIKES THAT BOTHER LOGIC ICs.

CURRENT REGULATOR

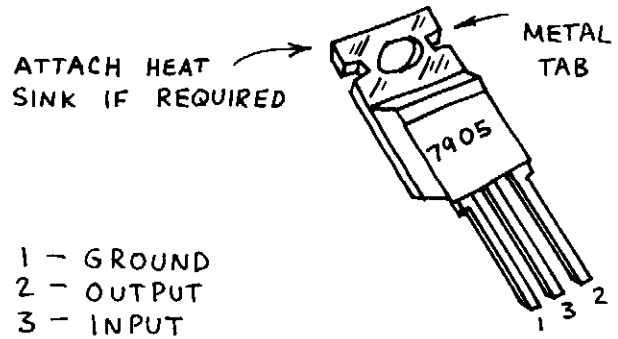


OUTPUT CURRENT = $\frac{\text{REGULATOR VOLTS}}{R1}$

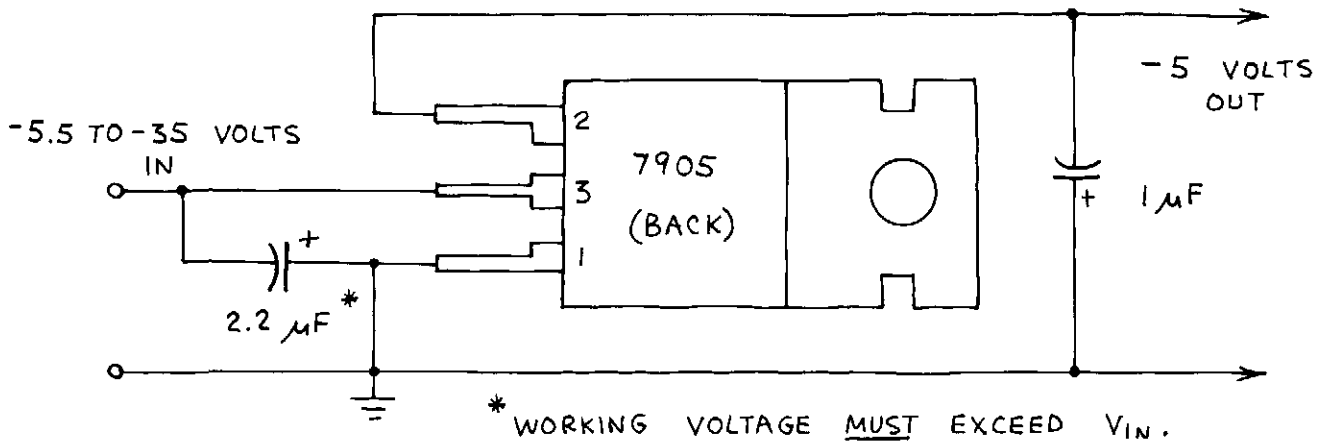
-5 VOLT REGULATOR

7905

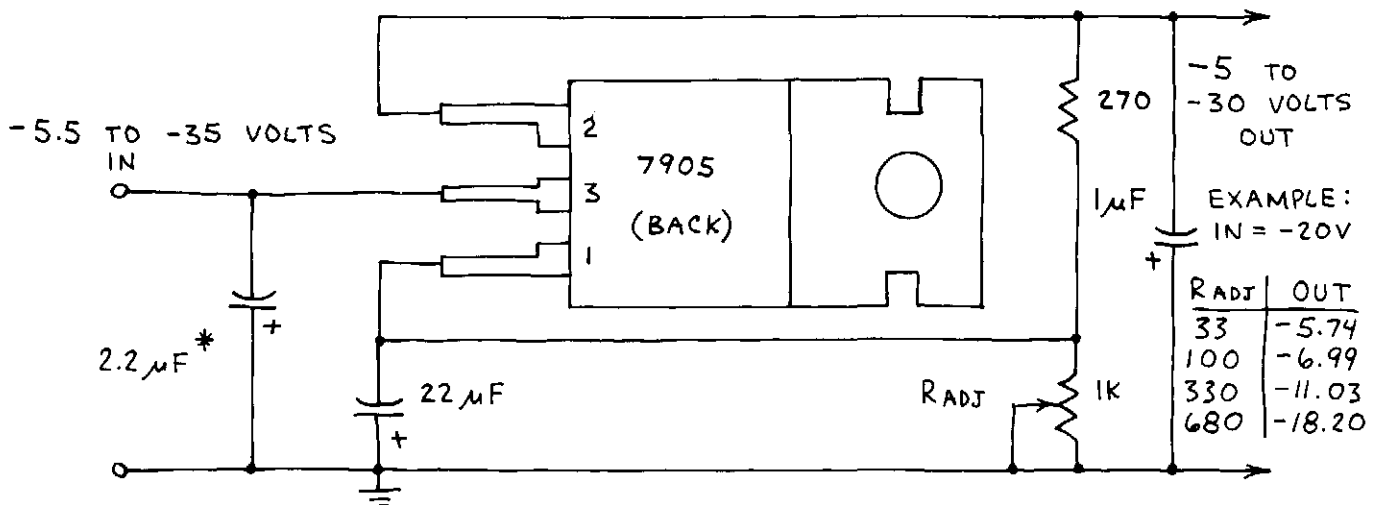
FIXED -5 VOLT REGULATOR. CAN BE USED TO GIVE ADJUSTABLE VOLTAGE OUTPUT. UP TO 1.5 AMPERES OUTPUT IF PROPERLY HEAT SUNK AND SUFFICIENT INPUT CURRENT AVAILABLE. THERMAL SHUTDOWN CIRCUIT TURNS REGULATOR OFF IF HEATSINK TOO SMALL.



FIXED -5 VOLT REGULATOR



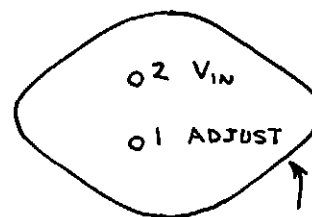
ADJUSTABLE NEGATIVE POWER SUPPLY



1.2-37 VOLT REGULATOR

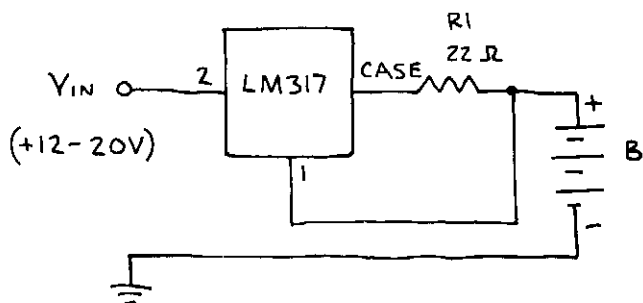
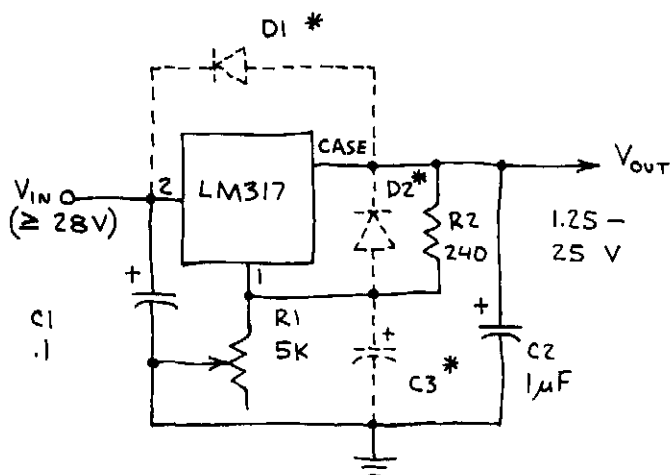
LM317

CAN SUPPLY UP TO 1.5 AMPERES OVER A 1.2-37 VOLT OUTPUT RANGE. NOTE MINIMUM NUMBER OF EXTERNAL COMPONENTS IN BASIC REGULATOR CIRCUIT BELOW. USE HEAT SINK FOR APPLICATIONS REQUIRING FULL POWER OUTPUT. SEE APPROPRIATE DATA BOOK FOR ADDITIONAL INFORMATION:



BOTTOM VIEW (TO-3 CASE) CASE = V_{out}

1.25-25 VOLT REGULATOR 6-VOLT NICAD CHARGER



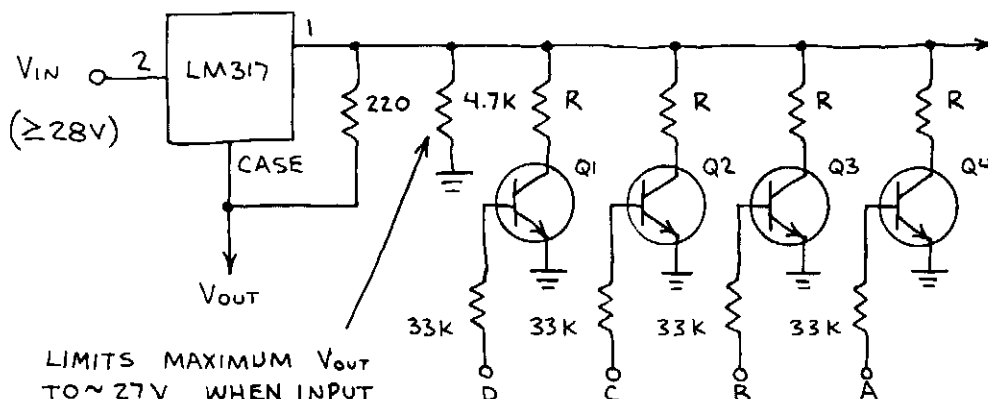
B1 IS BATTERY OF 4 NICKEL CADMIUM STORAGE CELLS IN SERIES. THIS CIRCUIT CHARGES B1 AT A CURRENT OF 51.2 mA. INCREASE R1 TO REDUCE CURRENT. FOR EXAMPLE, CURRENT IS 43 mA WHEN R1 IS 24 OHMS.

V_{IN} SHOULD BE FILTERED. OK TO OMIT C1 IF V_{IN} VERY CLOSE TO LM317.

R1 CONTROLS OUTPUT VOLTAGE.

* ADD IF OUTPUT > 25 V AND $C2 > 25\mu F$.

PROGRAMMABLE POWER SUPPLY



TO ADDITIONAL STAGES

DCBA INPUTS: CONNECT TO PIN 2 TO SELECT.

R	V_{out}
100	1.8
330	3.0
470	4.0
1K	7.3
2.2K	13.5
3.3K	18.0

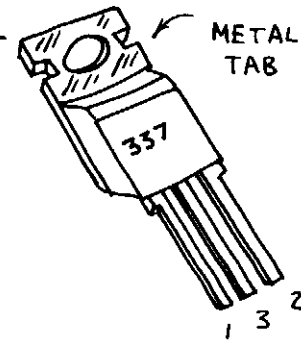
LIMITS MAXIMUM V_{out} TO ~ 27V WHEN INPUT IS 28V.

-1.2 TO -37 VOLT REGULATOR

337T

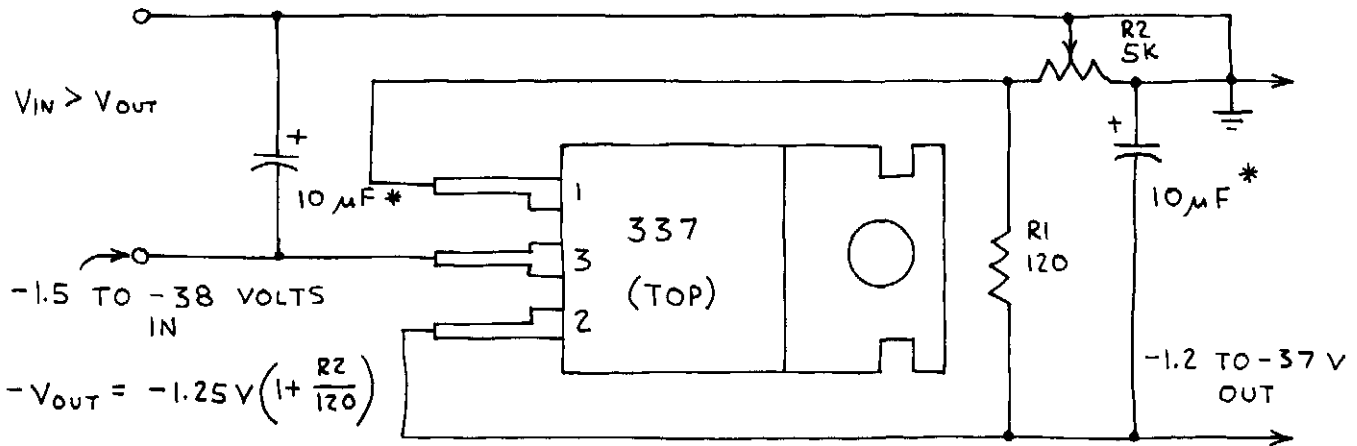
CAN SUPPLY UP TO -1.5 AMPERES OVER A -1.2 TO -37 VOLT OUTPUT RANGE. FEW EXTERNAL COMPONENTS REQUIRED. COMPLEMENTS LM317 ADJUSTABLE POSITIVE REGULATOR.

ATTACH HEAT SINK IF REQUIRED



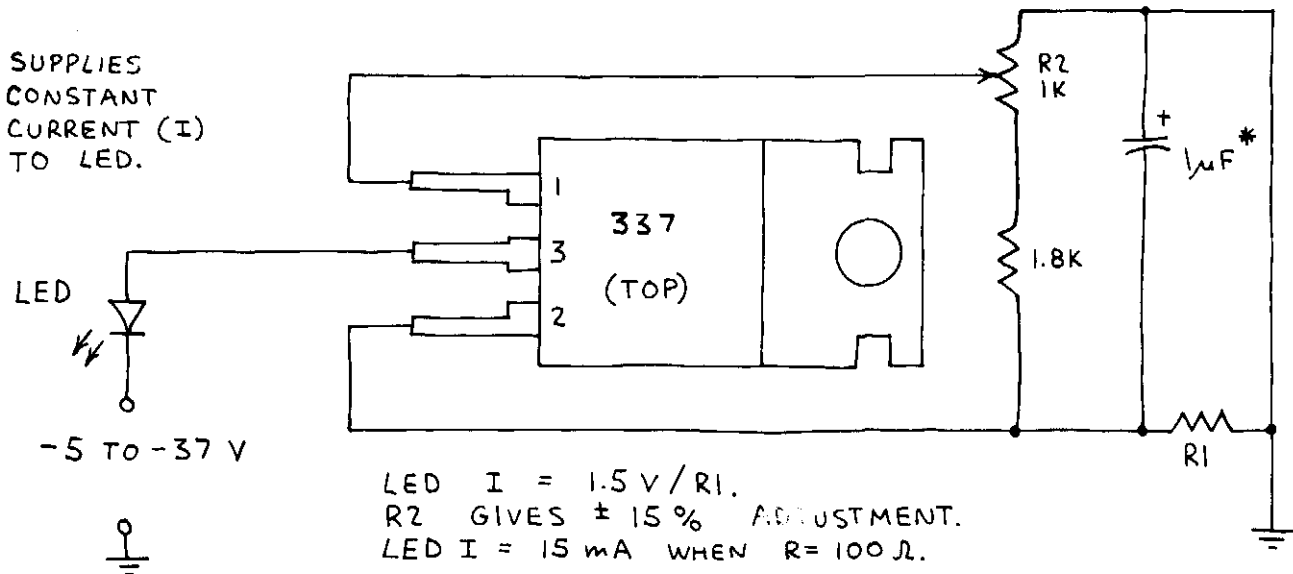
- 1 - ADJUST
- 2 - OUTPUT
- 3 - INPUT

ADJUSTABLE NEGATIVE REGULATOR



* WORKING VOLTAGE MUST EXCEED V_{IN} .

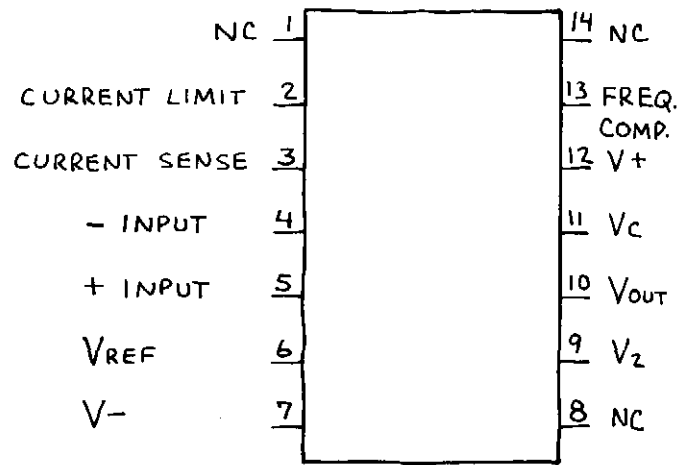
PRECISION LED REGULATOR



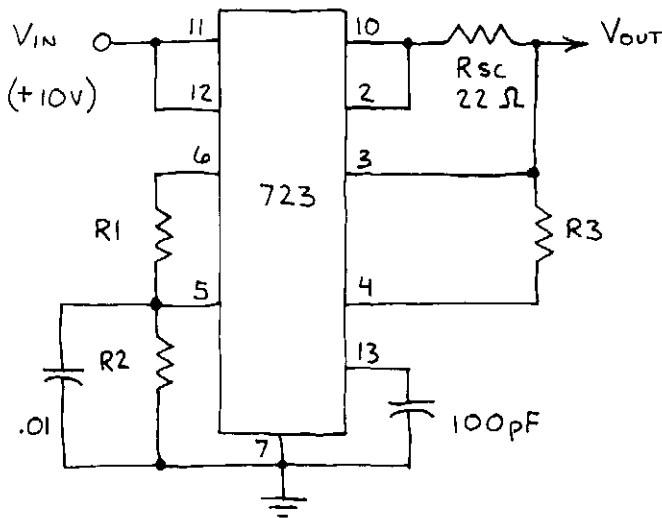
2-37 VOLT REGULATOR

723

VERY VERSATILE SERIES REGULATOR. UP TO 40 VOLTS INPUT AND 2-37 VOLT OUTPUT. MAXIMUM OUTPUT CURRENT OF 150 mA CAN BE EXTENDED TO 10 A BY ADDING EXTERNAL POWER TRANSISTORS. SHOWN BELOW ARE TWO BASIC CIRCUITS. TRY THESE, THEN SEE APPROPRIATE DATA BOOK FOR ADDITIONAL CIRCUITS.



2-7 VOLT REGULATOR



TYPICAL VALUES

V _{out}	R ₁	R ₂	R ₃
3.0	4.12 K	3.01 K	1.74 K
3.6	3.57 K	3.65 K	1.80 K
5.0	2.15 K	4.99 K	1.50 K
6.0	1.15 K	6.04 K	966

FOR ANY VOLTAGE BETWEEN 2-7 VOLTS:

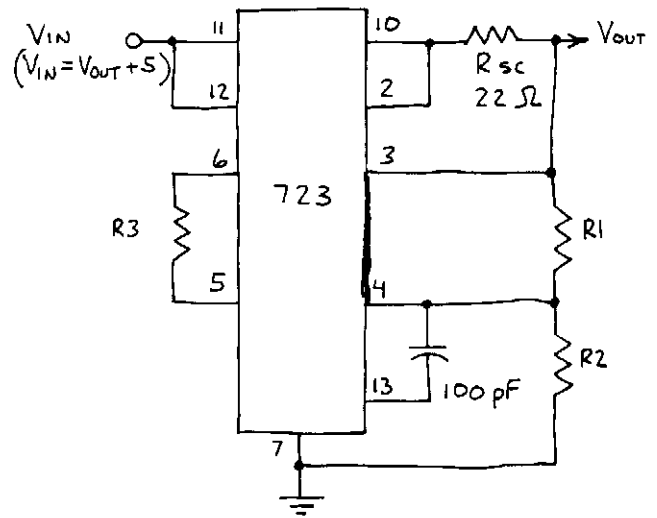
$$V_{out} = (V_{REF}^*) \times \left(\frac{R_2}{R + R_2} \right)$$

* V_{REF} = 6.8 - 7.5 V (MEASURE AT PIN 6)

$$R_3 = \frac{R_1 \times R_2}{R_1 + R_2}$$

90

7-37 VOLT REGULATOR



TYPICAL VALUES

V _{out}	R ₁	R ₂	R ₃
9	1.87 K	7.15 K	.48 K
12	4.87 K	7.15 K	2.90 K
15	7.87 K	7.15 K	3.75 K
28	21.0 K	7.15 K	5.33 K

FOR ANY VOLTAGE BETWEEN 7-37 VOLTS:

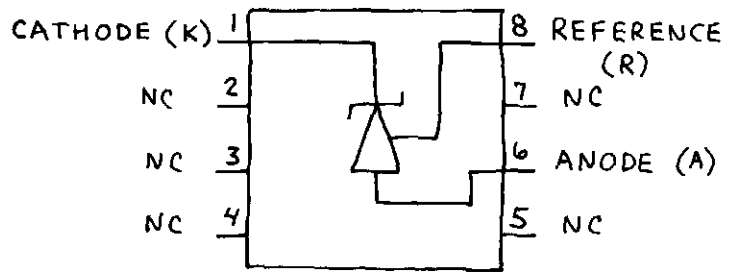
$$V_{out} = (V_{REF}^*) \times \left(\frac{R_1 + R_2}{R_2} \right)$$

$$R_3 = \frac{R_1 \times R_2}{R_1 + R_2} \quad (R_3, \text{ WHICH IS OPTIONAL, GIVES TEMPERATURE STABILITY})$$

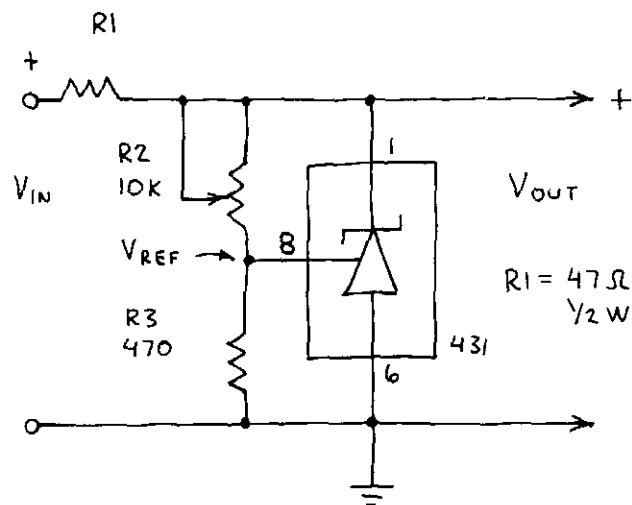
ADJUSTABLE SHUNT (ZENER) REGULATOR

TL431

EASY TO USE THREE TERMINAL ADJUSTABLE PRECISION SHUNT REGULATOR. OUTPUT CAN BE SET TO FROM 2.5 TO 36 VOLTS.

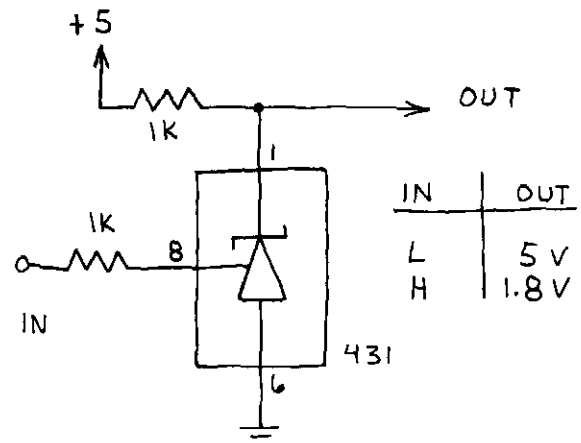


ADJUSTABLE REGULATOR



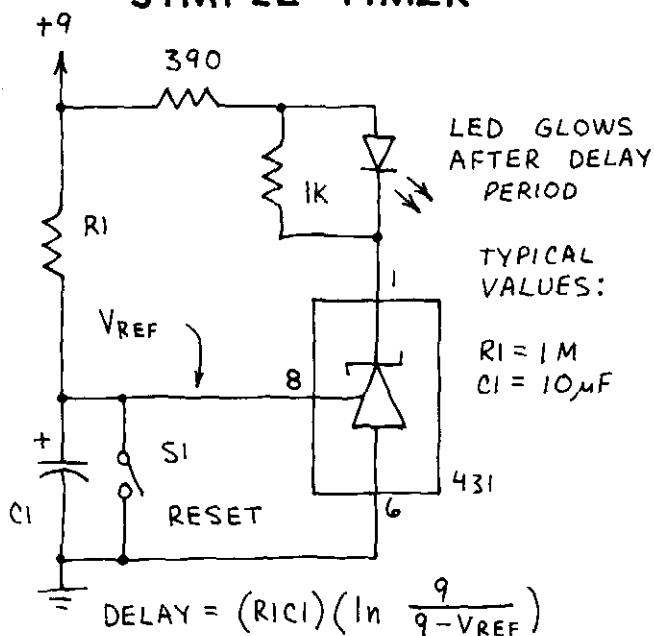
$$V_{OUT} = (1 + R_1/R_2) V_{REF} = 3-30V$$

VOLTAGE DETECTOR

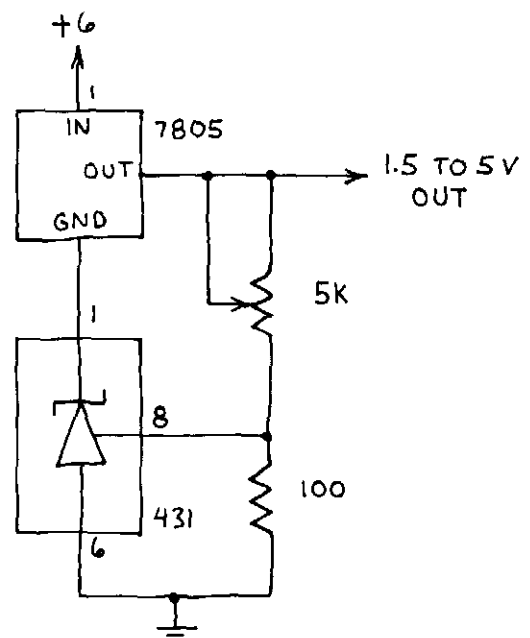


USE TO DETECT TTL LOGIC LEVELS.

SIMPLE TIMER



1.5 TO 5V POWER SUPPLY

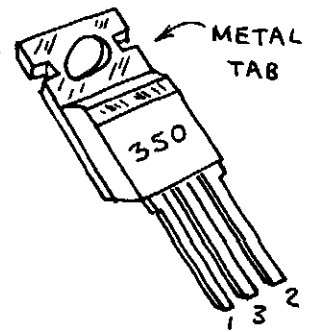


1.2 TO 33 VOLT REGULATOR

350T

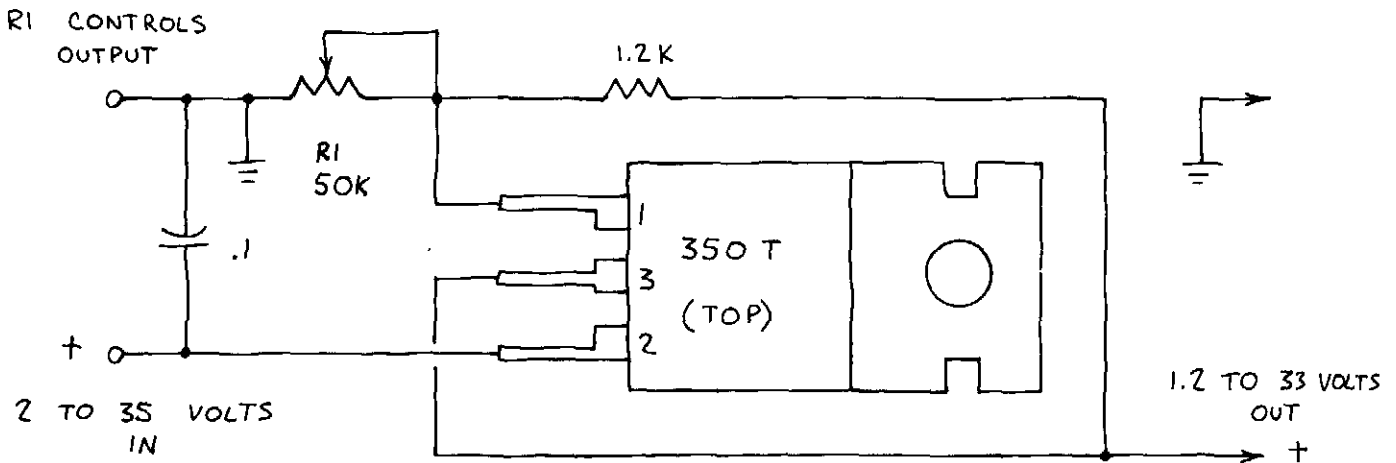
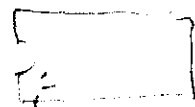
CAN SUPPLY UP TO 3 AMPERES OVER 1.2 TO 33 VOLT OUTPUT RANGE. FEW EXTERNAL COMPONENTS REQUIRED. HEAT SINK REQUIRED FOR FULL POWER OUTPUT.

ATTACH HEAT SINK IF REQUIRED

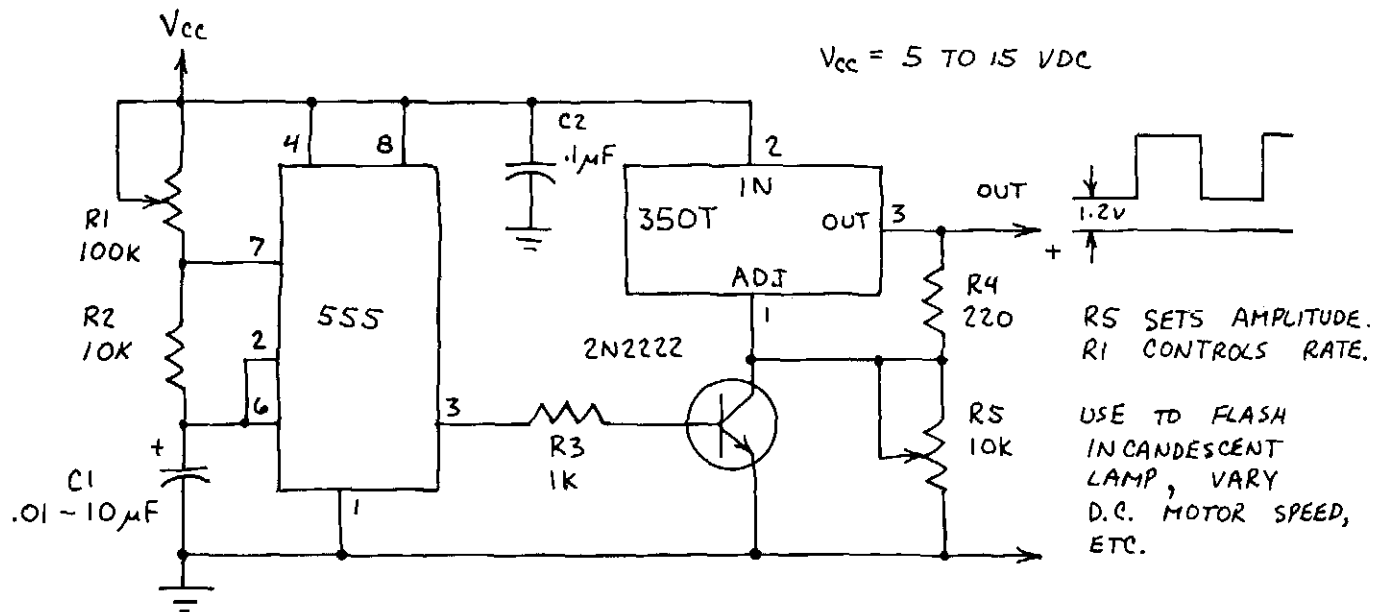


- 1 - ADJUST
- 2 - INPUT
- 3 - OUTPUT

1.2 TO 20 VOLT REGULATOR



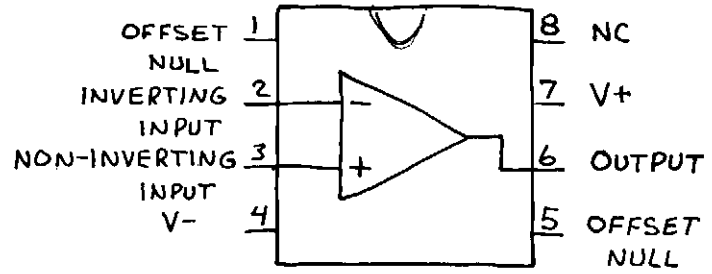
POWER PULSE GENERATOR



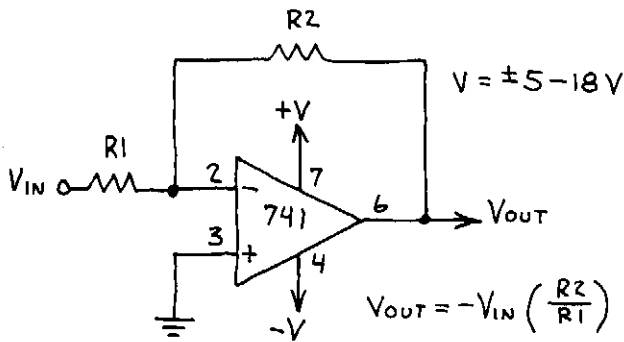
OPERATIONAL AMPLIFIER

741C

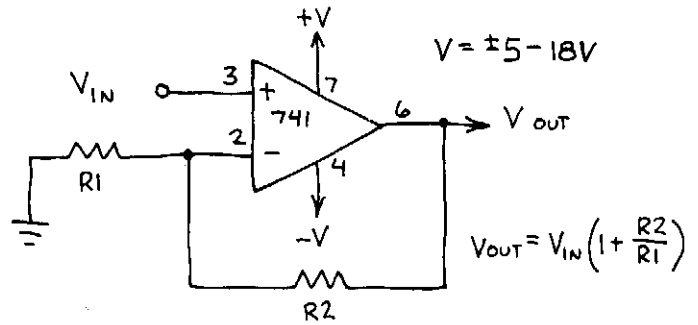
THE MOST POPULAR OP-AMP. USE FOR ALL GENERAL PURPOSE APPLICATIONS. (FOR SINGLE SUPPLY OPERATION AND VERY HIGH INPUT IMPEDANCE, USE OTHER OP-AMPS IN THIS NOTEBOOK.)



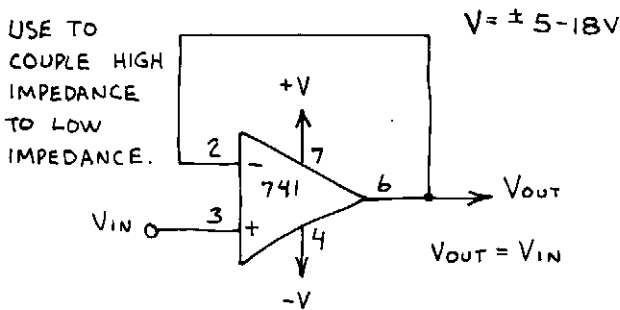
INVERTING AMPLIFIER



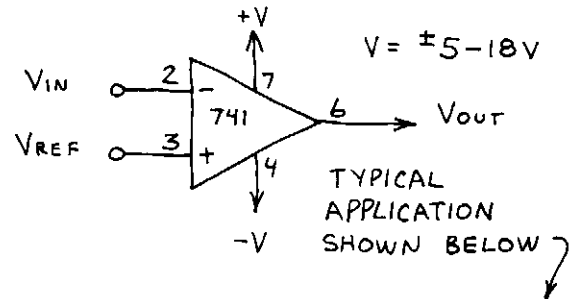
NON-INVERTING AMPLIFIER



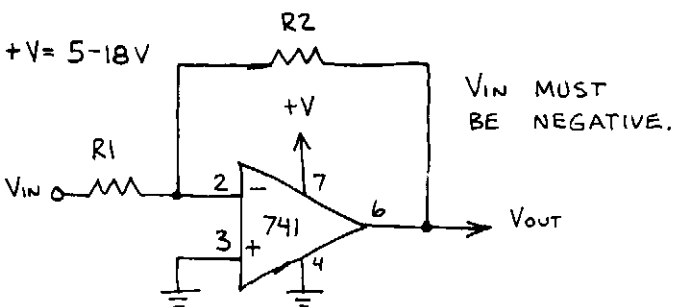
UNITY GAIN FOLLOWER



COMPARATOR

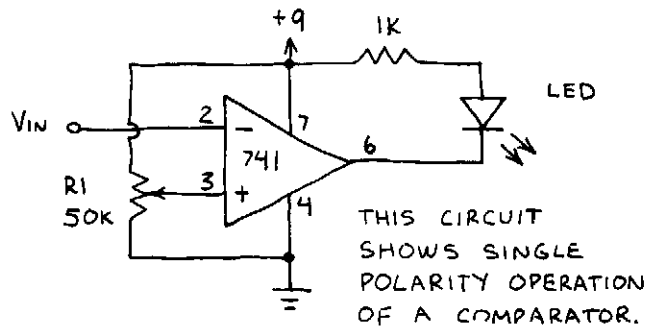


SINGLE POLARITY SUPPLY



TYPICAL USES:
AMPLIFICATION OF DC VOLTAGE AND PULSES.

LEVEL DETECTOR

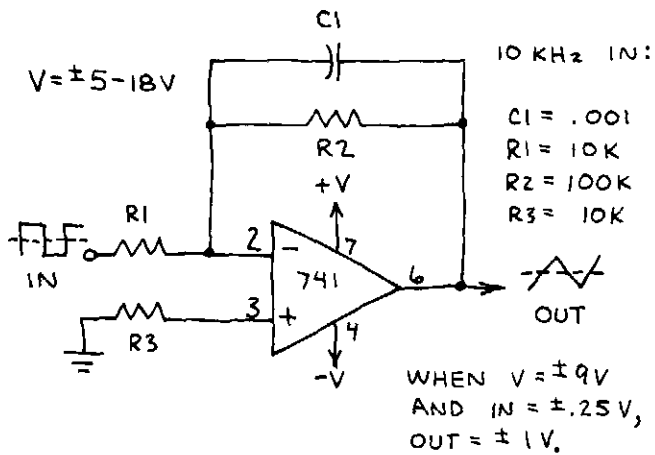


R1 SETS THE VOLTAGE DETECTION THRESHOLD (UP TO +9). WHEN VIN EXCEEDS THE THRESHOLD (ALSO CALLED THE REFERENCE), THE LED GLOWS.

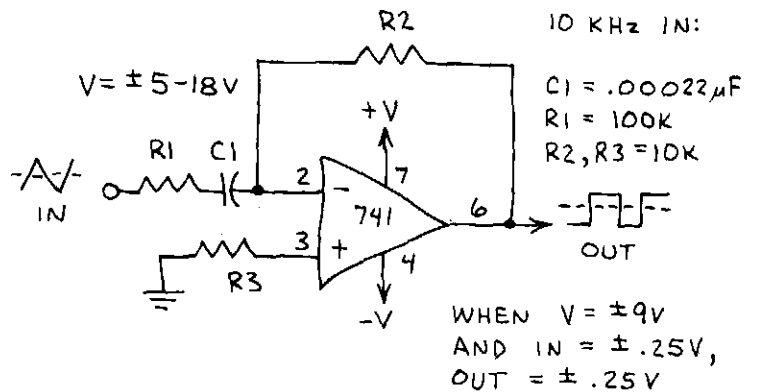
OPERATIONAL AMPLIFIER (CONTINUED)

741C

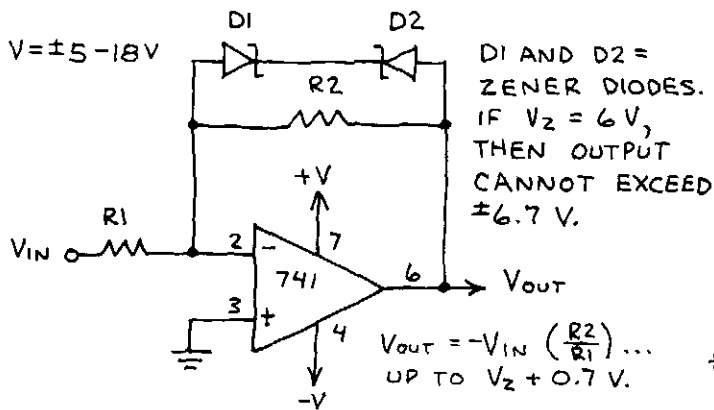
BASIC INTEGRATOR



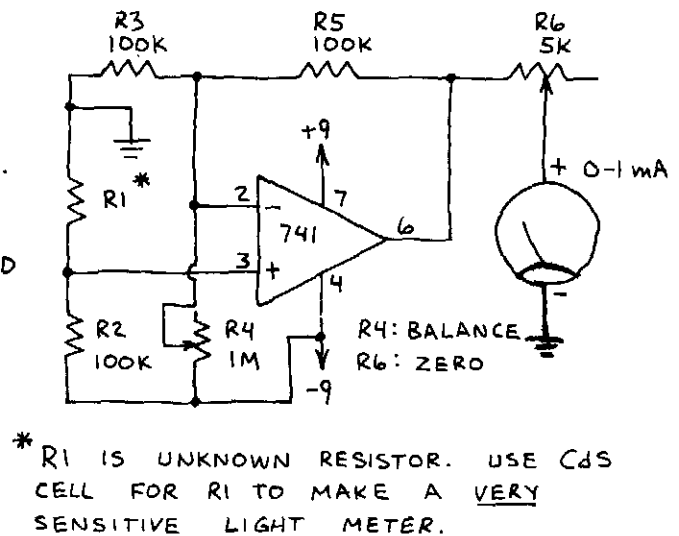
BASIC DIFFERENTIATOR



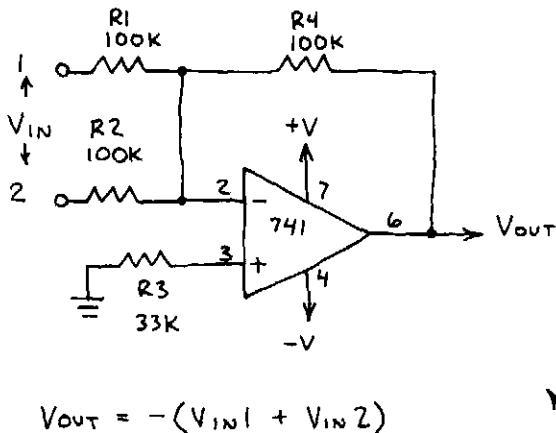
CLIPPING AMPLIFIER



BRIDGE AMPLIFIER

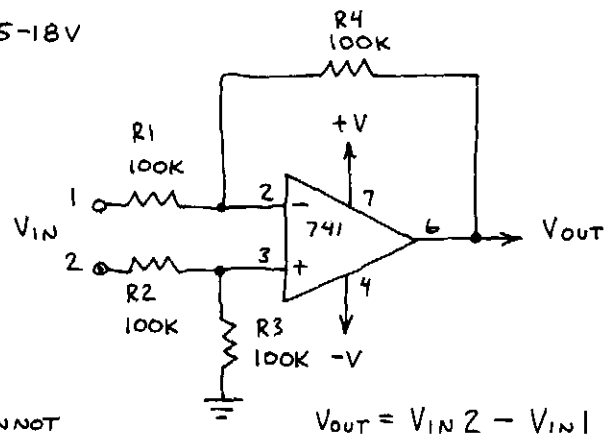


SUMMING AMPLIFIER



NOTE: V_{out} CANNOT EXCEED $\pm V$.

DIFFERENCE AMPLIFIER

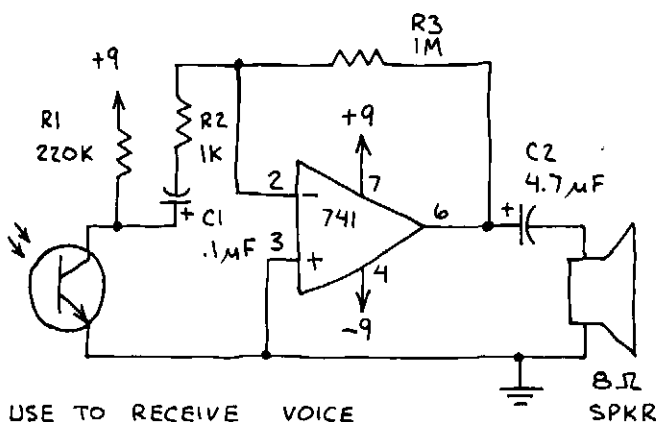


OPERATIONAL AMPLIFIER

(CONTINUED)

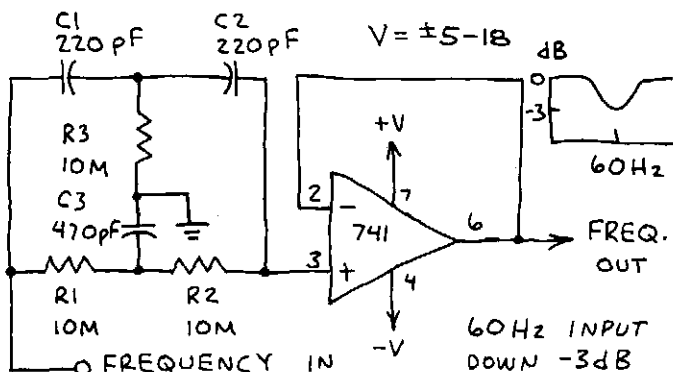
741C

LIGHT WAVE RECEIVER

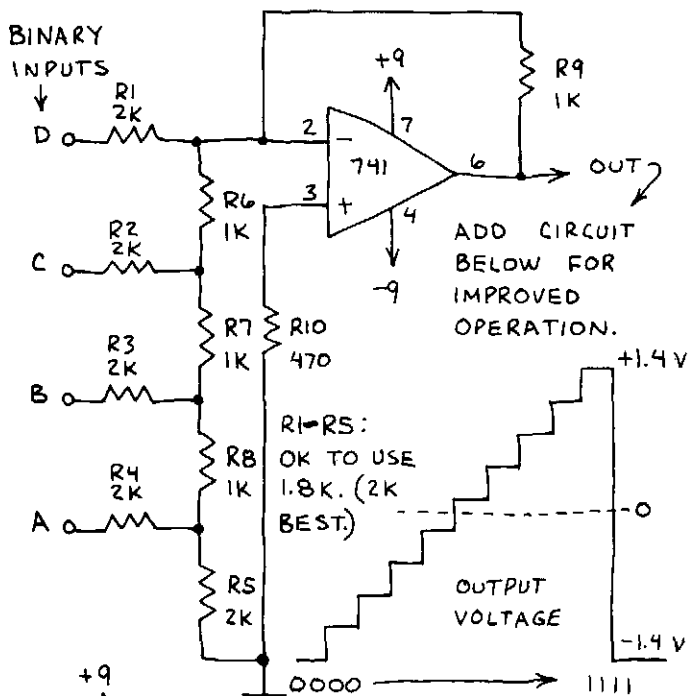


USE TO RECEIVE VOICE MODULATED LIGHT WAVES. OK TO USE SINGLE POLARITY POWER SUPPLY FOR NON-VOICE RECEPTION.

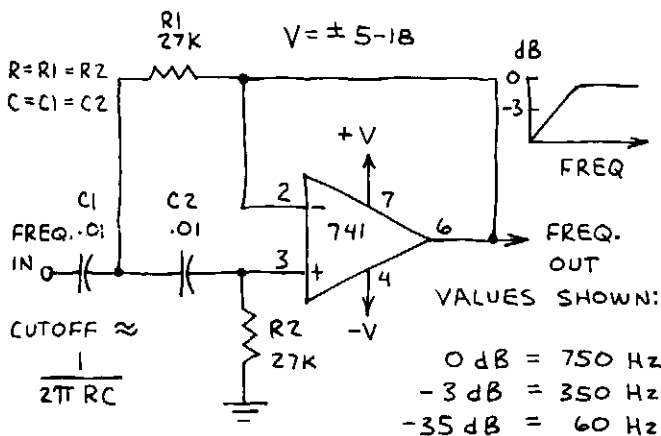
60-Hz NOTCH FILTER



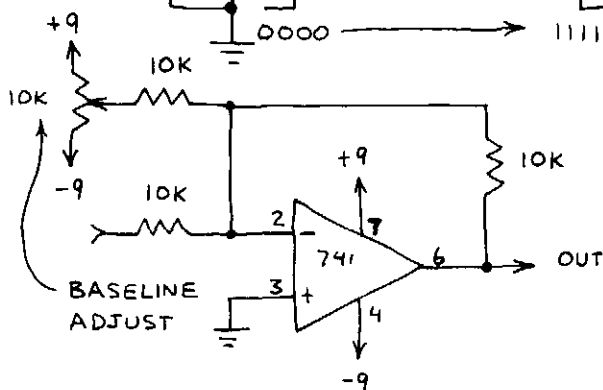
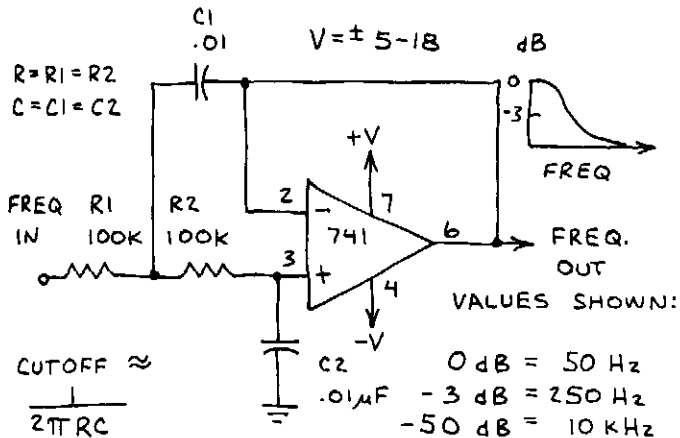
4-BIT D/A CONVERTER



HIGH PASS ACTIVE FILTER



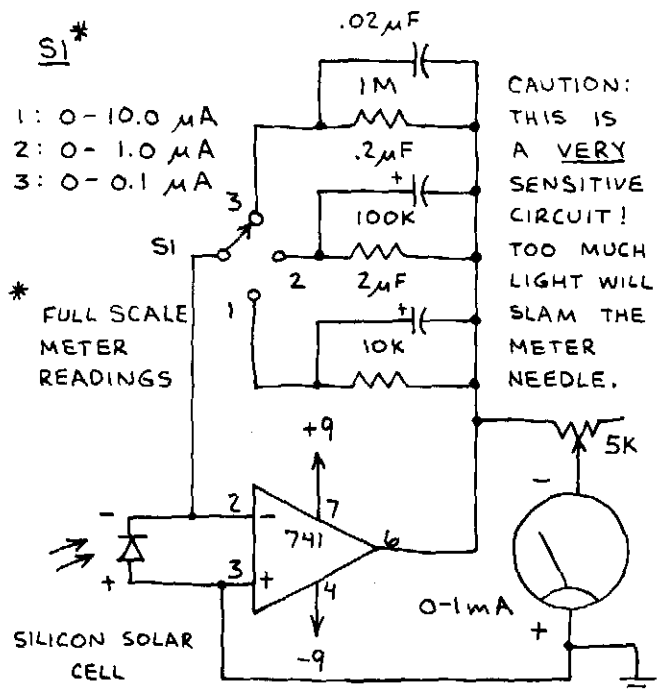
LOW PASS ACTIVE FILTER



OPERATIONAL AMPLIFIER 741C

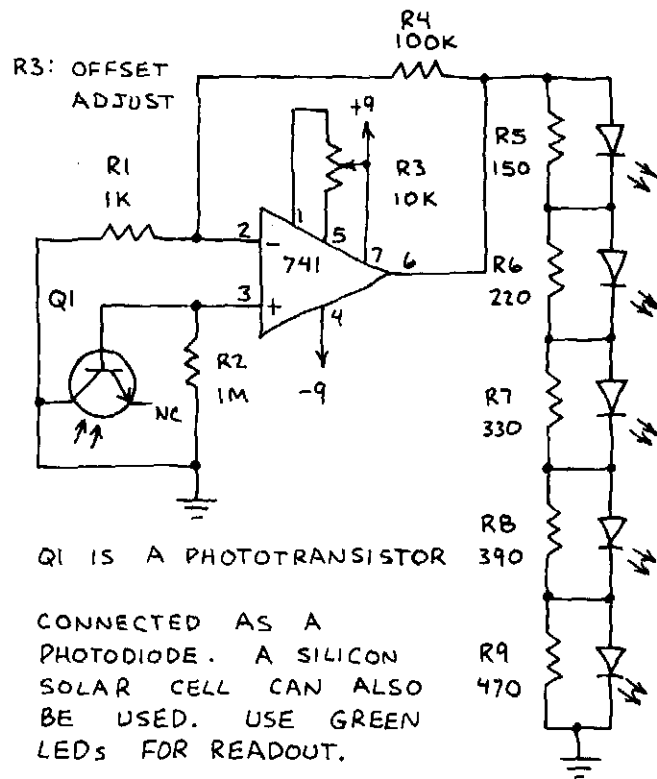
(CONTINUED)

OPTICAL POWER METER

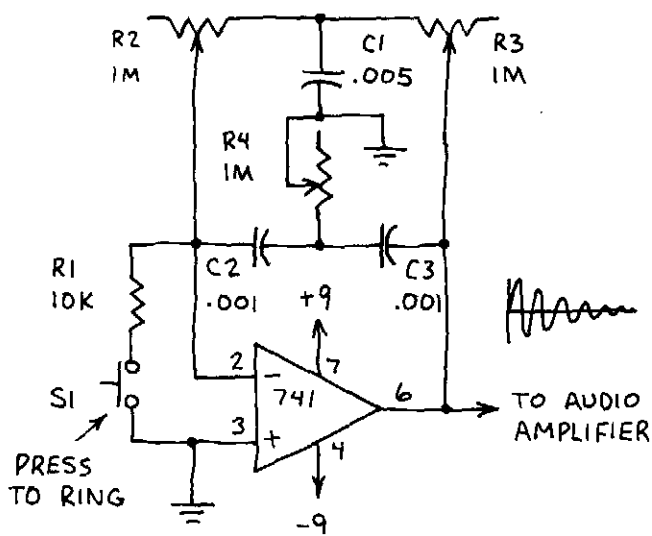


THIS CIRCUIT CAN BE USED AS A FAIRLY GOOD QUALITY RADIOMETER.

BARGRAPH LIGHT METER

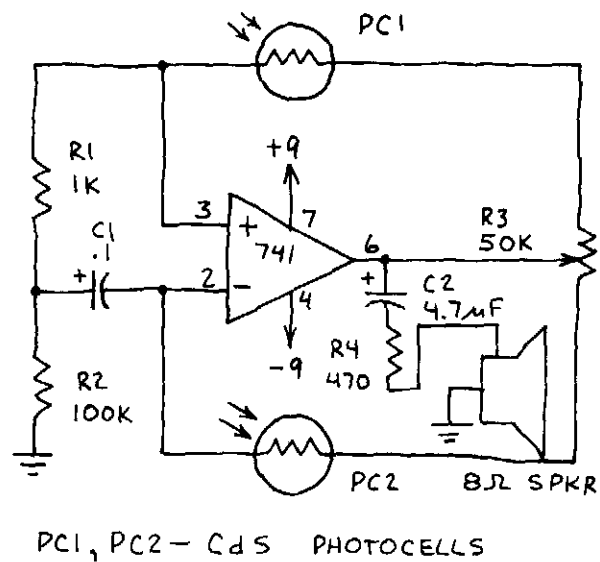


ELECTRONIC BELL



ADJUST R3 TO JUST BELOW OSCILLATION POINT. ADJUST R2 AND R3 FOR SOUNDS SUCH AS BELL, DRUM, TINKLING, ETC.

AUDIBLE LIGHT SENSOR

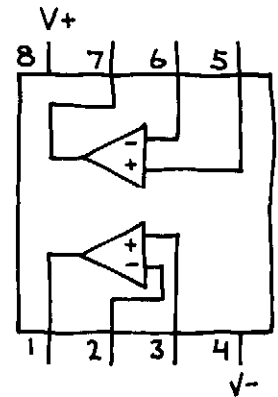


LIGHT ON PC1 DECREASES TONE FREQUENCY. LIGHT ON PC2 INCREASES TONE FREQUENCY.

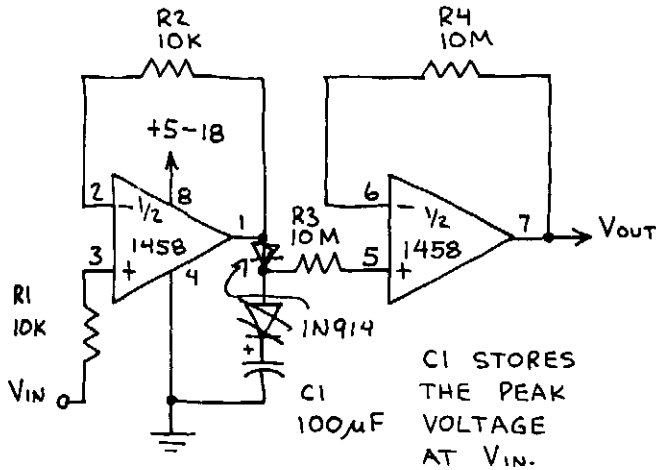
DUAL OPERATIONAL AMPLIFIER

1458

TWO 741C OP-AMPS IN A SINGLE 8-PIN MINI-DIP. TRY TO USE THIS CHIP FOR CIRCUITS THAT REQUIRE TWO OR MORE 741'S. YOU'LL SAVE TIME, SPACE AND MONEY.

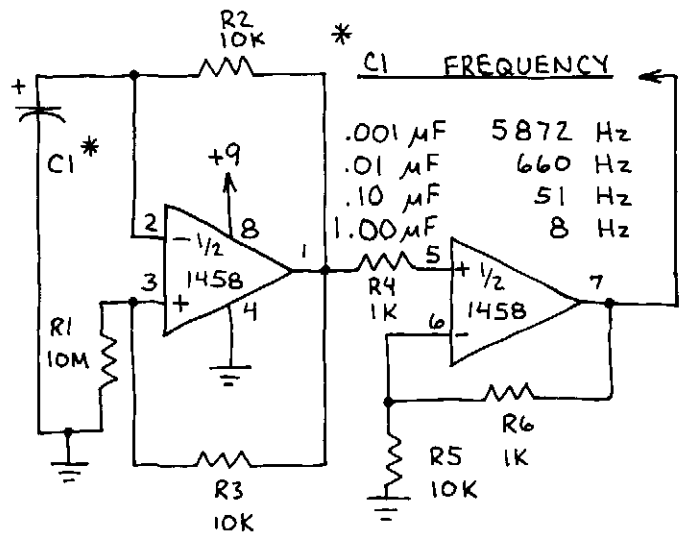


PEAK DETECTOR



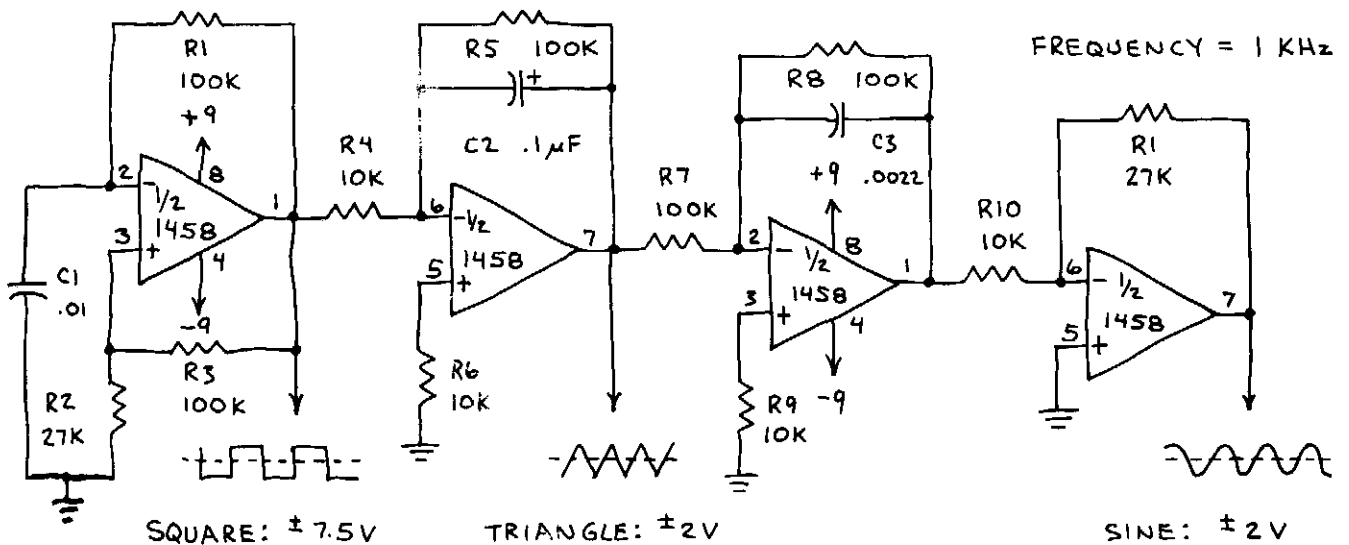
APPLICATIONS INCLUDE USE AS ANALOG "MEMORY" THAT STORES PEAK AMPLITUDE OF A FLUCTUATING VOLTAGE.

PULSE GENERATOR



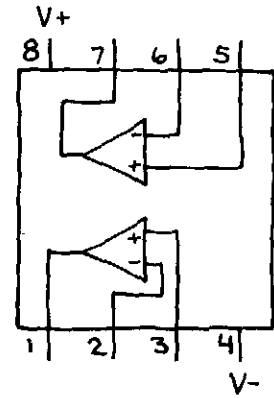
PULSES ARE DC. AMPLITUDE WHEN C1 = 0.1 µF IS 5 VOLTS.

FUNCTION GENERATOR

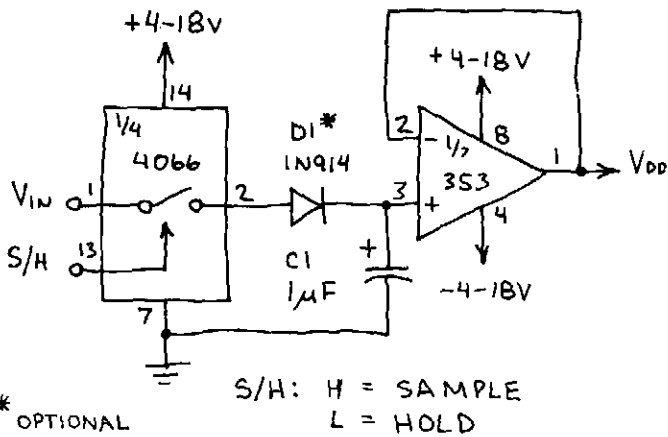


DUAL OPERATIONAL AMPLIFIER LF353N (JFET INPUT)

HIGH IMPEDANCE (10^{12} OHM) JUNCTION FET INPUTS. OUTPUT SHORT CIRCUIT PROTECTION. HIGH SLEW RATE ($13V/\mu\text{SEC}$), LOW NOISE OPERATION. AMPLIFIERS ARE SIMILAR TO THOSE IN THE TLO84C. NOTE THAT PIN CONNECTIONS ARE THE SAME AS 1458. THIS OP-AMP, HOWEVER, OFFERS MUCH BETTER PERFORMANCE.

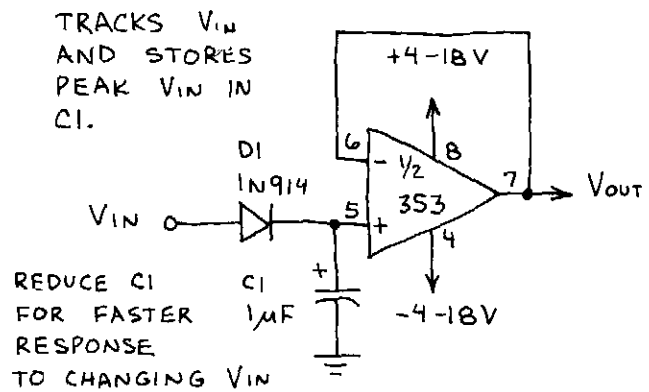


SAMPLE AND HOLD



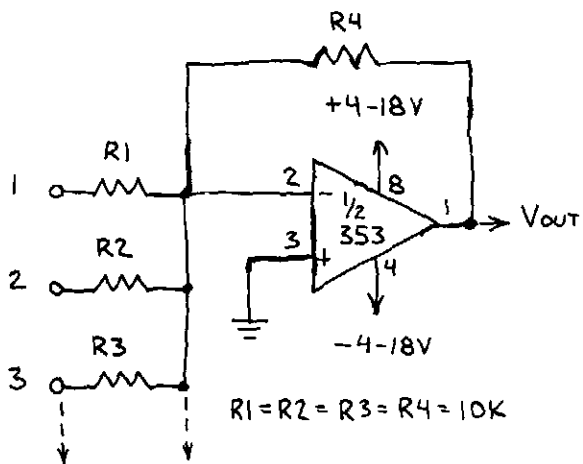
* OPTIONAL

PEAK DETECTOR

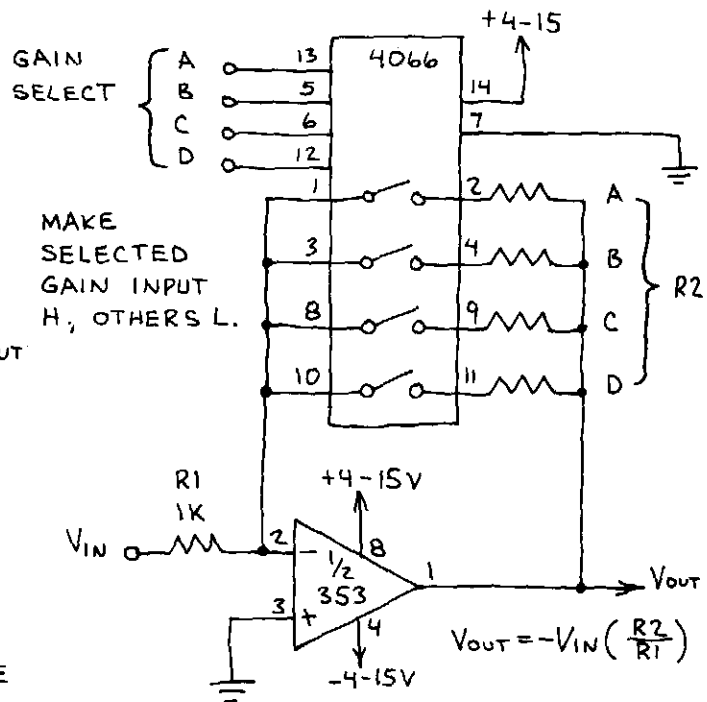


PROGRAMMABLE GAIN OP-AMP

AUDIO MIXER

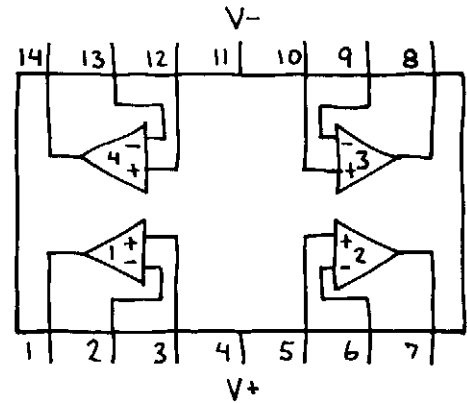


CONNECT OUTPUTS OF PREAMPLIFIERS TO INPUTS 1-3. OK TO ADD MORE CHANNELS. WORKS WELL WITH TLO84 MICROPHONE PREAMPLIFIERS.

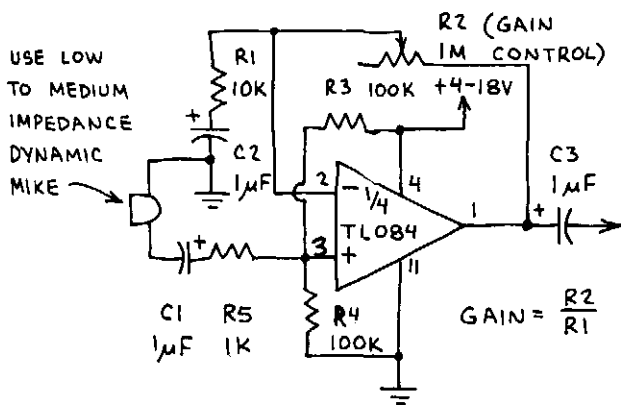


QUAD OPERATIONAL AMPLIFIER TLO84C (JFET INPUT)

HIGH IMPEDANCE (10^{12} OHMS) JUNCTION FET INPUTS. OUTPUT SHORT CIRCUIT PROTECTION. HIGH SLEW RATE (12 V/ μ SEC) PLUS LOW NOISE OPERATION. PERFORMANCE SIMILAR TO LF353N. NOTE THAT PIN CONNECTIONS ARE SAME AS LM324.

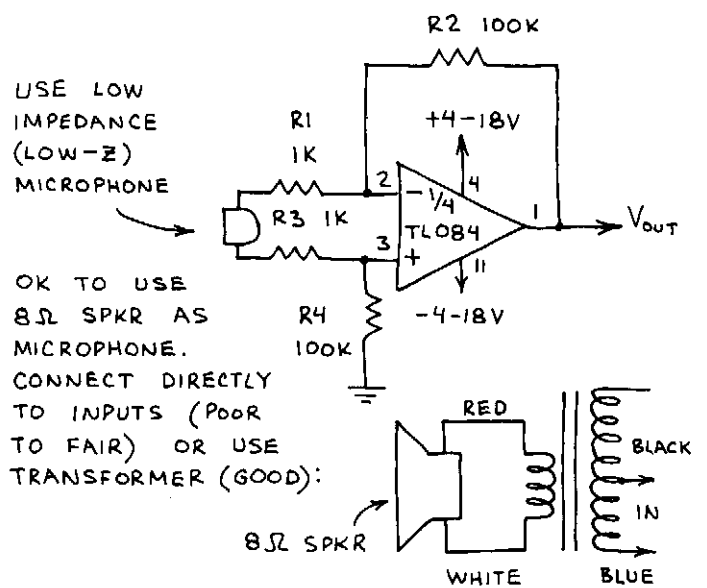


MICROPHONE PREAMPLIFIER

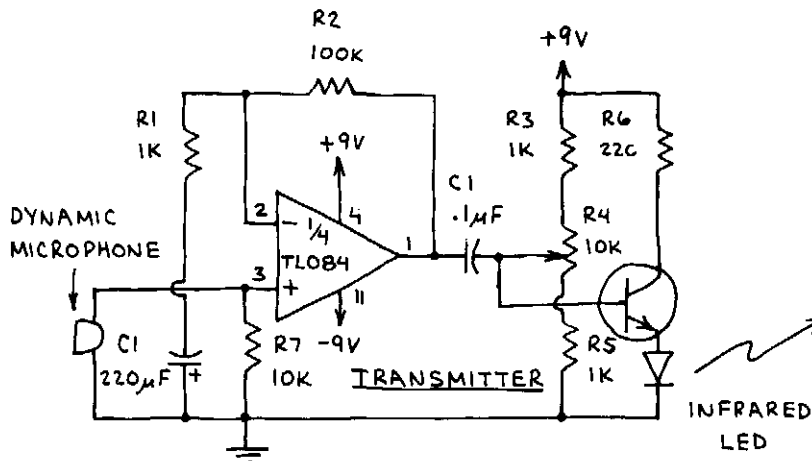


NOTE SINGLE POLARITY POWER SUPPLY (THANKS TO R3 AND R4) AND AC COUPLING.

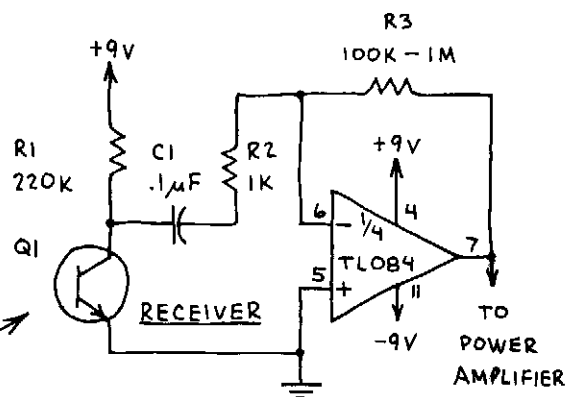
LOW-Z PREAMPLIFIER



INFRARED VOICE COMMUNICATOR



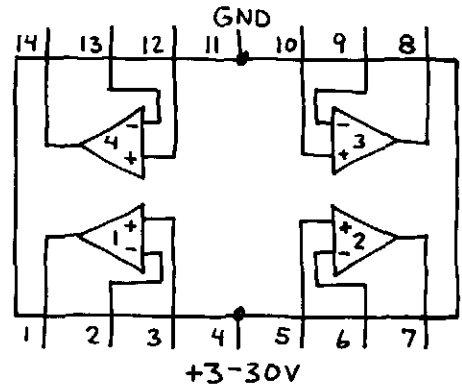
POINT THE LED AT Q1 AND ADJUST R4 UNTIL BEST VOICE QUALITY IS OBTAINED. (R4 APPLIES PREBIAS TO LED.) R6 LIMITS MAXIMUM LED CURRENT TO A SAFE 40 mA.



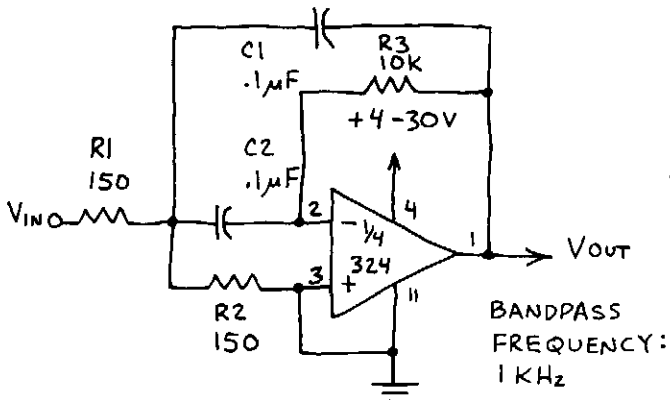
MAXIMUM RANGE: HUNDREDS OF FEET AT NIGHT WITH LENSES AT Q1 AND LED. POWER AMP: SEE LM386.

QUAD OPERATIONAL AMPLIFIER LM324N

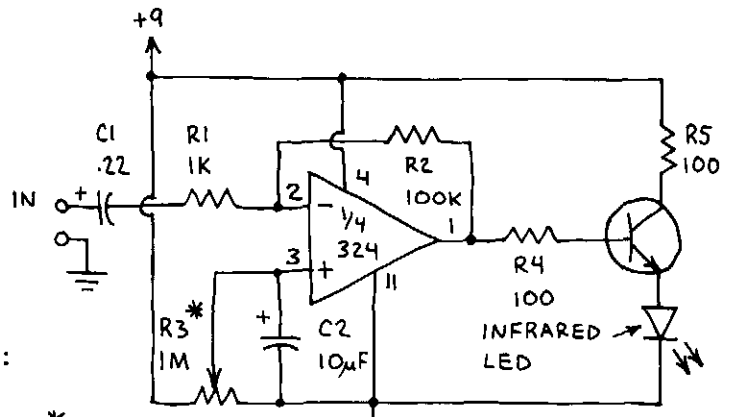
OPERATES FROM SINGLE POLARITY POWER SUPPLY. MORE GAIN (100 dB) BUT LESS BANDWIDTH (1 MHz WHEN GAIN IS 1) THAN THE LM3900 QUAD OP-AMP. NOTE UNUSUAL LOCATION OF POWER SUPPLY PINS. CAUTION: SHORTING THE OUTPUTS DIRECTLY TO V+ OR GND OR REVERSING THE POWER SUPPLY MAY DAMAGE THIS CHIP.



BANDPASS FILTER



INFRARED TRANSMITTER

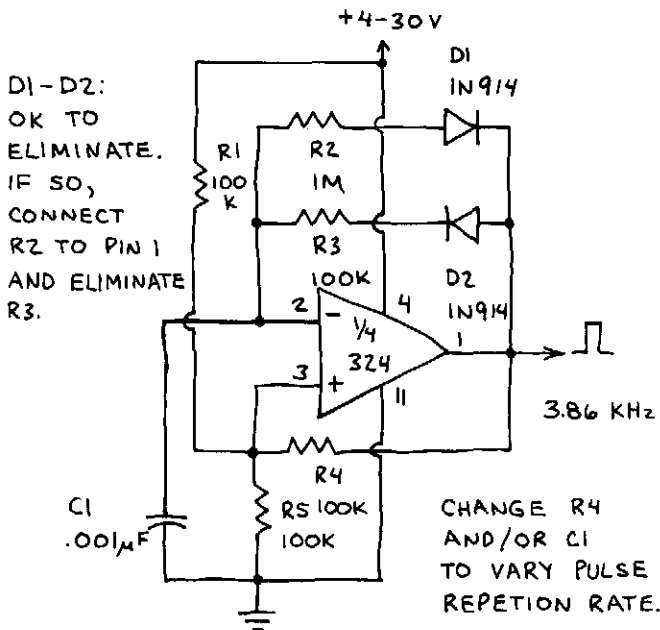


*

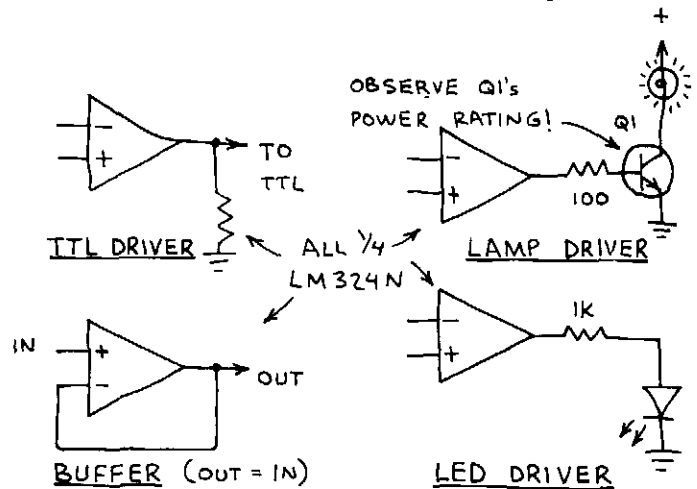
CAREFULLY ADJUST R3 FOR BEST VOICE QUALITY. FOR MORE POWER REDUCE R5 TO 50Ω... BUT DO NOT ALLOW MORE THAN PLUS OP-AMP. 30 mA THROUGH LED!

USE DYNAMIC MICROPHONE AT INPUT. RECEIVE SIGNAL WITH PHOTOTRANSISTOR

PULSE GENERATOR



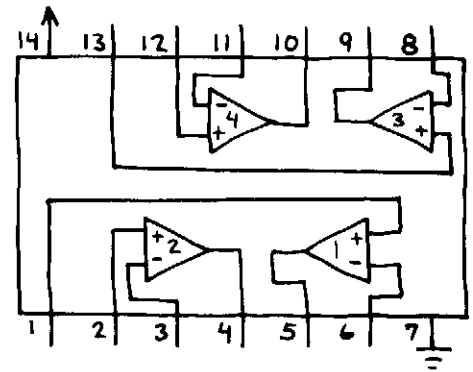
INTERFACE CIRCUITS



QUAD OPERATIONAL AMPLIFIER LM3900N

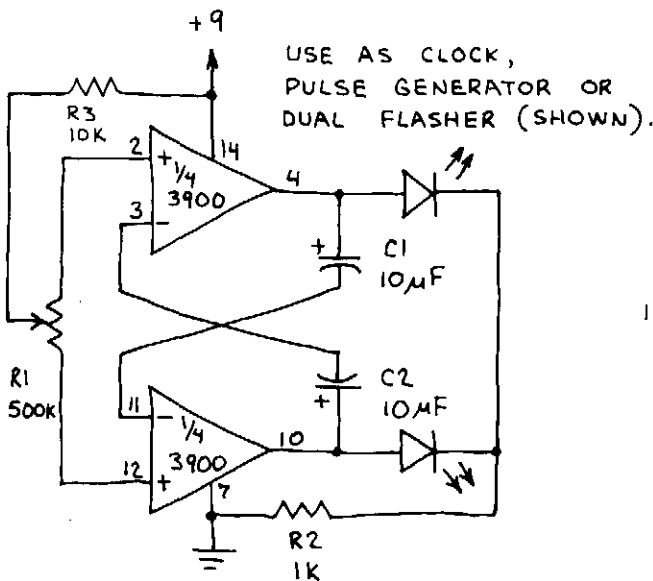
OPERATES FROM SINGLE POLARITY POWER SUPPLY. LESS GAIN (70 dB) BUT WIDER BANDWIDTH (25 MHz AT GAIN OF 1) THAN THE LM324 QUAD OP-AMP. NOTE STANDARD POWER SUPPLY PIN LOCATIONS. CAUTION: SHORTING THE OUTPUTS DIRECTLY TO $V+$ OR GROUND OR REVERSED POWER CONNECTIONS MAY DAMAGE THIS CHIP.

+4-36V

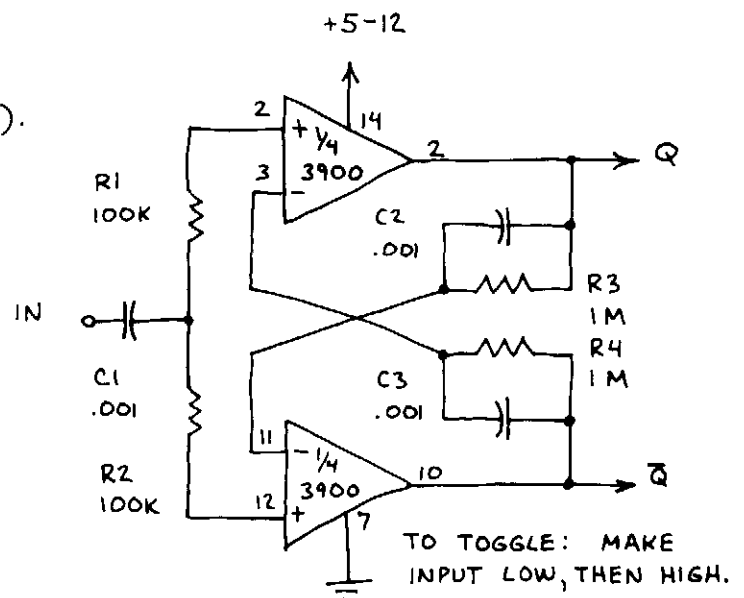


NOTE: DO NOT SUBSTITUTE LM3900 FOR OTHER OP-AMPS.

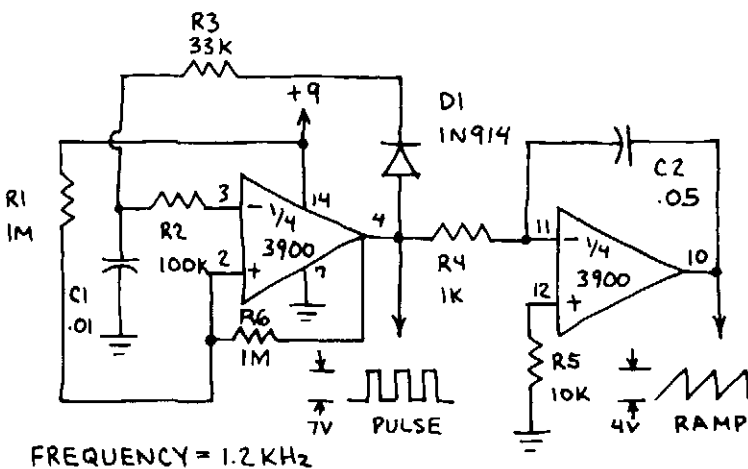
ASTABLE MULTIVIBRATOR



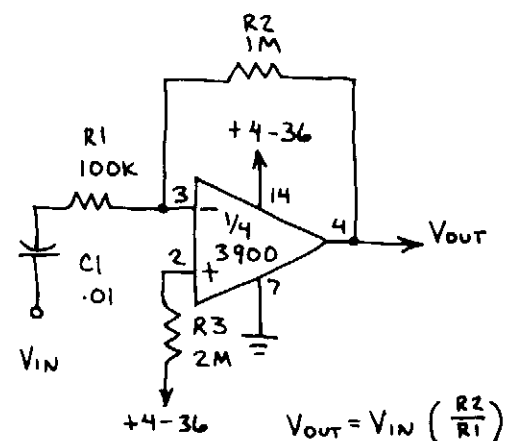
TOGGLE FLIP-FLOP



FUNCTION GENERATOR



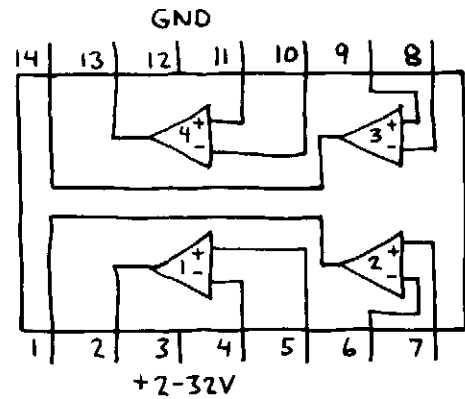
X10 AMPLIFIER



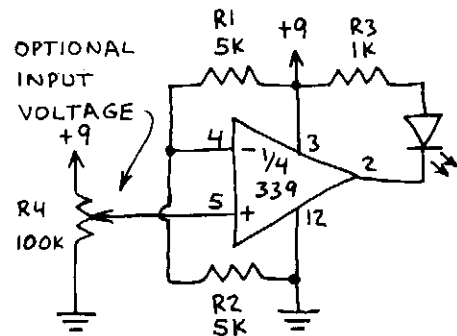
QUAD COMPARATOR

LM339

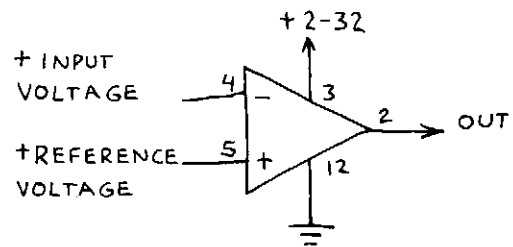
FOUR INDEPENDENT VOLTAGE COMPARATORS IN A SINGLE PACKAGE. NOTE THAT A SINGLE POLARITY POWER SUPPLY IS REQUIRED. (MOST COMPARATORS ARE DESIGNED PRIMARILY FOR DUAL SUPPLY OPERATION.) NOTE UNUSUAL LOCATION OF THE SUPPLY PINS. COMPARATORS MAY OSCILLATE IF OUTPUT LEAD IS TOO CLOSE TO INPUT LEADS. GROUND ALL PINS OF UNUSED COMPARATORS.



NON-INVERTING COMPARATOR INVERTING COMPARATOR



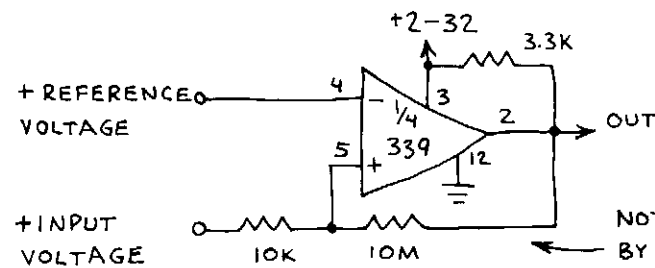
R1-R2 DETERMINE REFERENCE VOLTAGE (4.5 V AS SHOWN).



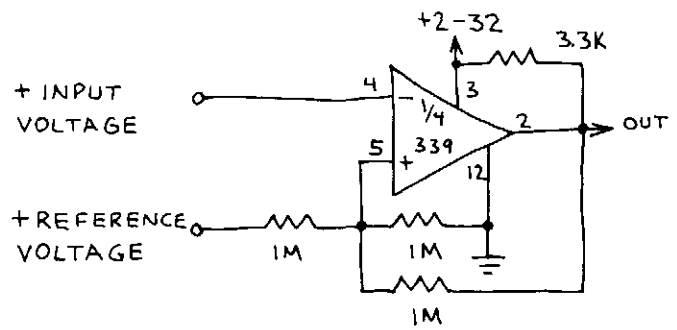
LED GLOWS WHEN INPUT VOLTAGE (PIN 5) FALLS BELOW REFERENCE VOLTAGE (PIN 4).

INVERTING COMPARATOR WITH HYSTERESIS

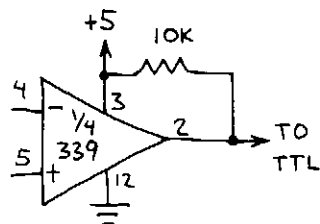
NON-INVERTING COMPARATOR WITH HYSTERESIS



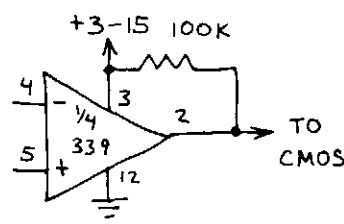
NOTE: HYSTERESIS PROVIDED BY FEEDBACK RESISTOR STOPS OSCILLATION.



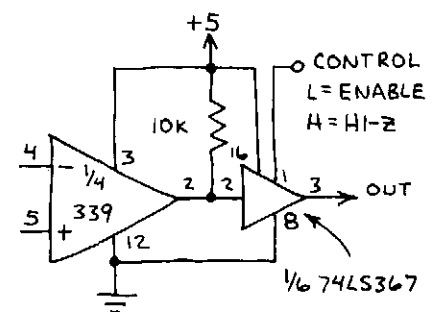
TTL DRIVER



CMOS DRIVER



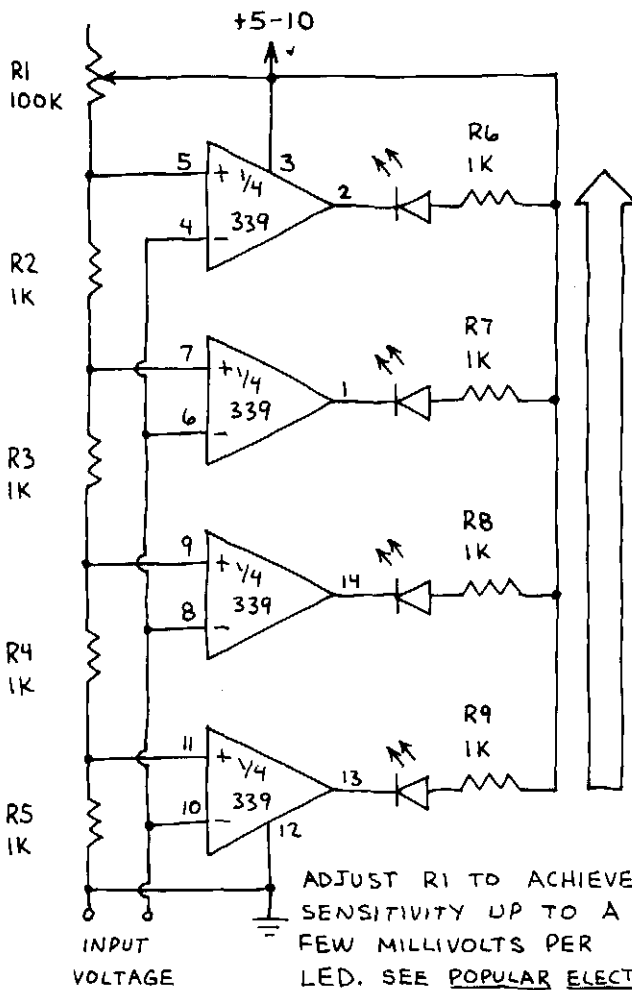
3-STATE OUTPUT



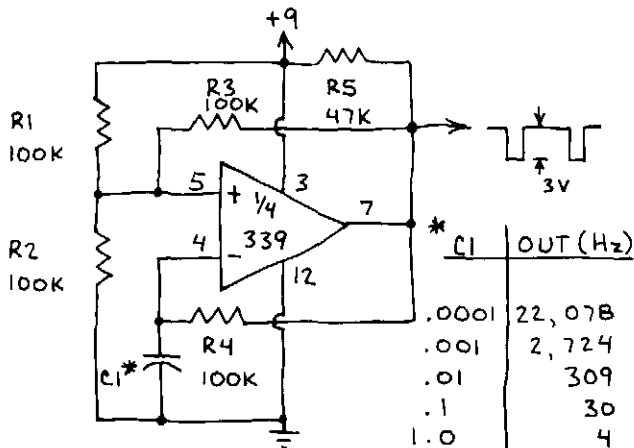
QUAD COMPARATOR (CONTINUED)

LM339

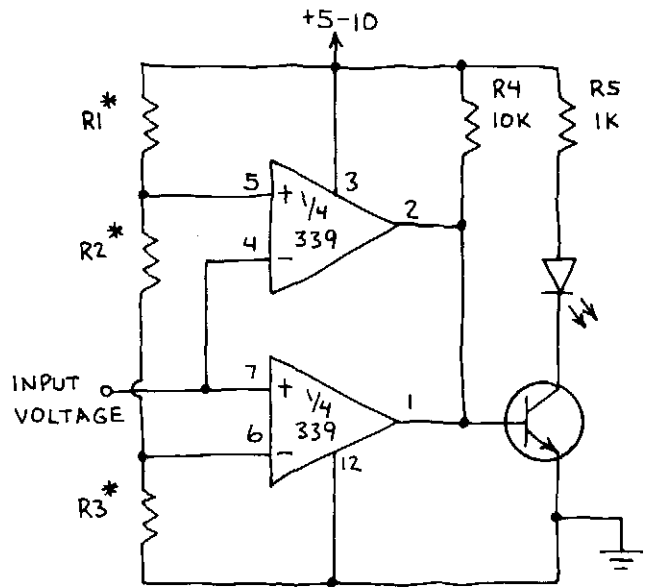
LED BARGRAPH READOUT



SQUAREWAVE OSCILLATOR

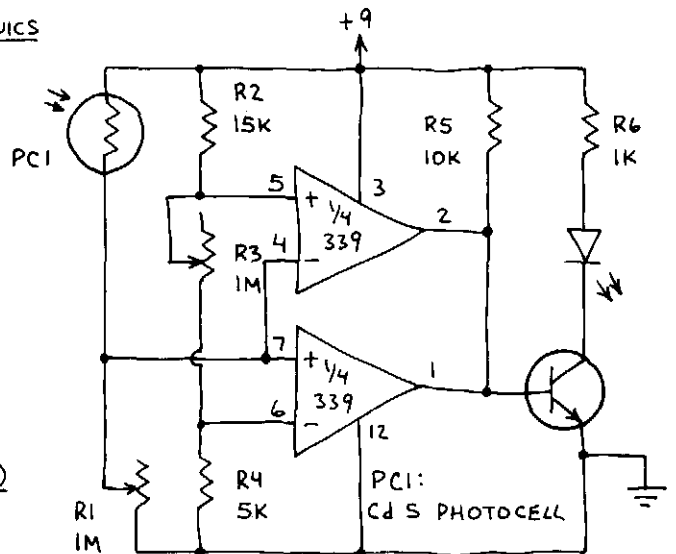


WINDOW COMPARATOR



THE LED GLOWS WHEN THE INPUT VOLTAGE IS WITHIN THE WINDOW DETERMINED BY R1-R3. THE WINDOW IS 4-8 MILLIVOLTS WIDE * WHEN R1=500Ω, R2=1200Ω AND R3=1M. IT EXTENDS FROM 1.5-4.2 VOLTS WHEN R1 AND R3=15,000Ω AND R2=25,000Ω. USE POTS FOR R1-R3 FOR A FULLY ADJUSTABLE WINDOW.

PROGRAMMABLE LIGHT METER

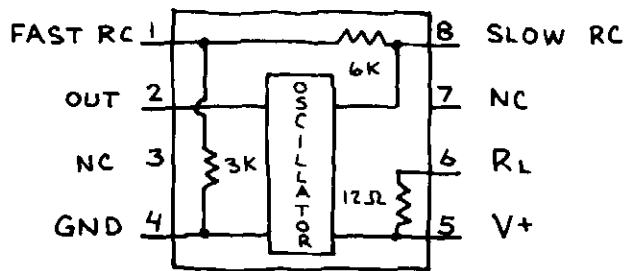


ADJUST R1 AND R3 SO LED GLOWS WHEN LIGHT AT PCI IS ABOVE OR BELOW ANY DESIRED LEVEL.

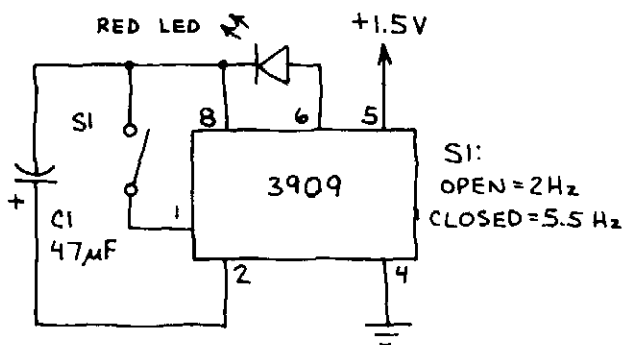
LED FLASHER / OSCILLATOR

3909

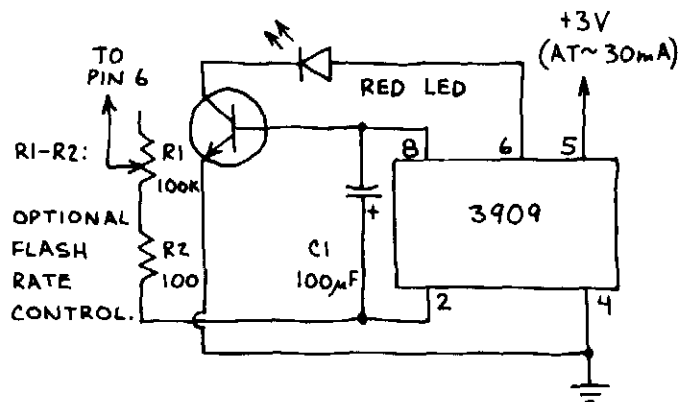
EASIEST TO USE IC IN THIS NOTEBOOK. FLASHES LEDs OR CAN BE USED AS TONE SOURCE. WILL DRIVE SPEAKER DIRECTLY. WILL FLASH A RED LED WHEN $V+$ IS ONLY 1.3 VOLTS.



LED FLASHER



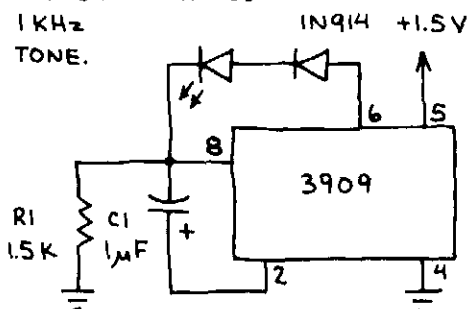
POWER FLASHER



INFRARED TRANSMITTERS

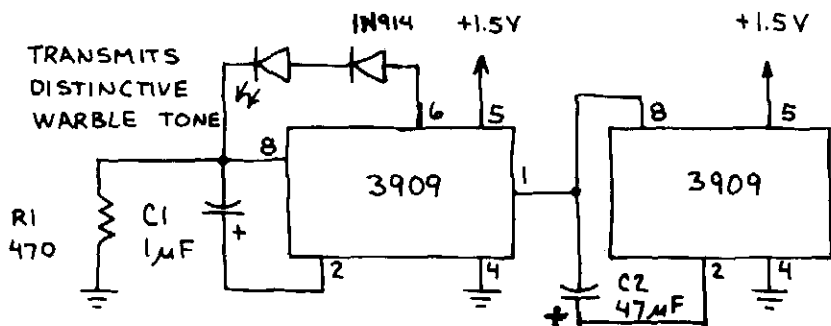
TRANSMITS

STEADY IR LED
1KHz
TONE.

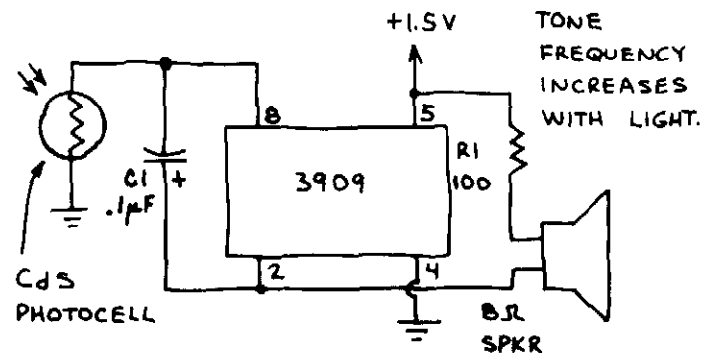


IR LED

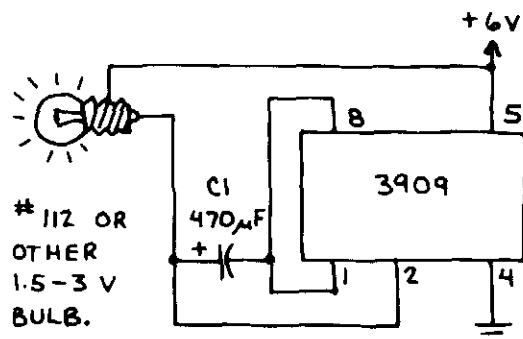
TRANSMITS
DISTINCTIVE
WARBLE TONE



LIGHT CONTROLLED TONE



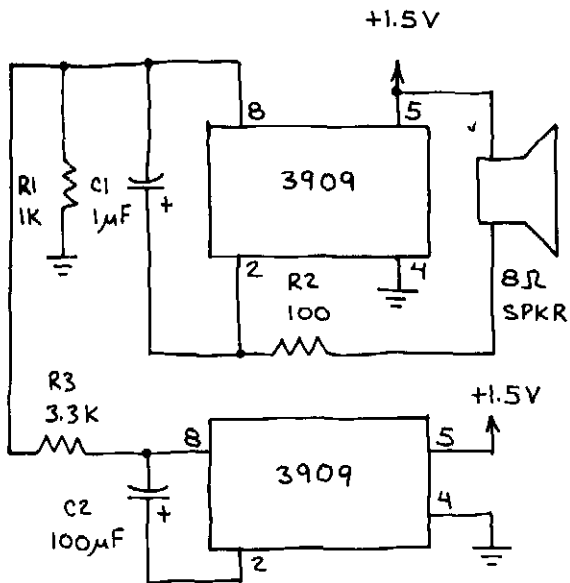
LAMP FLASHER



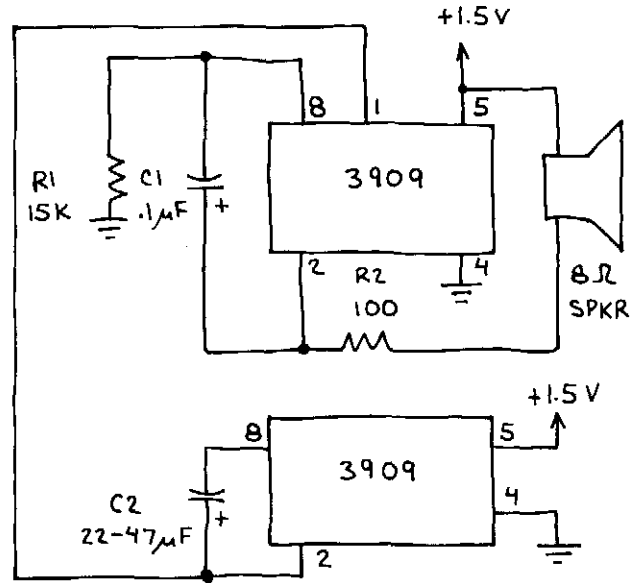
LED FLASHER / OSCILLATOR (CONTINUED)

3909

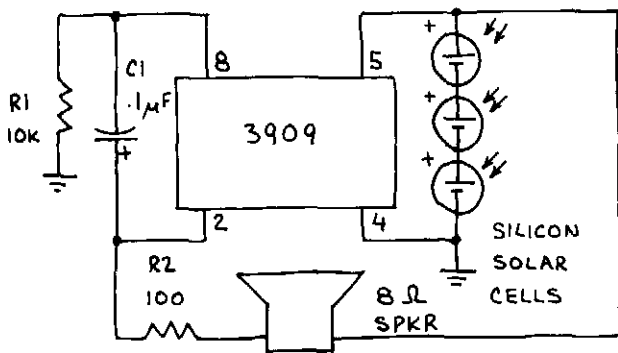
WHOOOPER



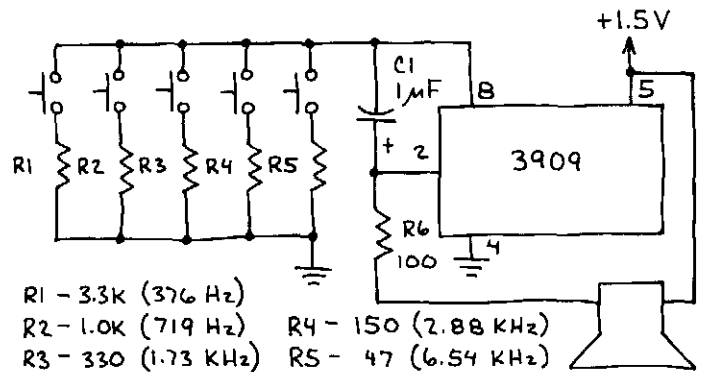
CHIRPER



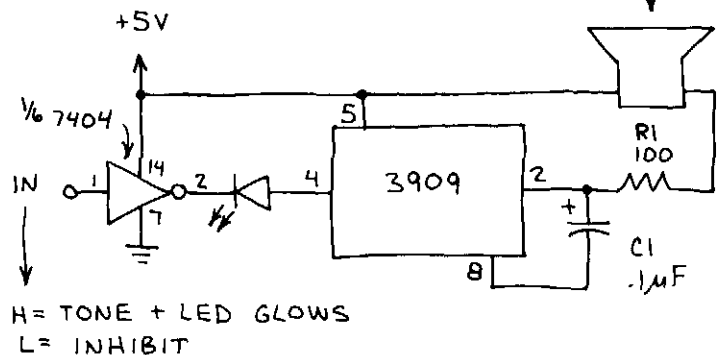
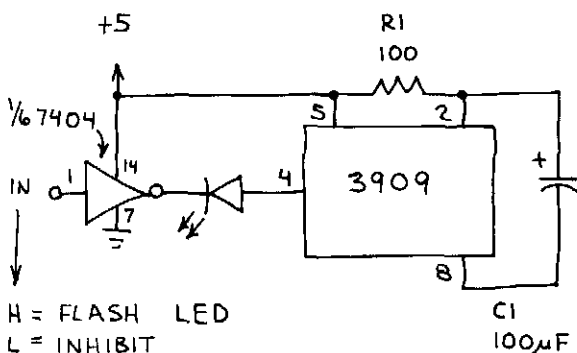
SUN POWERED OSCILLATOR



TOY ORGAN

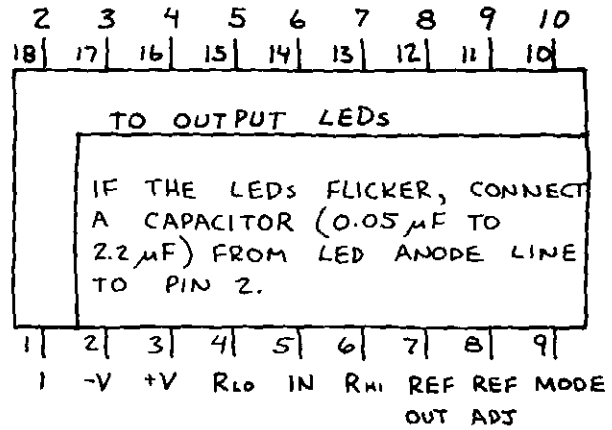


TTL CONTROLLED 3909

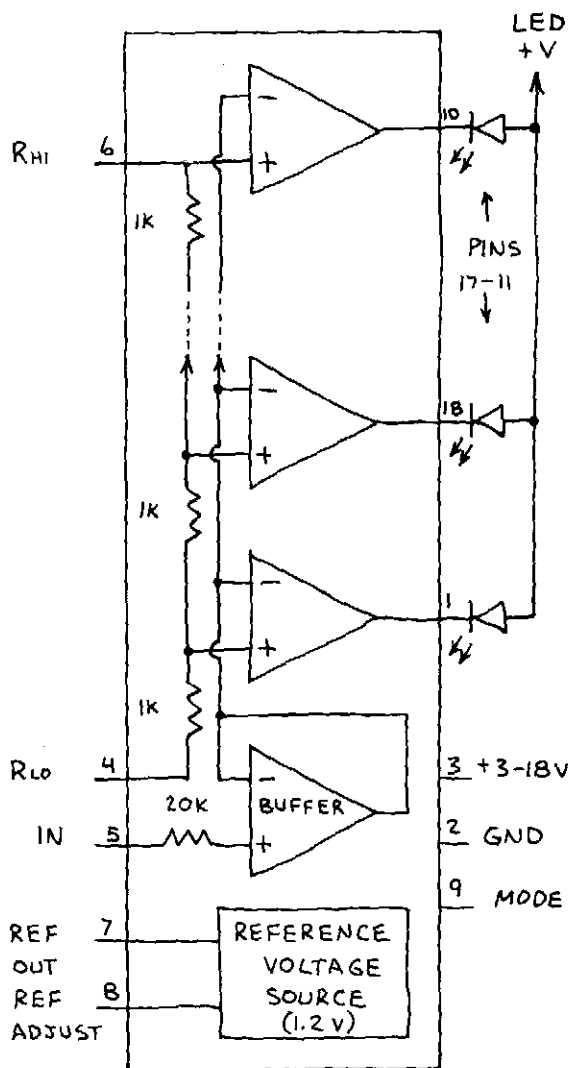


DOT/BAR DISPLAY DRIVER LM3914N

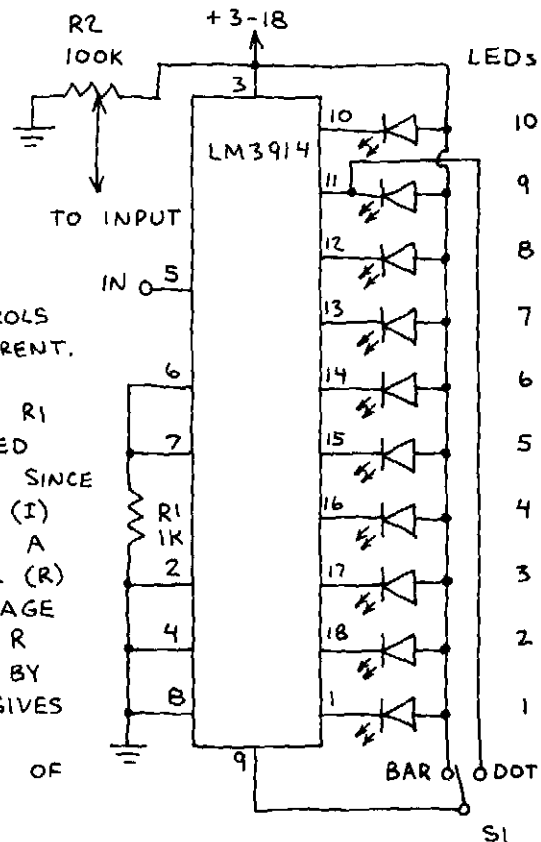
ONE OF THE MOST IMPORTANT CHIPS IN THIS NOTEBOOK. LIGHTS UP TO 10 LEDs (BAR MODE) OR 1-OF-10 LEDs (DOT MODE) IN RESPONSE TO AN INPUT VOLTAGE. CHIP CONTAINS A VOLTAGE DIVIDER AND 10 COMPARATORS THAT TURN ON IN SEQUENCE AS THE INPUT VOLTAGE RISES. HERE'S A SIMPLIFIED VERSION OF THE CIRCUIT:



DOT/BAR DISPLAY



R_{H1} AND R_{L0} ARE THE ENDS OF THE DIVIDER CHAIN. THE REFERENCE VOLTAGE OUTPUT (REF OUT) IS 1.2-1.3 VOLTS. CONNECT PIN 9 TO PIN 11 FOR DOT MODE OR +V FOR BAR MODE.

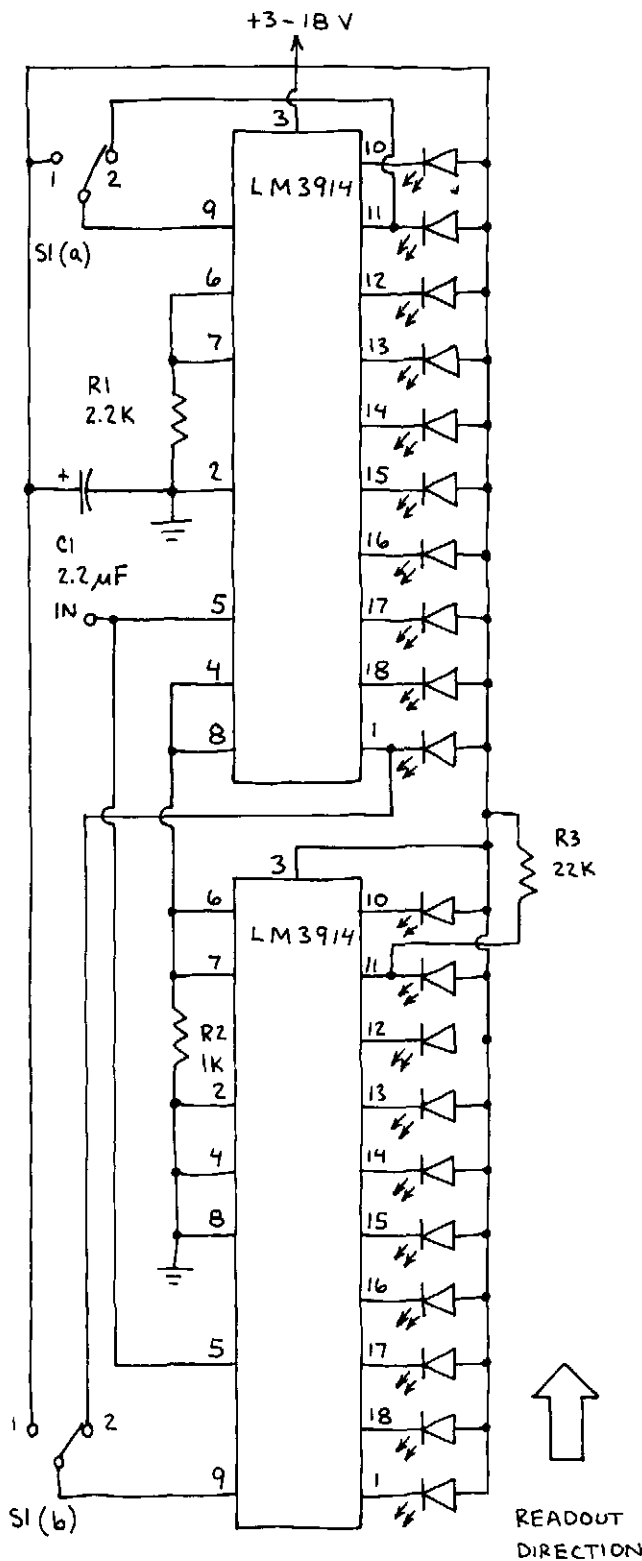


R_1 CONTROLS LED CURRENT. CURRENT THROUGH R_1 IS $\frac{1}{10}$ LED CURRENT. SINCE CURRENT (I) THROUGH A RESISTOR (R) IS VOLTAGE ACROSS R DIVIDED BY R, 1K GIVES AN LED CURRENT OF 10 mA.

WHEN +V = +3-18 VOLTS, THE READOUT RANGE IS 0.13-1.30 VOLTS. TO CHANGE RANGE TO 0.1-1.0 VOLT (0.1 VOLT PER LED), INSERT A 5K POTENTIOMETER BETWEEN PINS 6 AND 7. CONNECT VOLTMETER ACROSS PINS 5 AND 8 AND ADJUST R_2 FOR 1 VOLT AT PIN 5. THEN ADJUST 1K POT UNTIL LED 10 GLOWS. REPEAT THIS PROCEDURE FOR 0.1 VOLT AT PIN 5 AND LED 1. OK TO REPLACE THE 1K POT WITH A FIXED RESISTOR OF THE PROPER VALUE.

DOT/BAR DISPLAY DRIVER (CONTINUED)

LM3914N

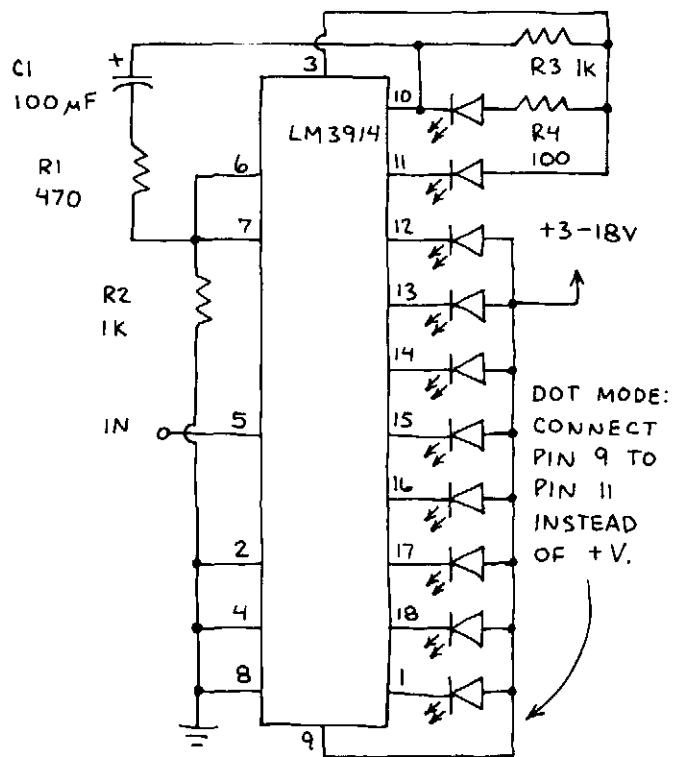


20-ELEMENT READOUT

THIS CIRCUIT SHOWS HOW TO CASCADE 2 OR MORE LM3914'S. WHEN $+V = 5$ VOLTS, THE READOUT RANGE IS 0.14 V TO 2.7 V. HIGHEST ORDER LED STAYS ON DURING OVERRANGE. AVOID SUBSTITUTIONS FOR R_1 , R_2 AND R_3 .

SI IS THE MODE SWITCH. USE A DPDT TOGGLE. POSITION 1 SELECTS BAR AND POSITION 2 SELECTS DOT. OMIT SI IF ONLY ONE MODE IS REQUIRED. SIMPLY WIRE IN THE CORRECT CONNECTIONS.

FLASHING BAR READOUT



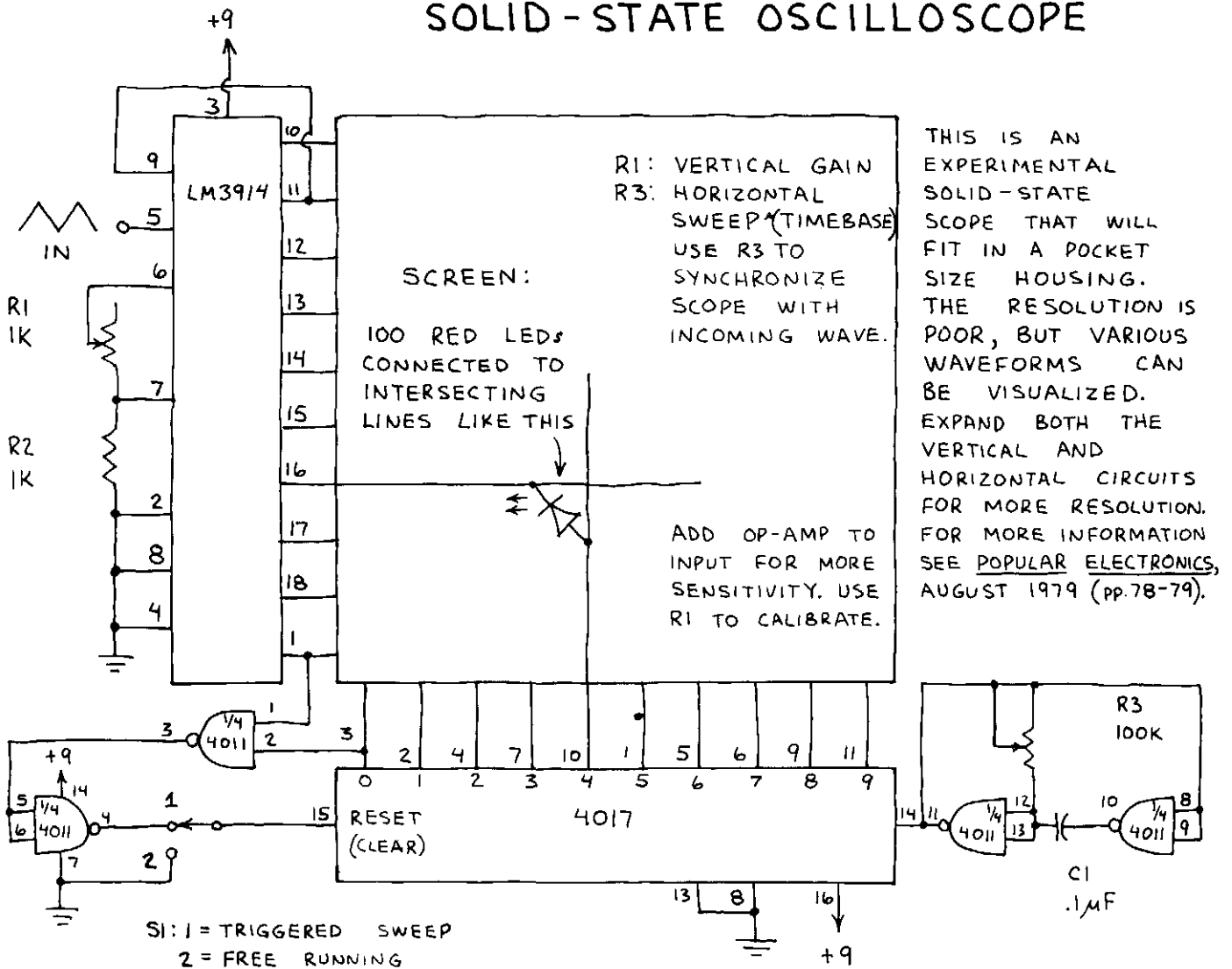
THE CIRCUITS ON THIS PAGE ARE ADAPTED FROM NATIONAL SEMICONDUCTOR'S LM3914 LITERATURE. BOTH WORK WELL.

WHEN ALL 10 LEDs ARE ON THE DISPLAY FLASHES. OTHERWISE THE LEDs DO NOT FLASH. INCREASE C_1 TO SLOW FLASH RATE.

DOT/BAR DISPLAY DRIVER (CONTINUED)

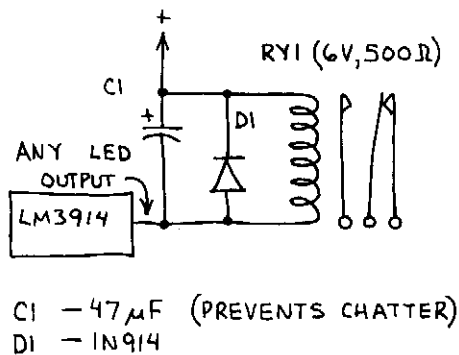
LM3914N

SOLID-STATE OSCILLOSCOPE

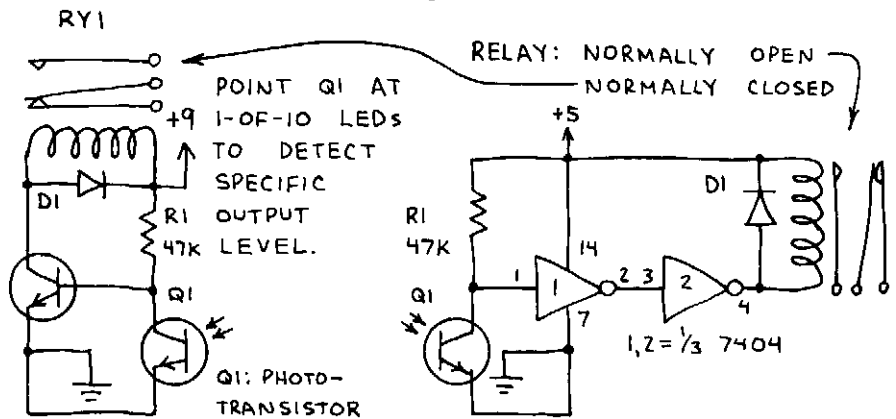


USING THE LM3914 AS A CONTROLLER:

RELAY

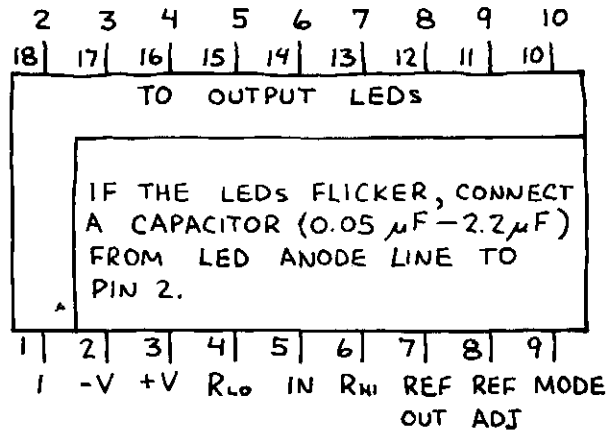


OPTICAL COUPLING



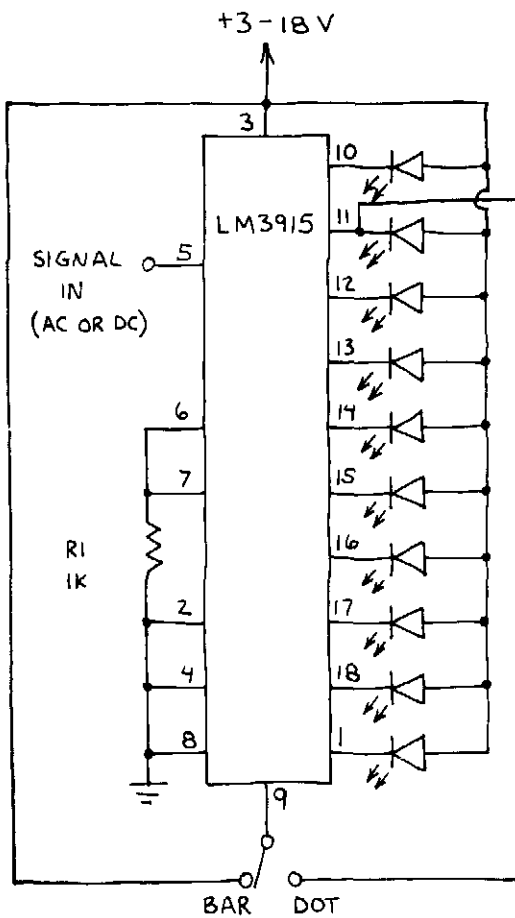
DOT/BAR DISPLAY DRIVER LM3915N

LOGARITHMIC VERSION OF THE LM3914N. THE LM3914N USES A STRING OF 1K RESISTORS AS A VOLTAGE DIVIDER WITH LINEARLY SCALED DIVISIONS. THE VOLTAGE DIVIDER RESISTORS OF THE LM3915N ARE SCALED TO GIVE A -3dB INTERVAL FOR EACH OUTPUT. THIS CHIP IS IDEAL FOR VISUALLY MONITORING THE AMPLITUDE OF AUDIO SIGNALS.



SEE LM3914N FOR EXPLANATION OF PIN FUNCTIONS.

0 TO -27 dB DOT/BAR DISPLAY



LED DISPLAY

	BAR MODE*
0 dB (FULLSCALE OR FS)	●●●●●●●●●●●●●●●●
-3 dB (.707 FS)	●●●●●●●●●●●●●●○
-6 dB (.500 FS)	●●●●●●●●●●●●○○
-9 dB (.354 FS)	●●●●●●●●●●●○○○
-12 dB (.250 FS)	●●●●●●●●●●○○○○
-15 dB (.177 FS)	●●●●●●●○○○○○○
-18 dB (.125 FS)	●●●●○○○○○○○○
-21 dB (.088 FS)	●●○○○○○○○○○○
-24 dB (.062 FS)	●○○○○○○○○○○○
-27 dB (.044 FS)	●○○○○○○○○○○○

* OK TO USE DOT MODE.

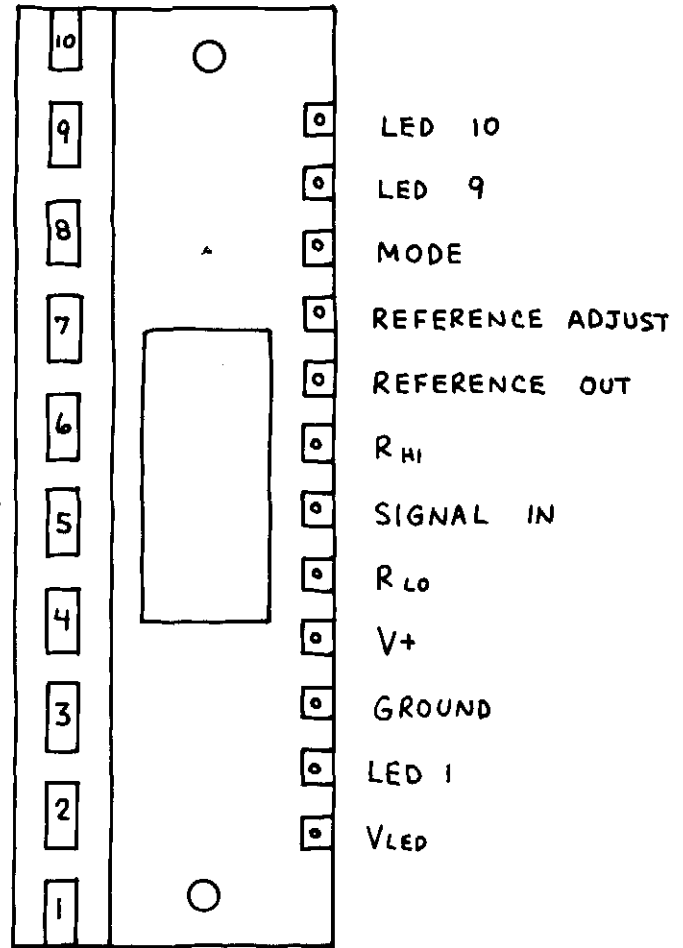
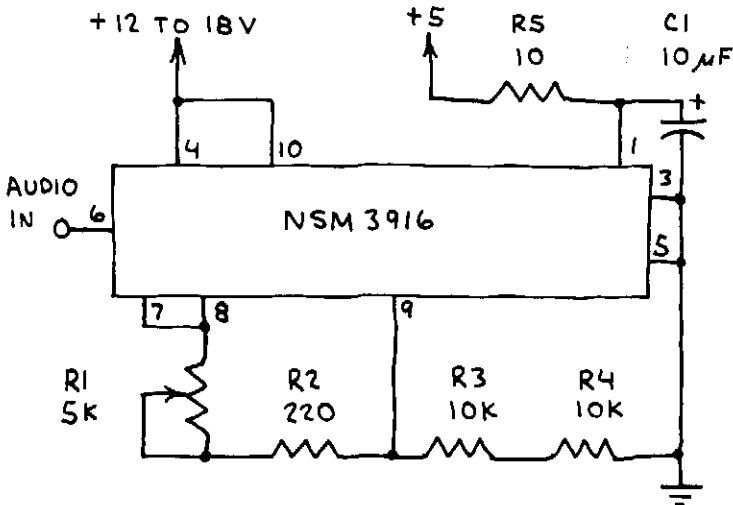
THE INPUT SIGNAL CAN BE CONNECTED DIRECTLY TO PINS WITHOUT RECTIFICATION, LIMITING OR AC COUPLING. SEE THE LM3914N FOR MORE IDEAS AND TIPS.

LED VU METER MODULE

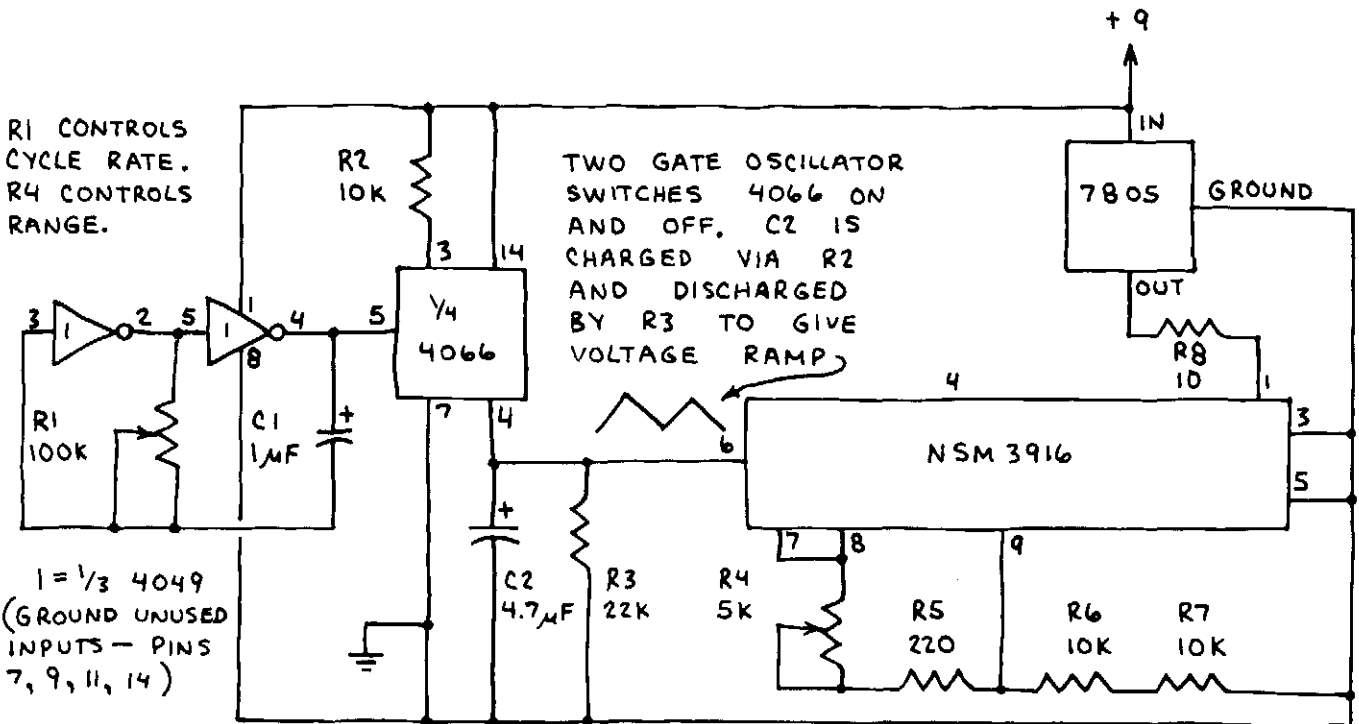
NSM3916

INCLUDES LED BARGRAPH DRIVER AND LEDs ON SAME SUBSTRATE. MAKE MODE PIN HIGH FOR BAR-GRAPH MODE. LEAVE OPEN FOR DOT MODE. SEE DATA SUPPLIED WITH MODULE FOR MORE INFORMATION. ALSO, SEE LM3914 AND LM3915.

VU BAR GRAPH DISPLAY

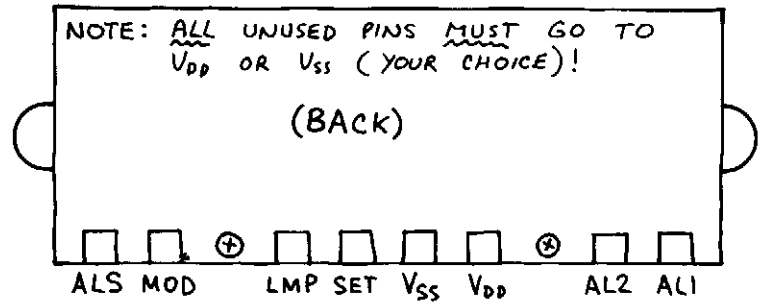


BACK AND FORTH FLASHER

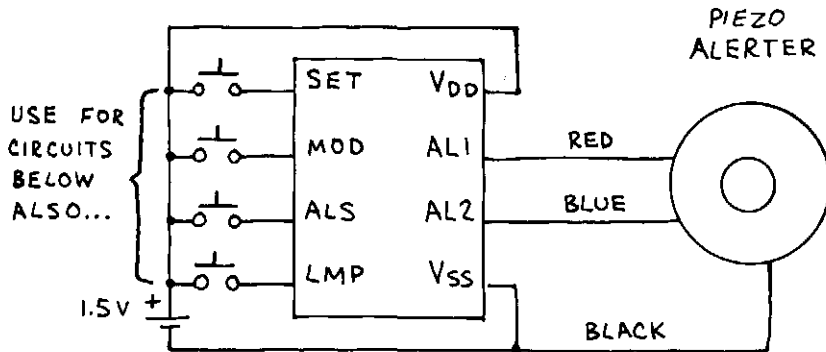


LCD CLOCK MODULE PCIM-161

COMPLETE CLOCK MODULE.
REQUIRES ONLY 1.5 VOLT
CELL AND SWITCHES.
FOR COMPLETE INFORMATION
SEE DATA SUPPLIED WITH
MODULE. V_{DD} MUST NOT
EXCEED 1.6 VOLTS!



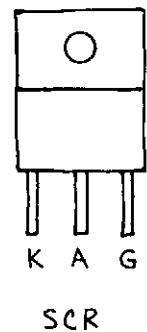
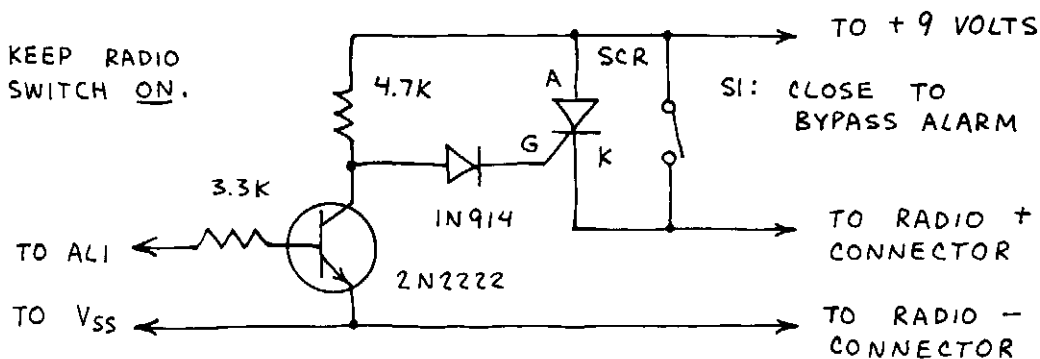
ALARM CLOCK



TO SET ALARM :

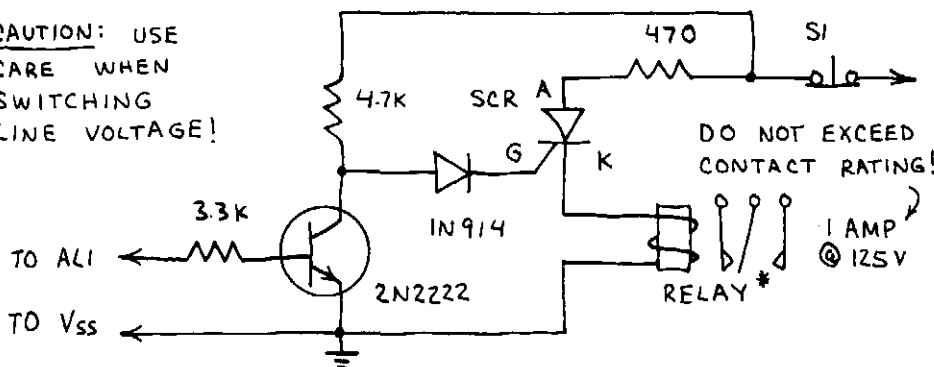
1. PRESS ALS TWICE; PRESS SET UNTIL HOUR APPEARS.
2. PRESS ALS; PRESS SET UNTIL MINUTES APPEAR.
3. PRESS ALS.

ALARM CLOCK RADIO



CLOCK CONTROLLED RELAY

*CAUTION: USE
CARE WHEN
SWITCHING
LINE VOLTAGE!



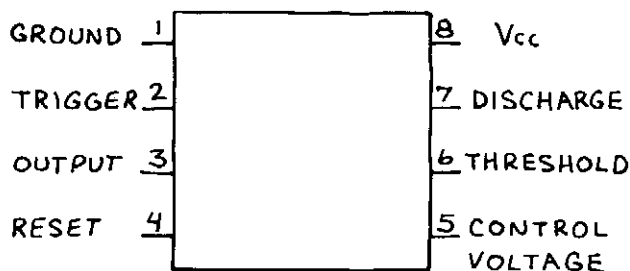
CURRENT DRAIN:
RELAY ON = 14.8 mA
RELAY OFF = 1.8 mA

SI: NORMALLY CLOSED
PUSHBUTTON.
OPEN (PRESS) TO
RESET. MUST
WAIT FOR 15
SECOND ALARM
CYCLE BEFORE
RESETTING.

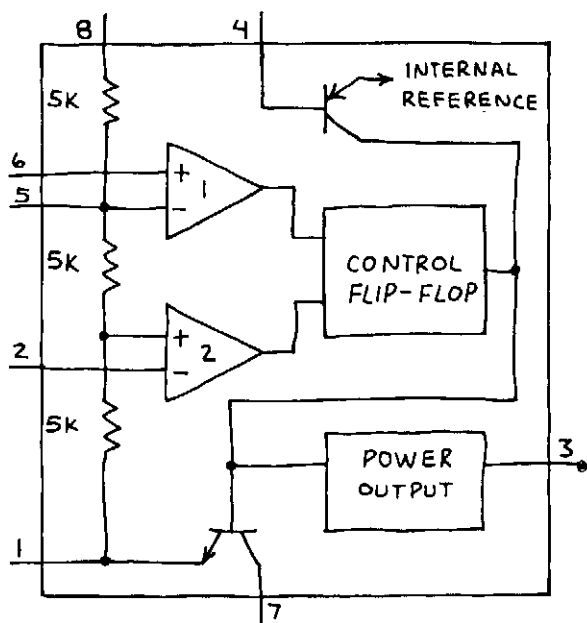
TIMER

555

THE FIRST AND STILL THE MOST POPULAR IC TIMER CHIP. OPERATES AS A ONE-SHOT TIMER OR AN ASTABLE MULTIVIBRATOR. THE 556 IS TWO 555 CIRCUITS ON ONE CHIP.

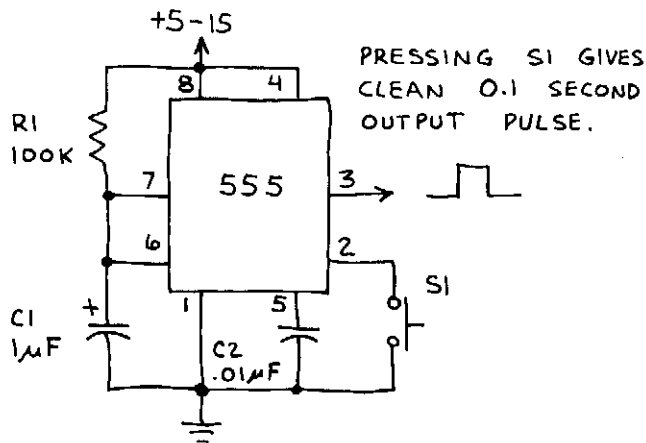


555 EQUIVALENT CIRCUIT

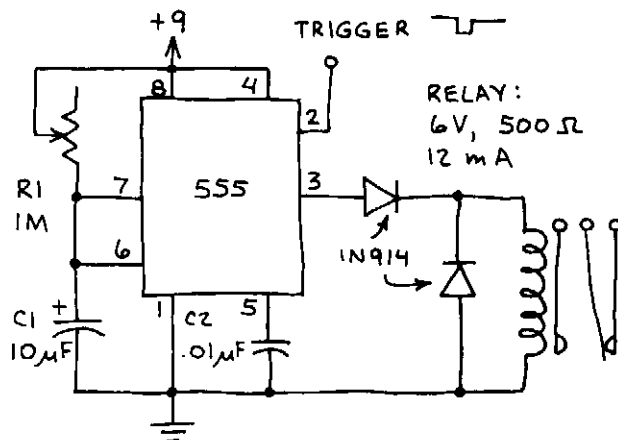


1 AND 2 ARE COMPARATORS. CIRCUIT CAN BE MADE FROM INDIVIDUAL PARTS AS SHOWN... BUT 555 IS MUCH SIMPLER.

BOUNCELESS SWITCH

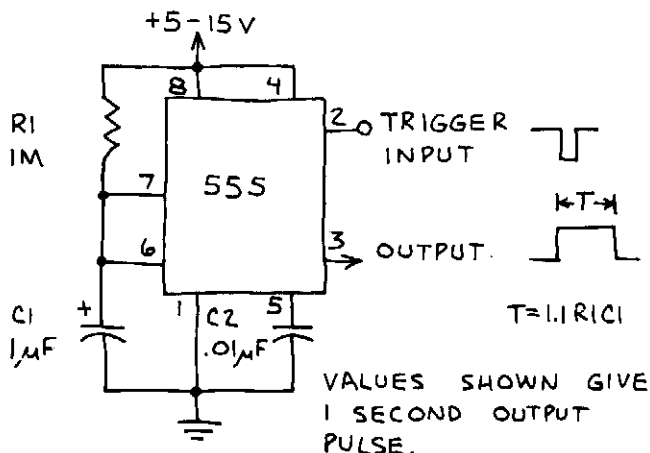


TIMER PLUS RELAY



VALUES OF R1 AND C1 SHOWN WILL PULL RELAY IN FOR UP TO ABOUT 11 SECONDS. USE POINTER KNOB AND PAPER SCALE TO HELP CALIBRATE CIRCUIT. USES INCLUDE DARKROOM TIMING. CIRCUIT CAN BE TRIGGERED BY A NEGATIVE PULSE OR WITH A PUSHBUTTON SWITCH ACROSS PINS 1 AND 2.

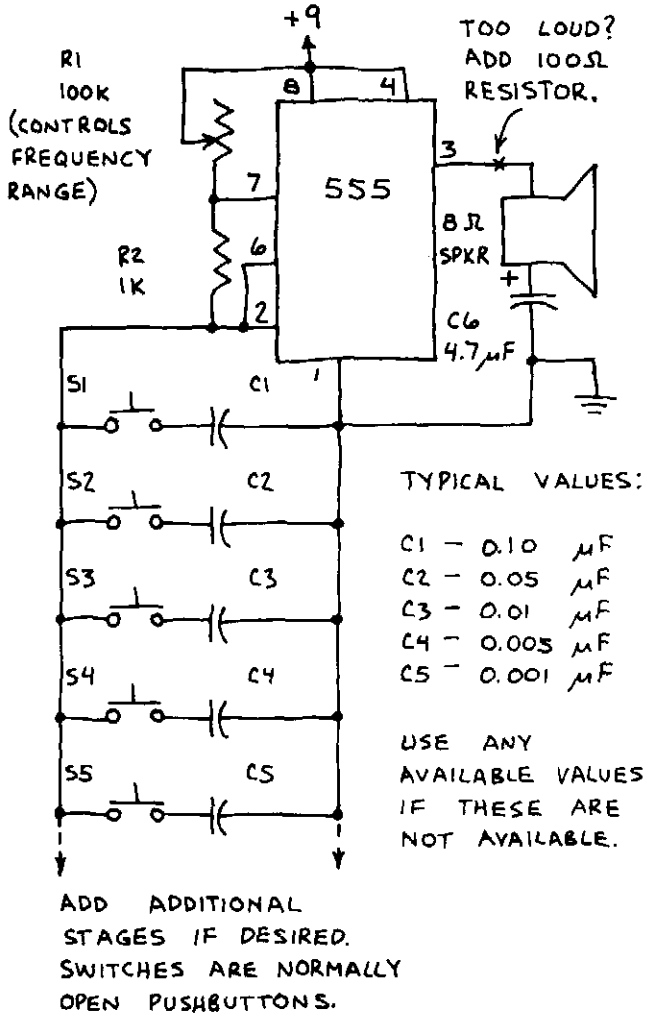
ONE-SHOT TIMER



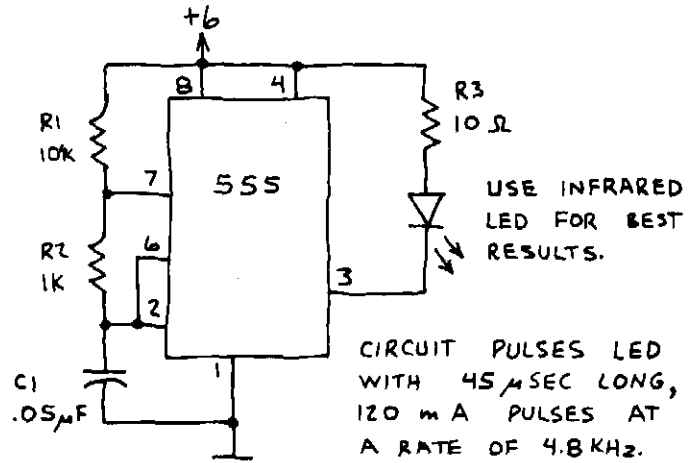
TIMER (CONTINUED)

555

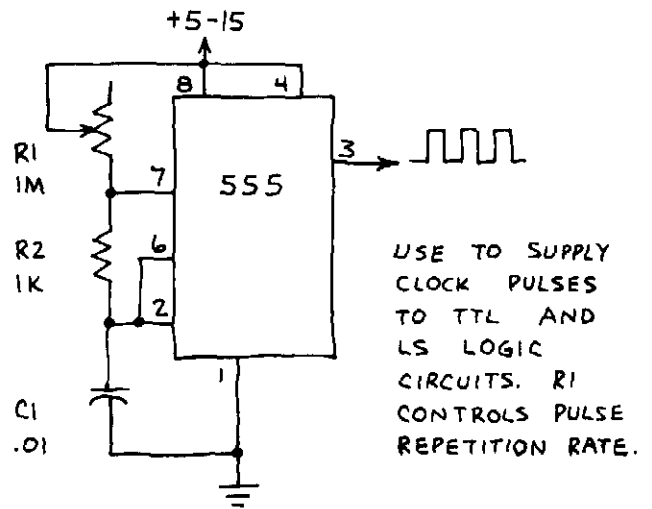
TOY ORGAN



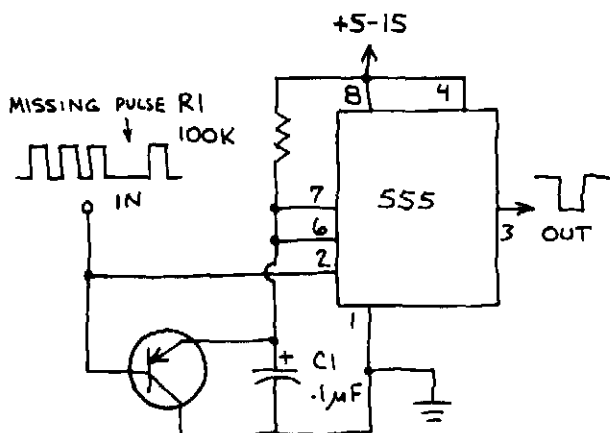
LED TRANSMITTER



PULSE GENERATOR



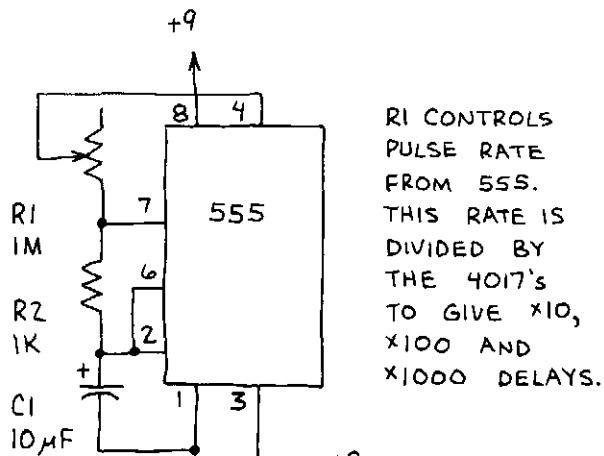
MISSING PULSE DETECTOR



TIMER (CONTINUED)

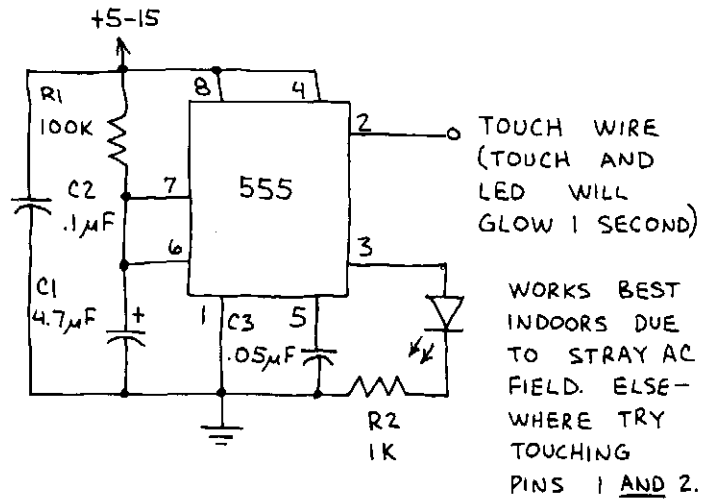
555

ULTRA-LONG TIME DELAY

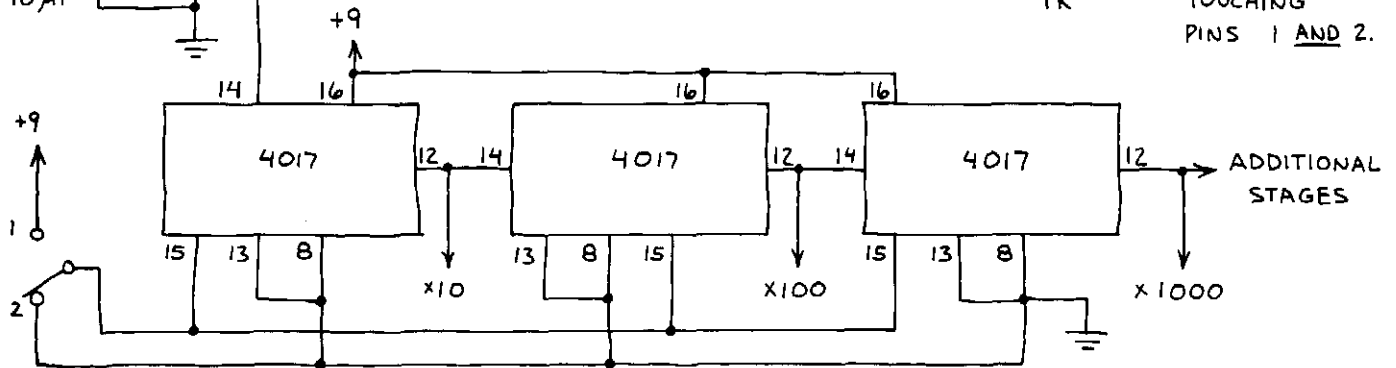


R1 CONTROLS PULSE RATE FROM 555. THIS RATE IS DIVIDED BY THE 4017'S TO GIVE X10, X100 AND X1000 DELAYS.

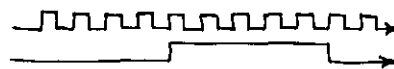
TOUCH SWITCH



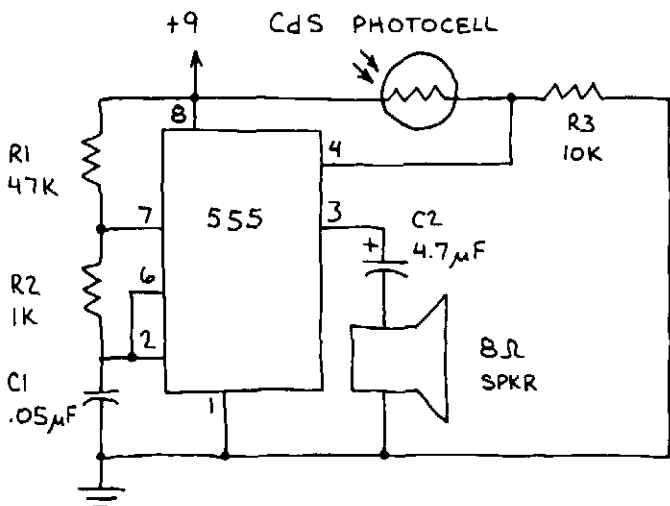
TOUCH WIRE (TOUCH AND LED WILL GLOW 1 SECOND)
WORKS BEST INDOORS DUE TO STRAY AC FIELD. ELSEWHERE TRY TOUCHING PINS 1 AND 2.



1 = RESET TYPICAL OUTPUT: 555 (PIN 3)
2 = RUN 4017 (X10 OUTPUT)

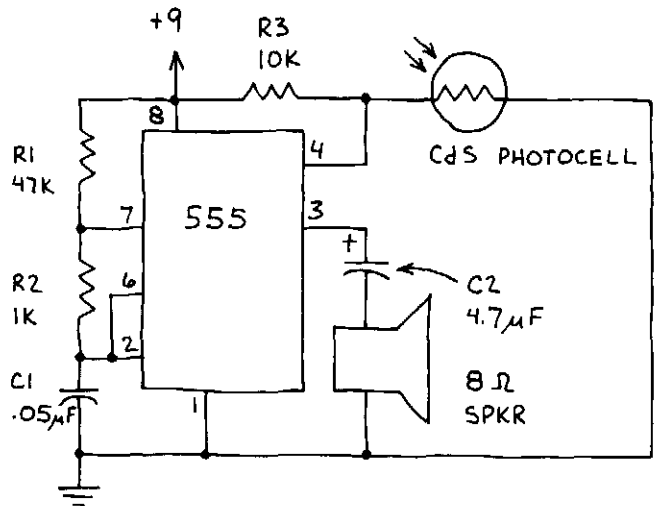


LIGHT DETECTOR



PRODUCES WARNING TONE WHEN LIGHT STRIKES PHOTOCELL. MAKES A GOOD OPEN DOOR ALARM FOR REFRIGERATOR OR FREEZER.

DARK DETECTOR

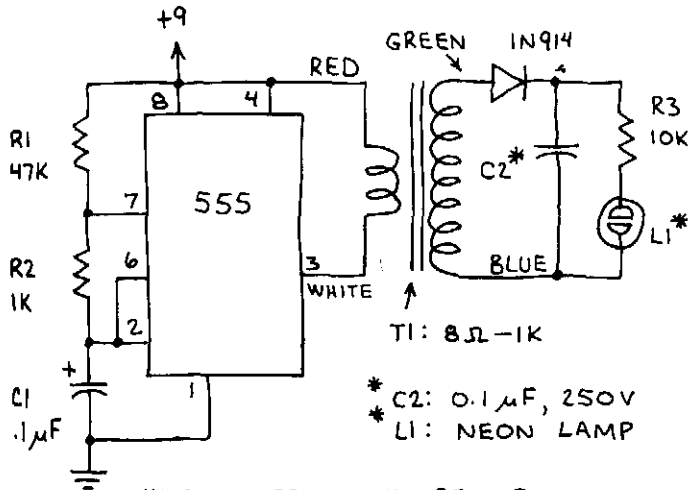


SILENT WHEN LIGHT STRIKES PHOTOCELL. REMOVE LIGHT AND TONE SOUNDS. FASTER RESPONSE THAN ADJACENT CIRCUIT.

TIMER (CONTINUED)

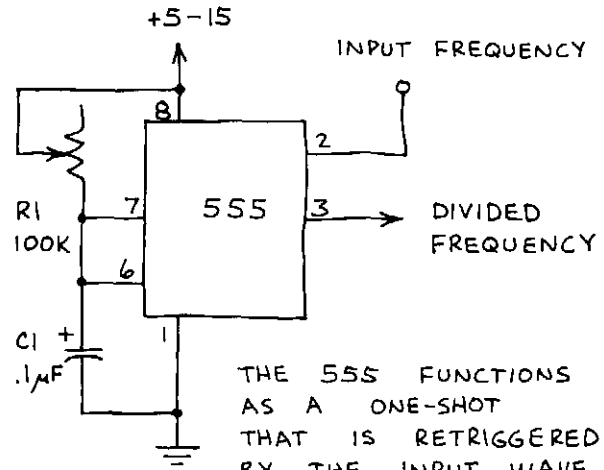
555

NEON LAMP POWER SOURCE



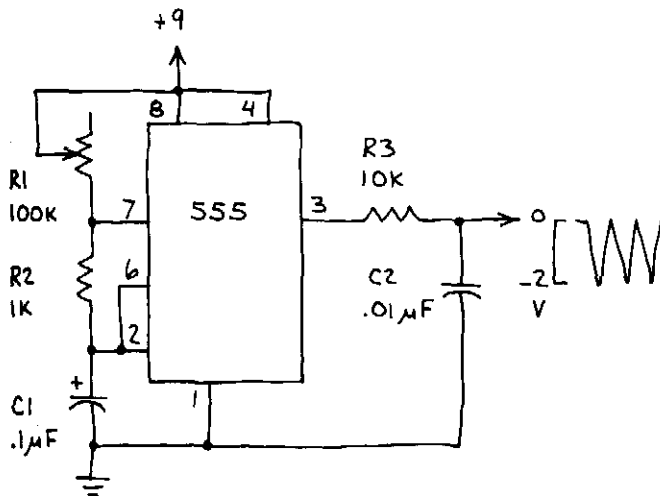
WORKS BEST WITH BETTER QUALITY NEON LAMPS. REDUCE R1 SLIGHTLY FOR MORE OUTPUT VOLTAGE.

FREQUENCY DIVIDER



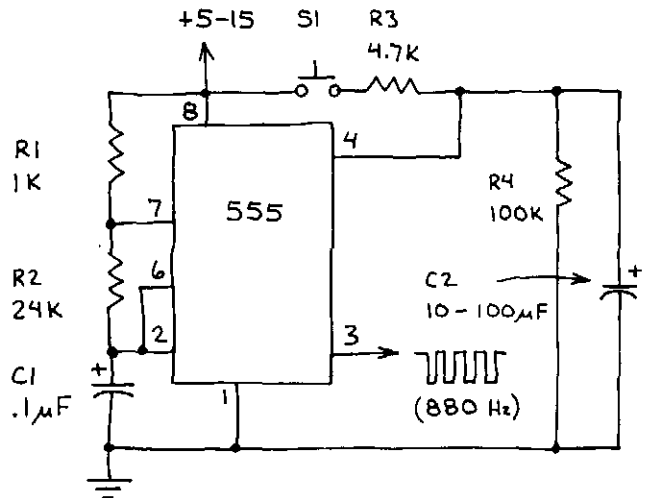
THE 555 FUNCTIONS AS A ONE-SHOT THAT IS RETRIGGERED BY THE INPUT WAVE. WAVES ARRIVING DURING THE TIMING CYCLE ARE IGNORED.

TRIANGLE WAVE GENERATOR



ADJUST R1 TO PROVIDE UP TO 10 KHz. OUTPUT FREQUENCY THIS HIGH PRODUCES CLOSELY SPACED TRIANGLE WAVES. THE WAVES ARE SEPARATED AT SLOWER FREQUENCIES (V V V).

ONE-SHOT TONE BURST



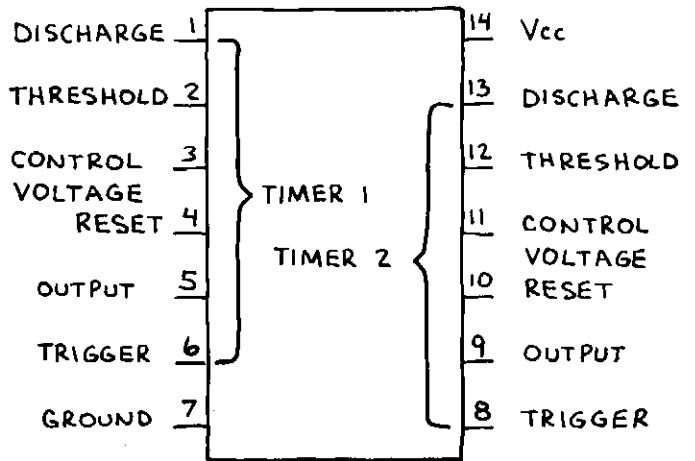
PRESS S1 AND STEADY OUTPUT FREQUENCY APPEARS AT PIN 3. RELEASE S1 AND OUTPUT FREQUENCY CONTINUES UNTIL C2 IS DISCHARGED BY R4. INCREASE C2 (OR R4) TO INCREASE LENGTH OF THE BURST. CHANGE FREQUENCY OF TONE BURST VIA R2 OR C1.

DUAL TIMER

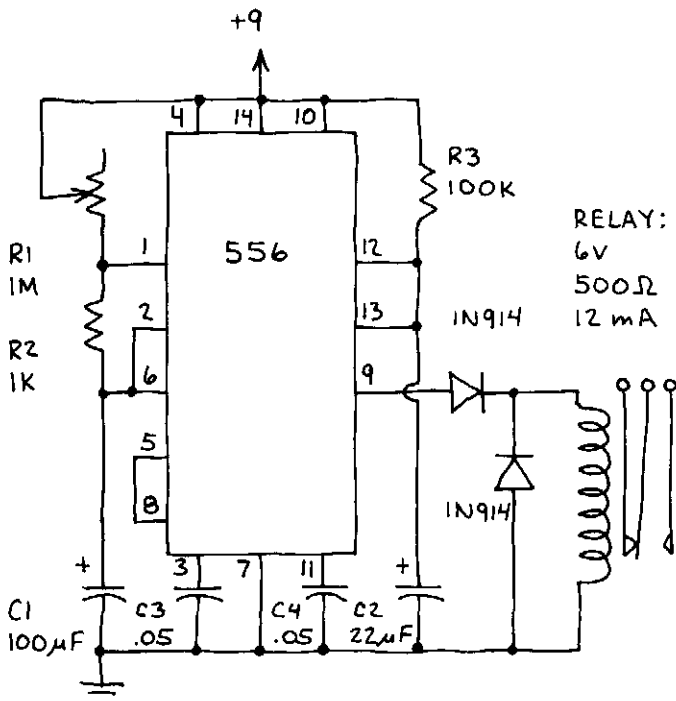
556

CONTAINS TWO INDEPENDENT TIMERS ON A SINGLE CHIP. BOTH TIMERS ARE IDENTICAL TO THE 555. ALL THE APPLICATION CIRCUITS CAN ALSO BE BUILT WITH TWO 555'S. THIS PIN CROSS REFERENCE WILL SIMPLIFY SUBSTITUTING TWO 555'S FOR A 556 OR HALF A 556 FOR A 555:

FUNCTION	555	556(1)	556(2)
GROUND	1	7	7
TRIGGER	2	6	8
OUTPUT	3	5	9
RESET	4	4	10
CONTROL V.	5	3	11
THRESHOLD	6	2	12
DISCHARGE	7	1	13
Vcc	8	14	14

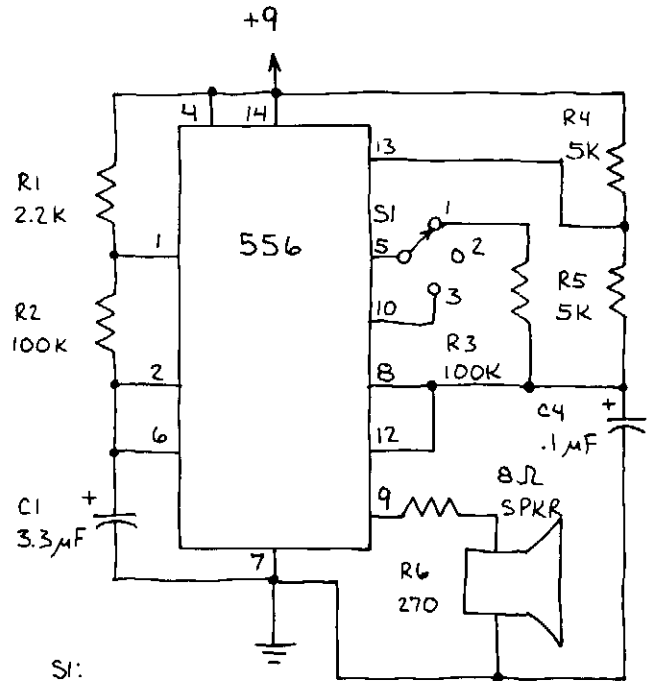


INTERVAL TIMER



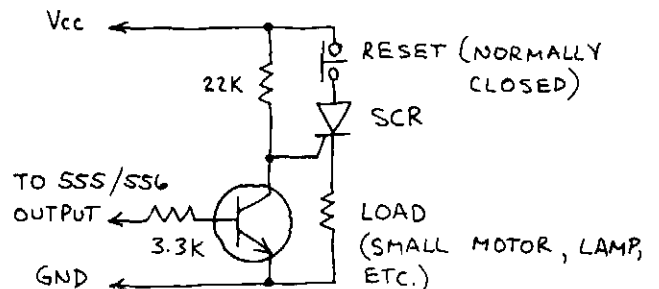
TIMER 1 IS CONNECTED AS ASTABLE OSCILLATOR. TIMER 2 IS A ONE-SHOT RELAY DRIVER. 1 FIRES 2 ONCE EACH CYCLE. 2 PULLS RELAY IN FOR 3-5 SECONDS.

3-STATE TONE SOURCE



S1:
 1- TWO TONE
 2- STEADY TONE
 3- TONE BURST

555/556 SCR OUTPUT

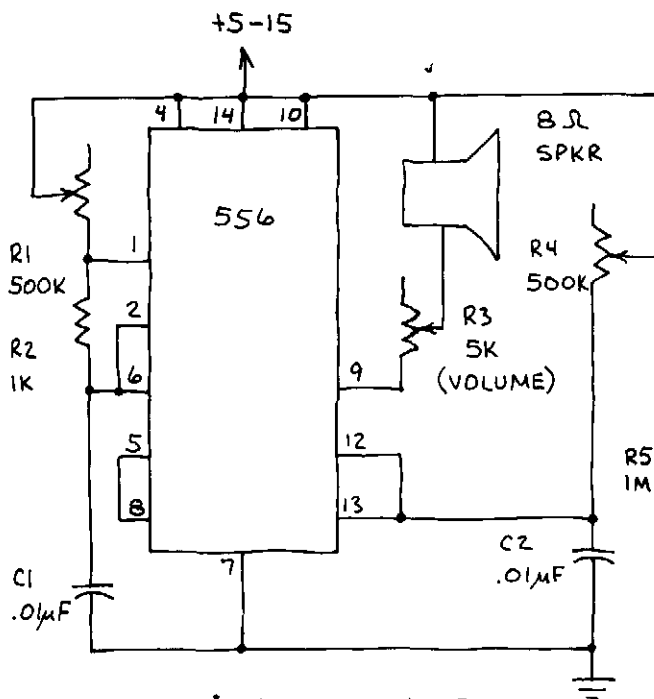


DUAL TIMER (CONTINUED)

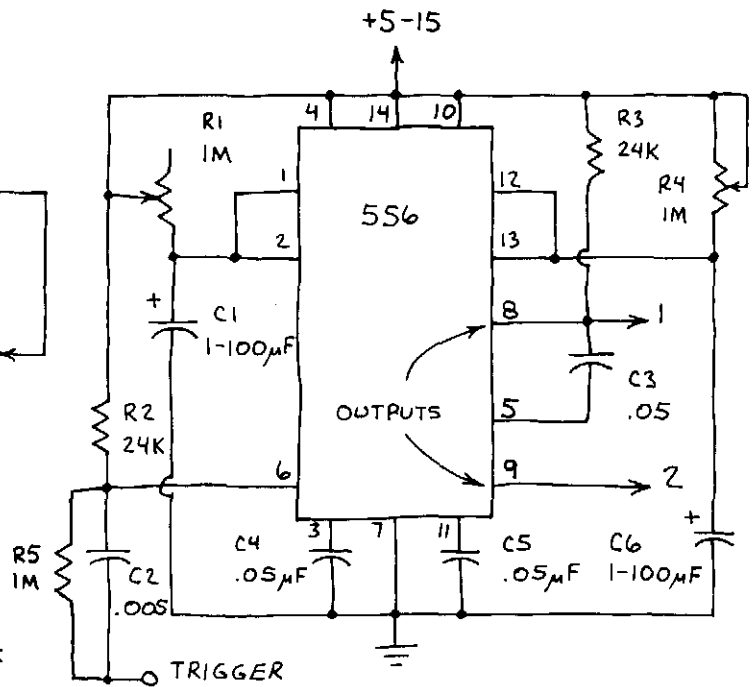
556

TWO-STAGE TIMER

SOUND SYNTHESIZER

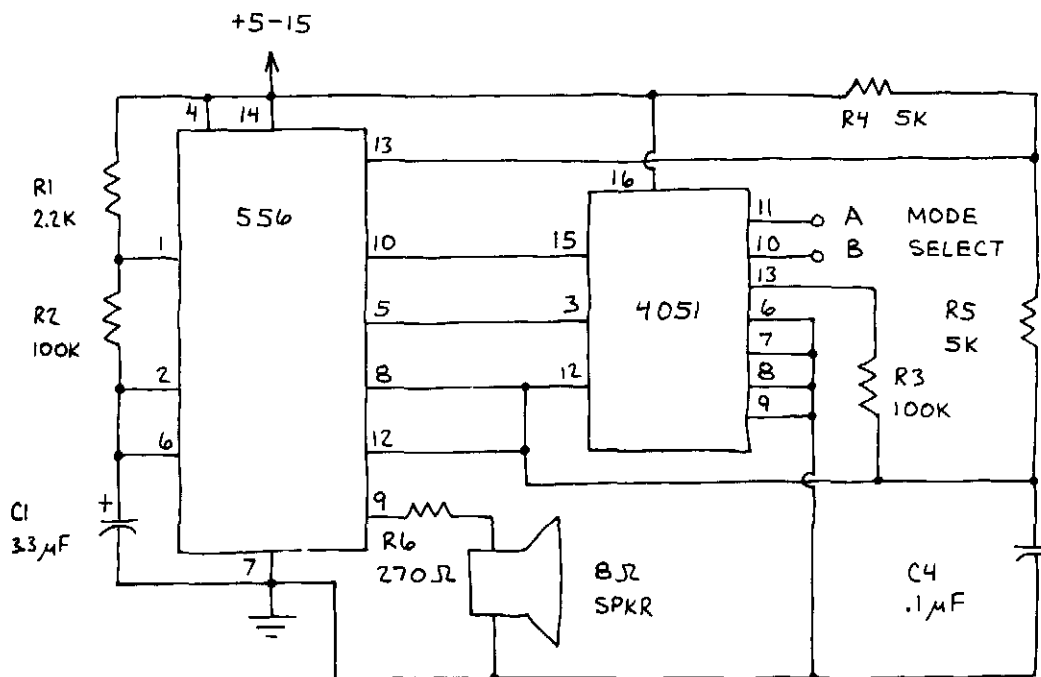


THIS CIRCUIT IS AN OSCILLATOR FOLLOWED BY A FREQUENCY DIVIDER. ADJUST R1 AND R4 FOR VERY UNUSUAL SOUND EFFECTS.



BOTH TIMERS ARE IN ONE-SHOT MODE. GROUNDING THE TRIGGER INPUT INITIATES THE FIRST TIMER'S CYCLE TIME. THE SECOND TIMER'S CYCLE BEGINS AFTER THE FIRST IS COMPLETE.

PROGRAMMABLE 4-STATE TONE GENERATOR



MODE SELECT

BA	OUTPUT
LL	TWO-TONE
LH	STEADY
HL	BURST
HH	METRONOME

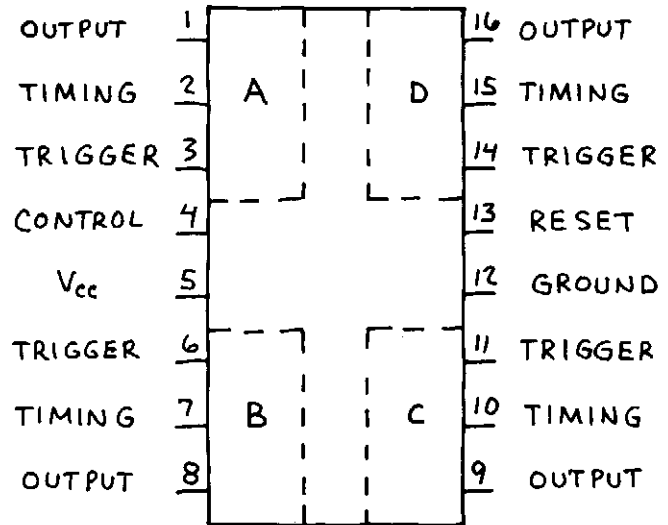
L = GND
H = +5-15 (V_{DD})

CHANGE C1 AND C4 TO ALTER THE OUTPUT TONES.

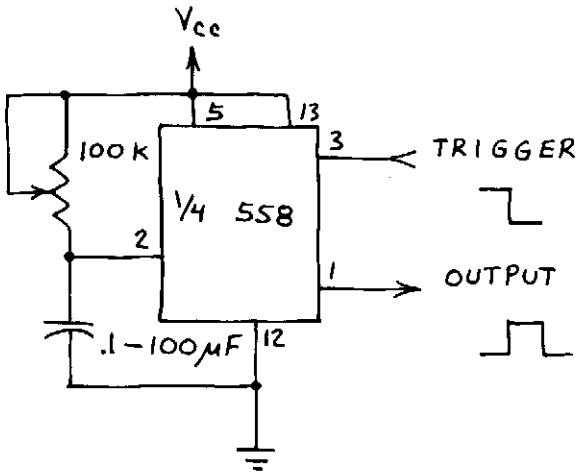
QUAD TIMER

558

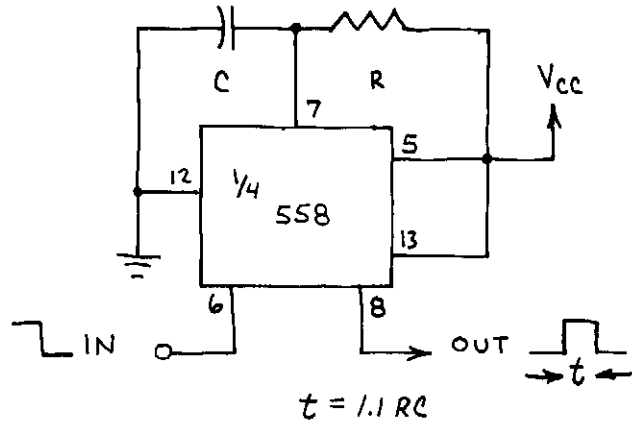
CONTAINS FOUR INDEPENDENT MONOSTABLE TIMERS. EACH TIMER IS SIMILAR TO PART OF A 555 TIMER. ASTABLE OPERATION POSSIBLE WITH ONE TIMER. $V_{cc} = +4.5$ TO 18 VOLTS! CONTROL AND RESET PINS ARE COMMON.



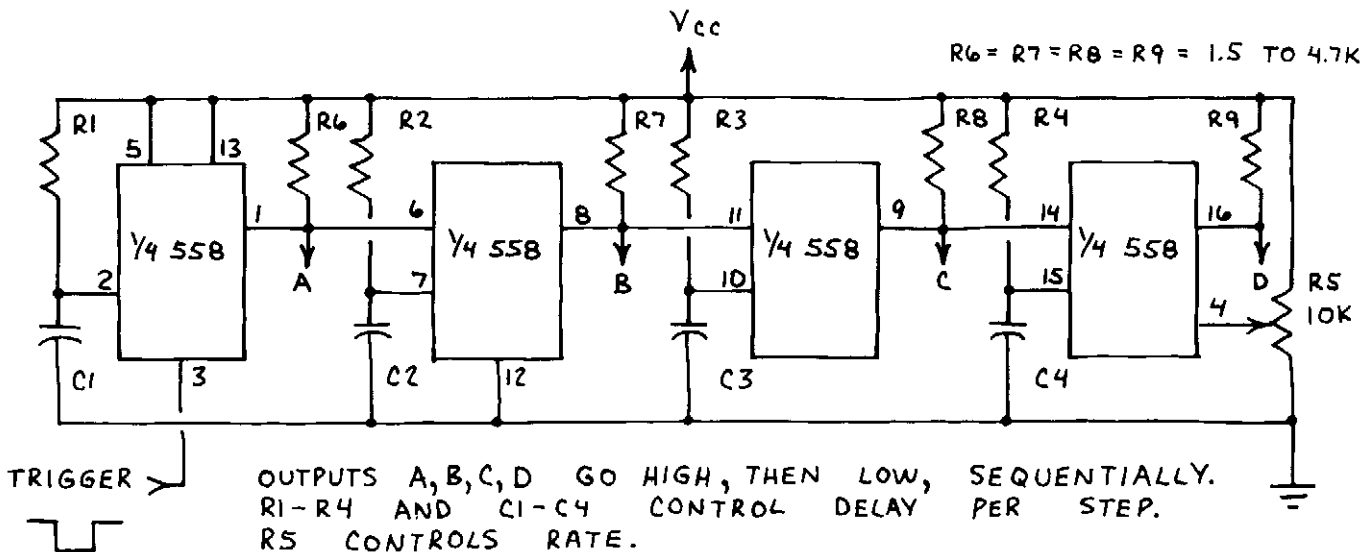
BASIC TIMER



ONE - SHOT



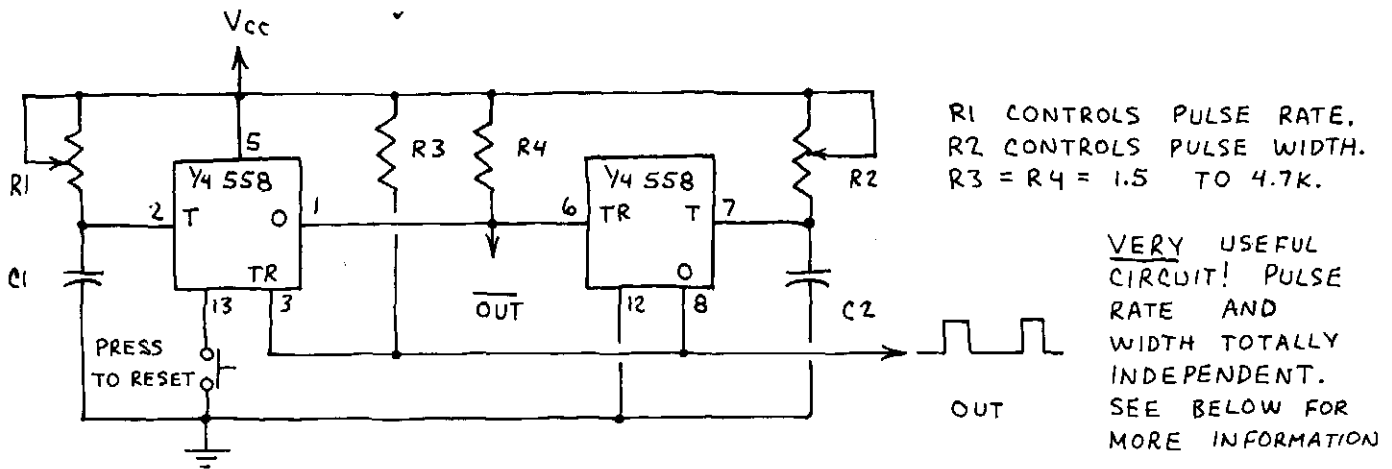
PROGRAMMABLE SEQUENCER



QUAD TIMER (CONTINUED)

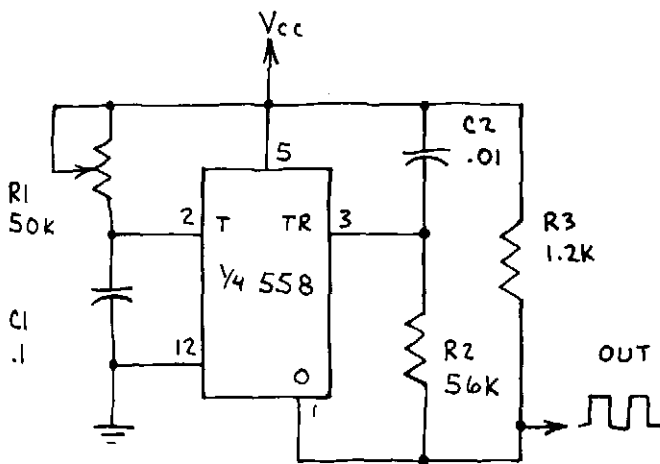
558

FULLY ADJUSTABLE PULSE GENERATOR

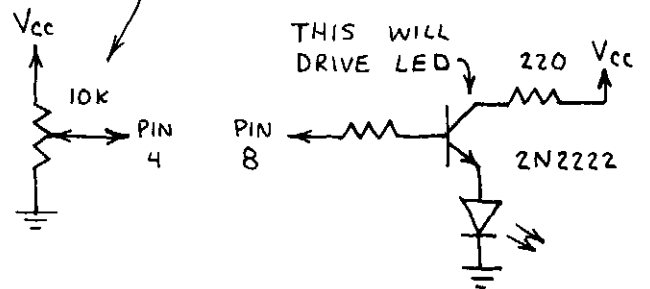


SIMPLE OSCILLATOR

FIXED DUTY CYCLE PULSER

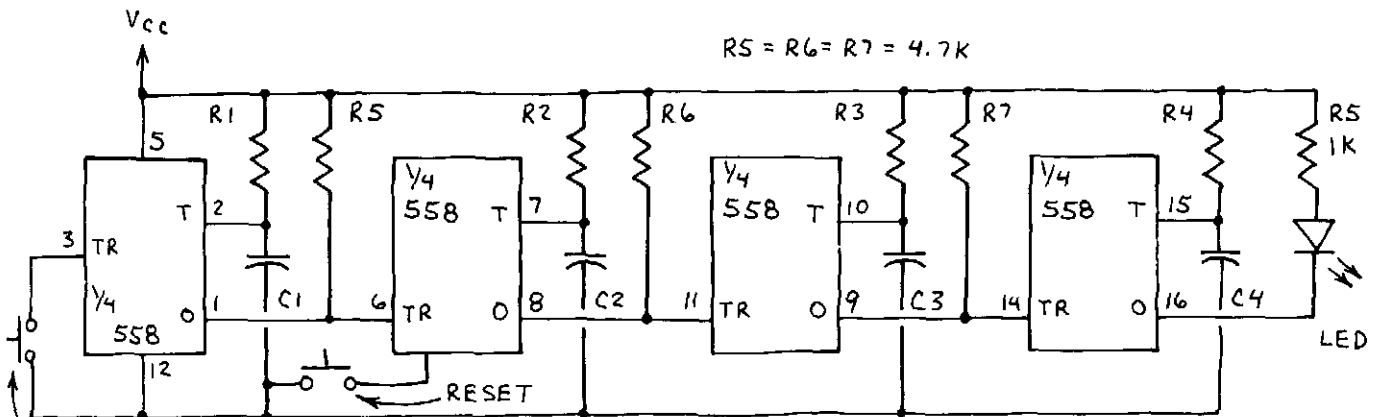


SEE ABOVE CIRCUIT. ADD THIS
VOLTAGE DIVIDER TO KEEP DUTY
CYCLE CONSTANT WHEN RATE IS
CHANGED



R1 CONTROLS
FREQUENCY

LONG DURATION TIMER



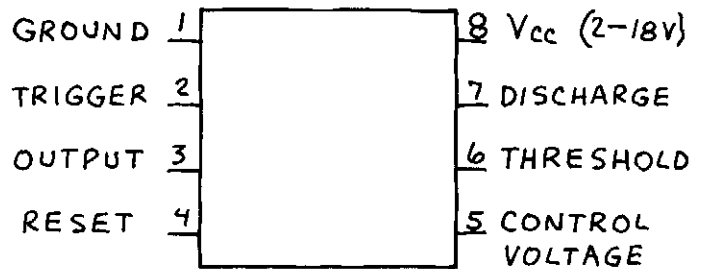
PUSH TO
START

SELECT R1C1, R2C2, R3C3 AND R4C4 TO GIVE DESIRED DELAY PER
STAGE. DELAY = R X C. TOTAL DELAY = SUM OF ALL STAGES. LED TURNS
OFF AFTER TIME DELAY AND TURNS ON AGAIN.

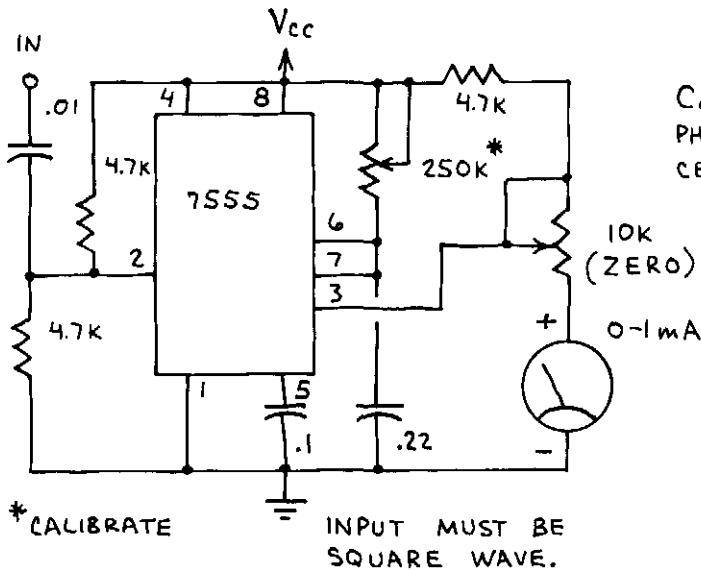
TIMER

7555

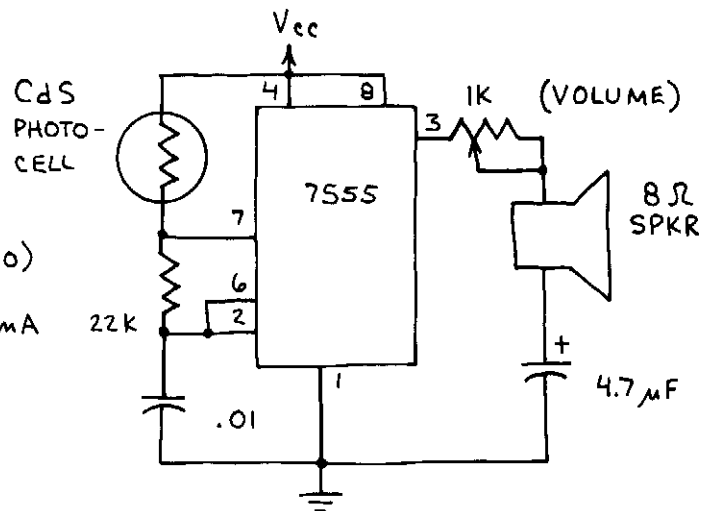
CMOS VERSION OF THE 555. VERY LOW POWER CONSUMPTION. WIDER SUPPLY VOLTAGE RANGE. LONGER TIMING CYCLES. CAUTION: APPLY POWER TO 7555 BEFORE CONNECTING EXTERNAL CIRCUIT.



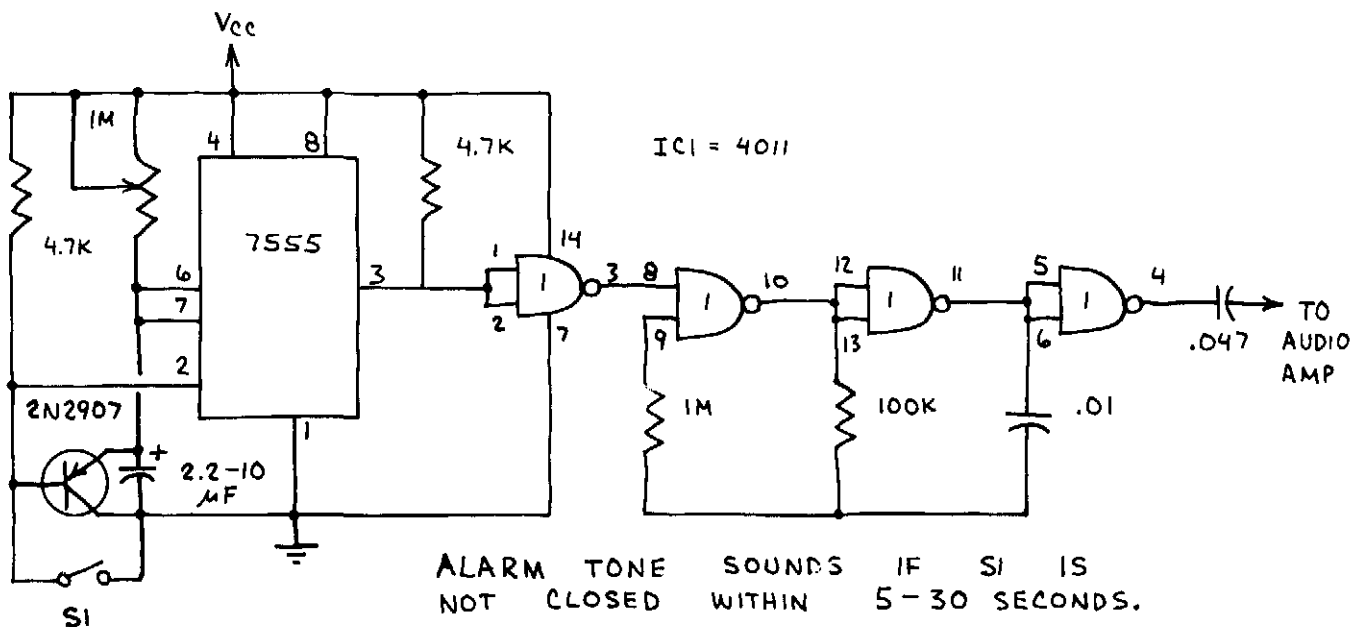
FREQUENCY METER



LIGHT PROBE FOR BLIND



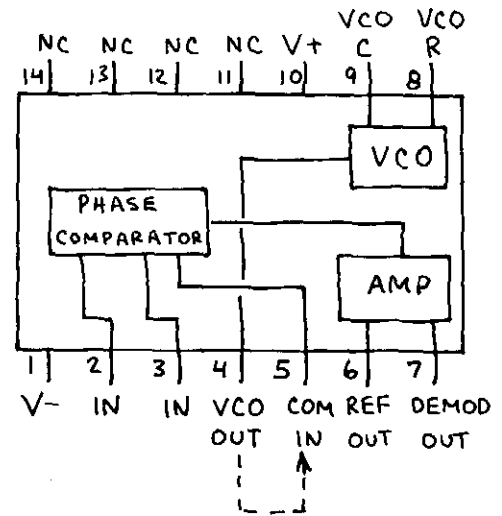
EVENT FAILURE ALARM



PHASE-LOCKED LOOP

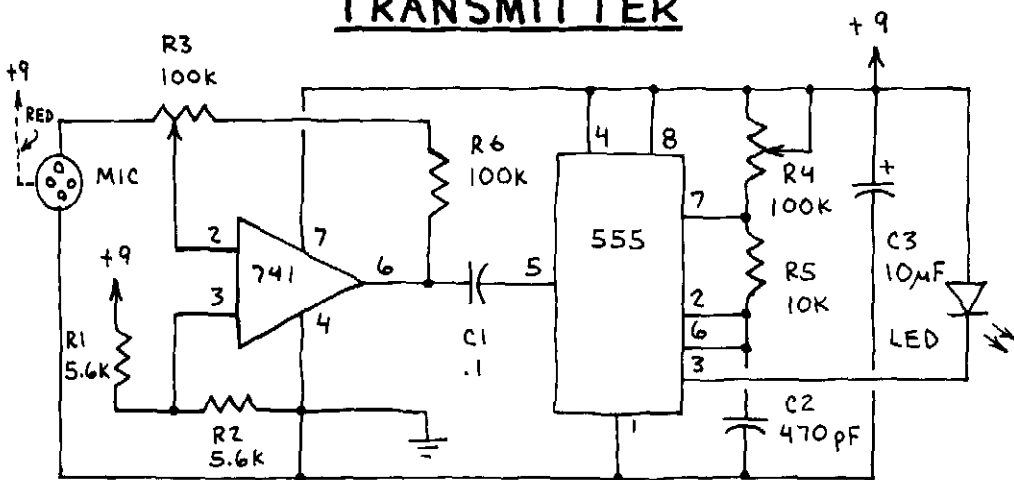
565

SOPHISTICATED ANALOG SYSTEM THAT AUTOMATICALLY TRACKS A FLUCTUATING INPUT SIGNAL. VOLTAGE CONTROLLED OSCILLATOR (VCO) FREQUENCY IS CONTROLLED BY OUTPUT VOLTAGE FROM PHASE COMPARATOR. THIS CAUSES VCO FREQUENCY TO MOVE TOWARD INPUT SIGNAL. THE COMPARATOR VOLTAGE OUTPUT IS AMPLIFIED AND AVAILABLE FOR COMMUNICATIONS APPLICATIONS... AS SHOWN BELOW.



PULSE-FREQUENCY-MODULATED INFRARED COMMUNICATOR

TRANSMITTER

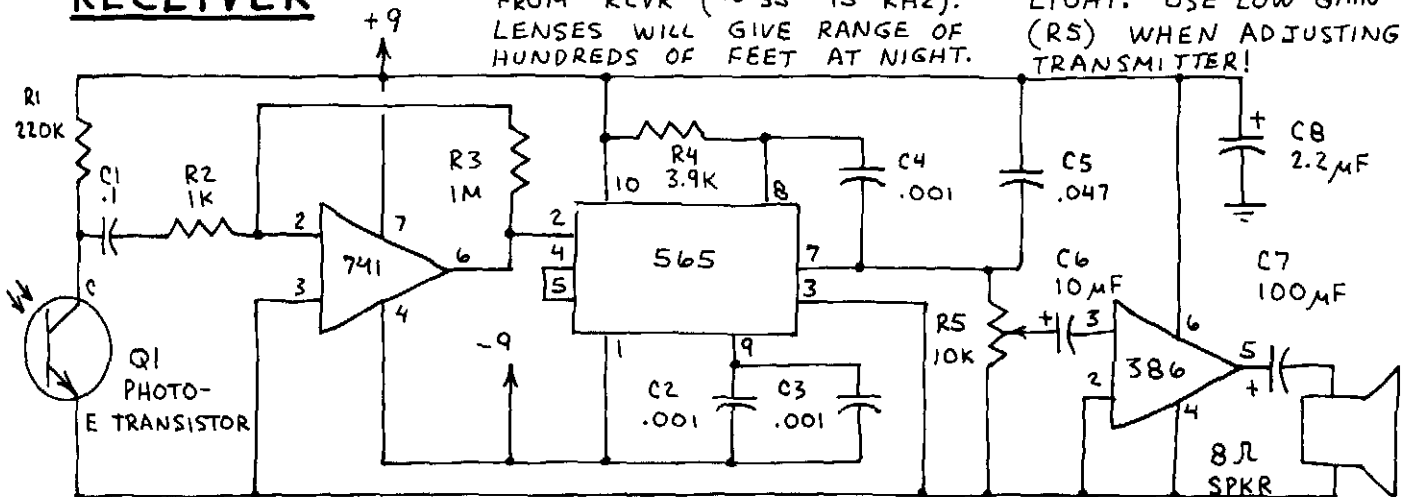


TRANSMITTER: R3 CONTROLS GAIN. R4 CONTROLS CARRIER FREQUENCY. FOR INITIAL TESTS, REMOVE MIC AND CONNECT TRANSISTOR RADIO PHONE OUTPUT TO R3 VIA 4.7 uF AND GND. USE LOW VOLUME SETTING. R3 MUST BE 100K.

RECEIVER: R5 CONTROLS GAIN. C2 AND C3 GIVE VCO CENTER FREQUENCY OF ~40.6 KHZ. SHIELD Q1 WITH TUBE TO BLOCK EXTERNAL LIGHT. USE LOW GAIN (R5) WHEN ADJUSTING TRANSMITTER!

OPERATION: POINT LED AT Q1. APPLY POWER AND ADJUST R4 IN XMTR UNTIL GOOD QUALITY SOUND HEARD FROM RCVR (~35-45 KHZ). LENSES WILL GIVE RANGE OF HUNDREDS OF FEET AT NIGHT.

RECEIVER

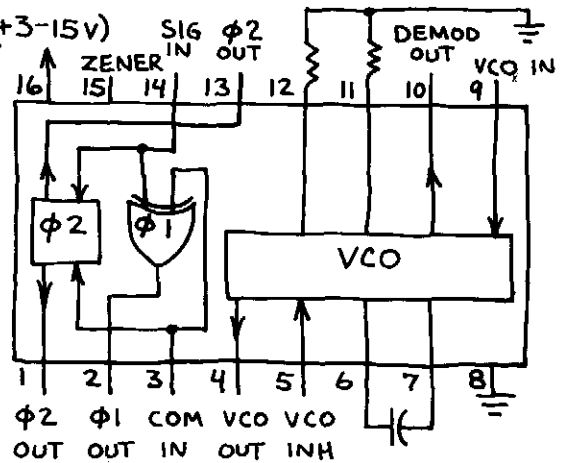


KEEP PWR LEADS ON BOTH UNITS SHORT. USE 0.1 uF ACROSS PWR CONNECTIONS (AT CHIPS) IF OSCILLATION OCCURS. HAVE FUN.

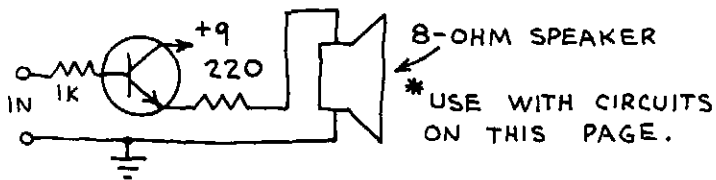
PHASE-LOCKED LOOP (PLL)

4046

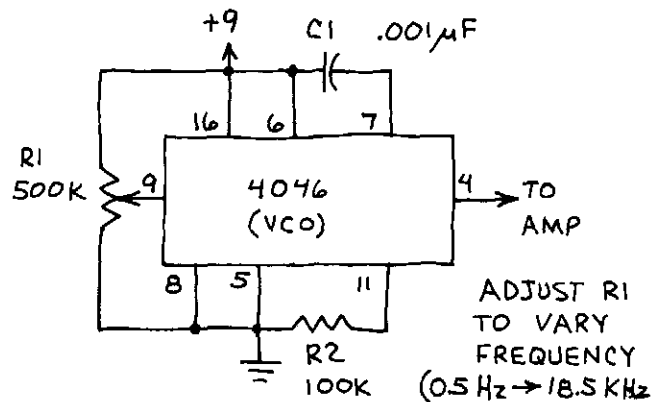
EXCEPTIONALLY VERSATILE CHIP. CONTAINS TWO PHASE COMPARATORS AND VOLTAGE CONTROLLED OSCILLATOR (VCO). USE VCO AND ONE PHASE COMPARATOR TO MAKE PLL. CIRCUITS ON THIS PAGE USE VCO ONLY.



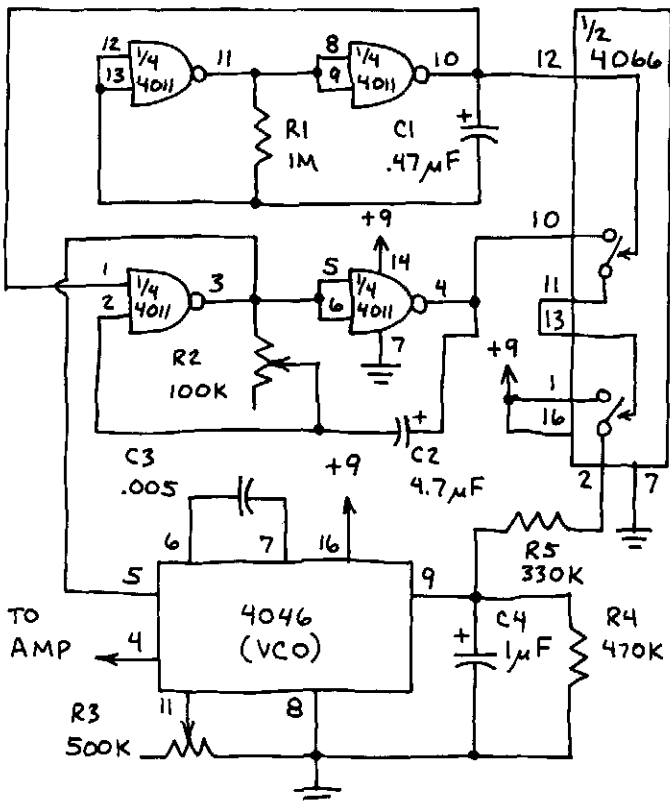
SPEAKER AMPLIFIER*



TUNABLE OSCILLATOR



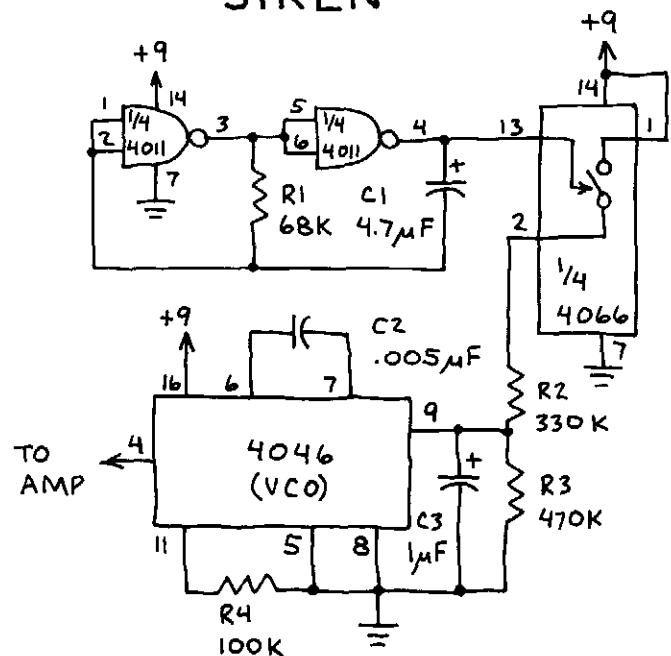
CHIRP BURST SEQUENCER



R2: ADJUST FOR 1-4 CHIRPS PER CYCLE. CHIRPS WILL HAVE DIFFERENT FREQUENCIES.

R3: CONTROLS PITCH OF CHIRPS. FOR TONES INSTEAD OF CHIRPS, CONNECT TO PIN 12 INSTEAD OF PIN 11.

SIREN

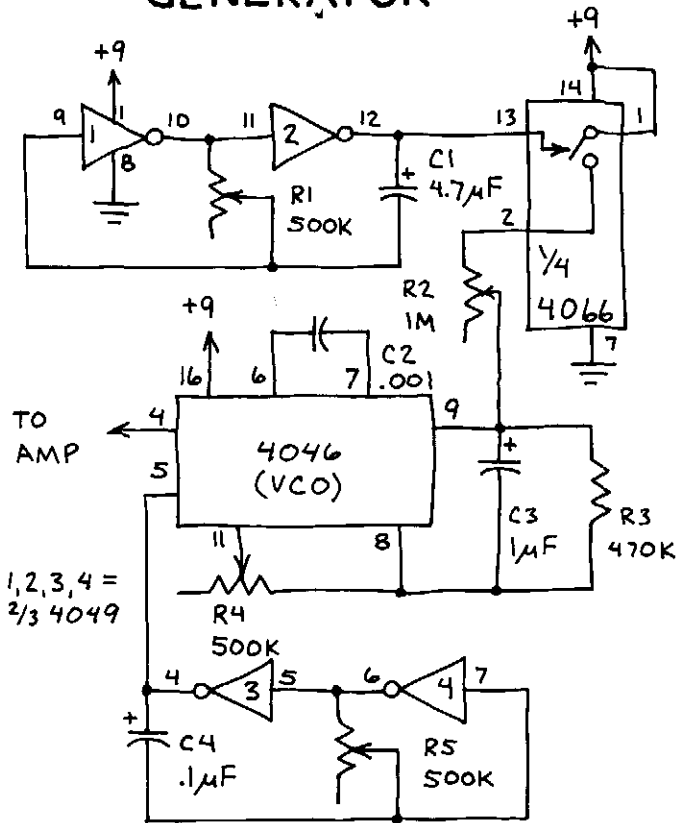


CHANGE R1 OR C1 TO ALTER CYCLE TIME. CHANGE R4 OR C2 TO ALTER FREQUENCY. CHANGE R3 OR C3 TO ALTER WAIL.

PHASE LOCKED LOOP (CONTINUED)

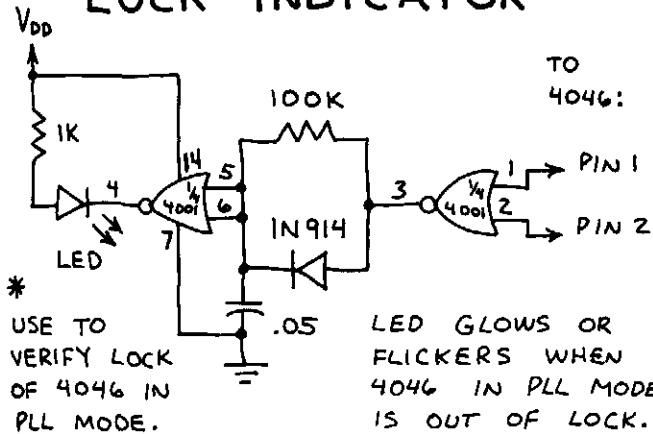
4046

SOUND EFFECTS GENERATOR



PRODUCES FASCINATING VARIETY OF UNDULATING AND CHOPPED TONES. R1 CONTROLS CYCLE TIME. R2 CONTROLS DELAY TIME. R4 CONTROLS FREQUENCY RANGE. R5 CONTROLS CHOPPING RATE. CHANGING R5'S SETTING GIVES MOST DRAMATIC RESULTS.

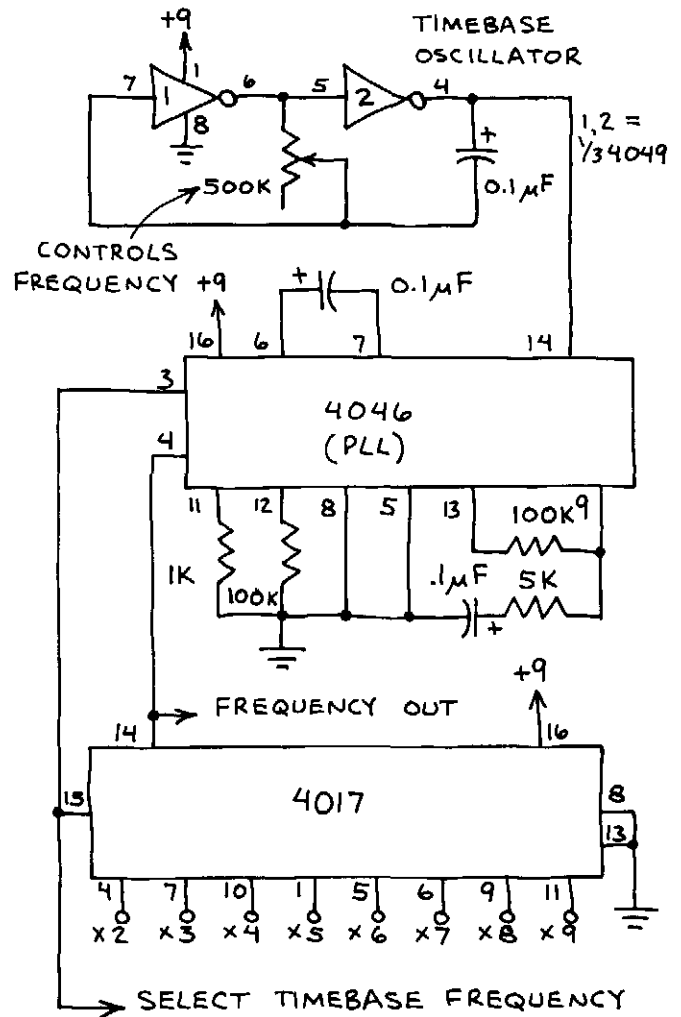
LOCK INDICATOR *



* USE TO VERIFY LOCK OF 4046 IN PLL MODE.

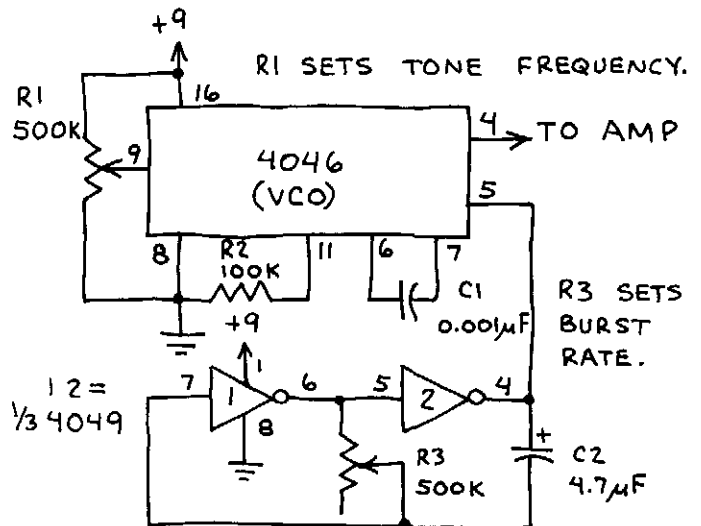
LED GLOWS OR FLICKERS WHEN 4046 IN PLL MODE IS OUT OF LOCK.

FREQUENCY SYNTHESIZER



SELECT TIMEBASE FREQUENCY MULTIPLICATION FACTOR. SET TIMEBASE TO ~100Hz.

TONE BURST GENERATOR



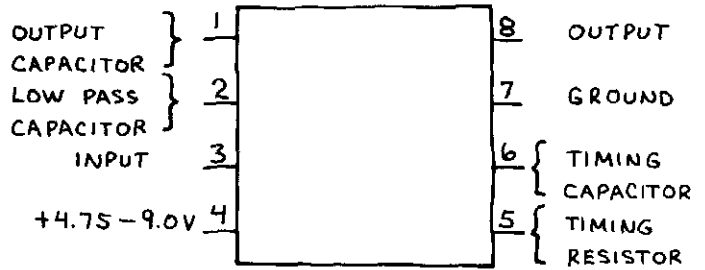
R1 SETS TONE FREQUENCY.

R3 SETS BURST RATE.

TONE DECODER

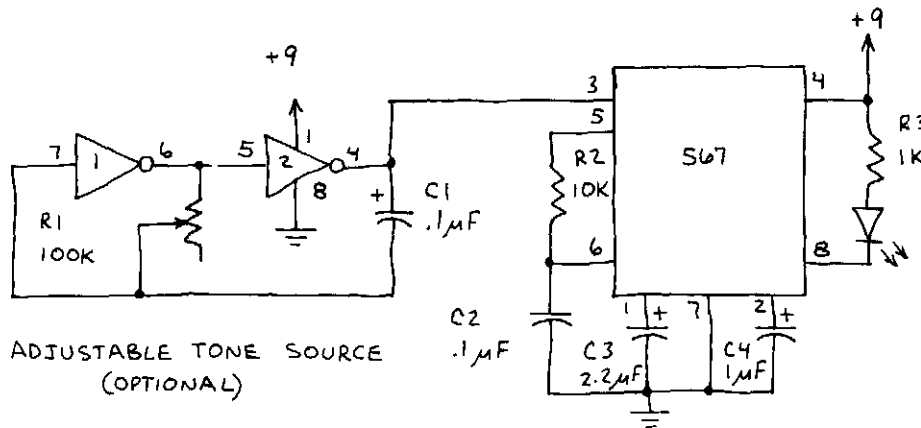
567

CONTAINS A PHASE-LOCKED LOOP. PIN 8 GOES LOW WHEN THE INPUT FREQUENCY MATCHES THE CHIP'S CENTER FREQUENCY (f_0). THE LATTER FREQUENCY IS SET BY THE TIMING RESISTOR AND CAPACITOR (R AND C) AND IS $(1.1) \div (RC)$. R SHOULD BE BETWEEN 2K-20K. THE 567 CAN BE ADJUSTED TO DETECT ANY INPUT BETWEEN 0.01 HZ TO 500KHZ. NOTE: 1 SECOND OR MORE MAY BE REQUIRED FOR THE 567 TO LOCK ON TO LOW FREQUENCY INPUTS! SEE THIS CHIP'S SPECIFICATIONS FOR MORE INFORMATION.



THE VALUE IN MICROFARADS OF THE LOW PASS CAPACITOR SHOULD BE n / f_0 WHERE n RANGES BETWEEN 1300 (FOR UP TO 14% f_0 DETECTION BANDWIDTH) TO 62,000 (UP TO 2% f_0 DETECTION BANDWIDTH). THE OUTPUT CAPACITOR SHOULD HAVE ABOUT TWICE THE CAPACITANCE OF THE LOW PASS FILTER CAPACITOR.

BASIC TONE DETECTOR CIRCUIT

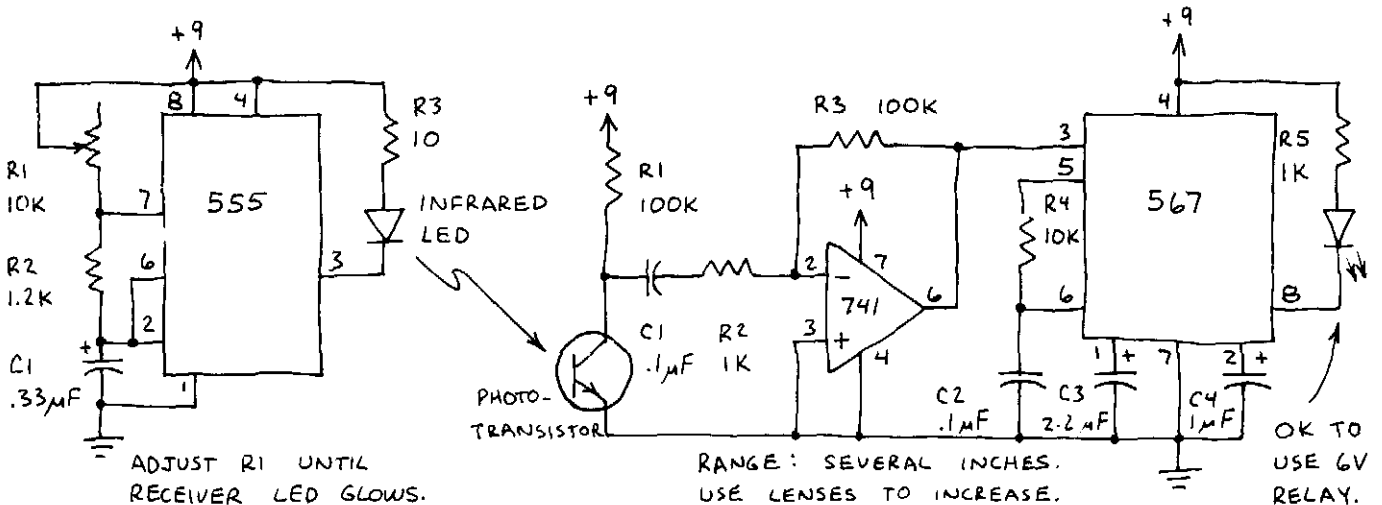


THIS CIRCUIT IS HANDY FOR LEARNING TONE DECODER BASICS. THE 567 PORTION CAN BE USED IN MANY DIFFERENT APPLICATIONS (SEE BELOW). THE PREDICTED f_0 IS 1.1 KHZ. THE TEST CIRCUIT f_0 WAS 1.3 KHZ.

INFRARED REMOTE CONTROL SYSTEM

TRANSMITTER

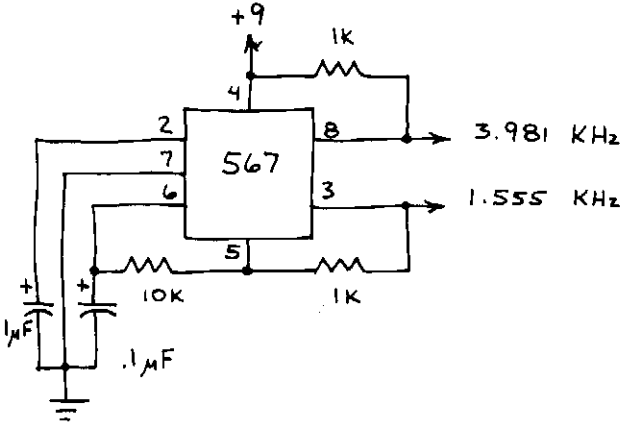
RECEIVER



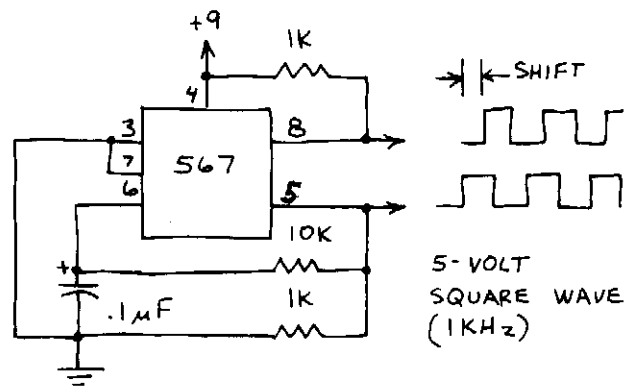
TONE DECODER (CONTINUED)

567

2-FREQUENCY OSCILLATOR



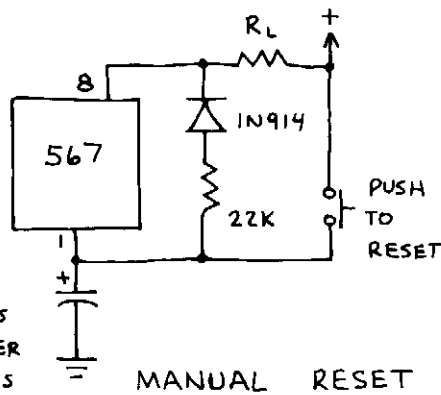
2-PHASE OSCILLATOR



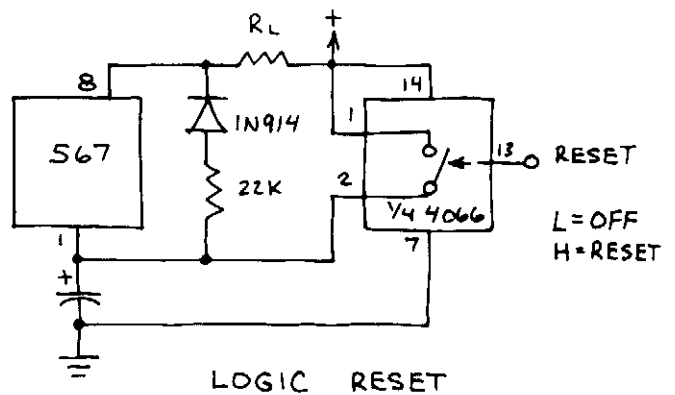
LATCHING THE 567 OUTPUT *

BOTH CIRCUITS SHOW ONLY THE LATCH COMPONENTS. R_L IS THE LOAD (LED, RELAY, ETC.).

* OUTPUT STAYS ON EVEN AFTER INPUT TONE IS REMOVED.

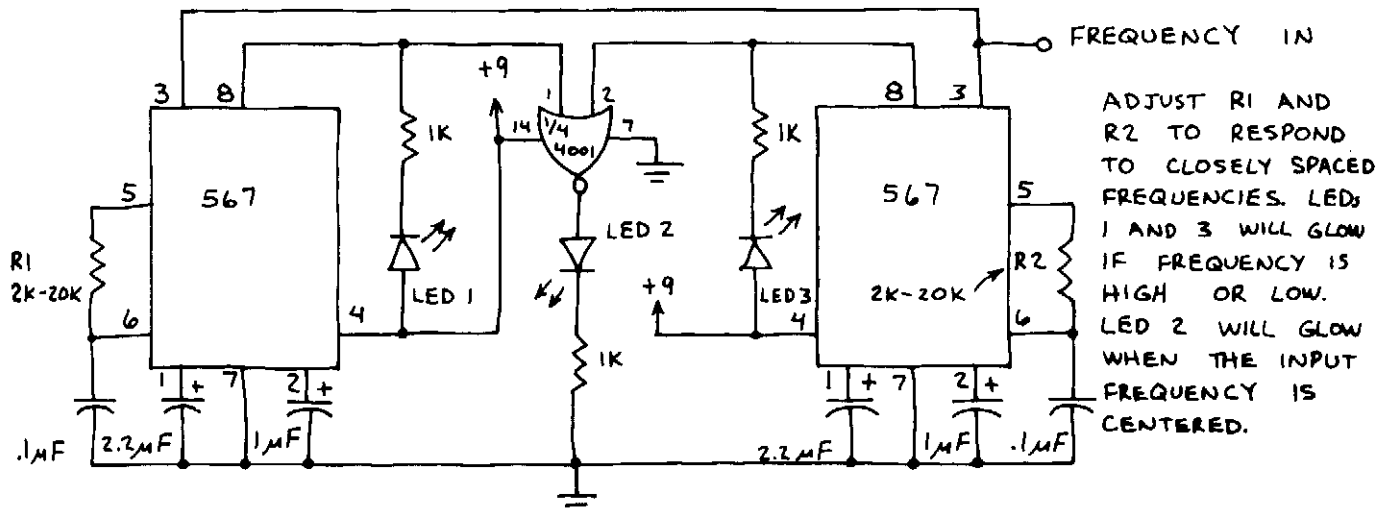


MANUAL RESET



LOGIC RESET

NARROW BAND FREQUENCY DETECTOR

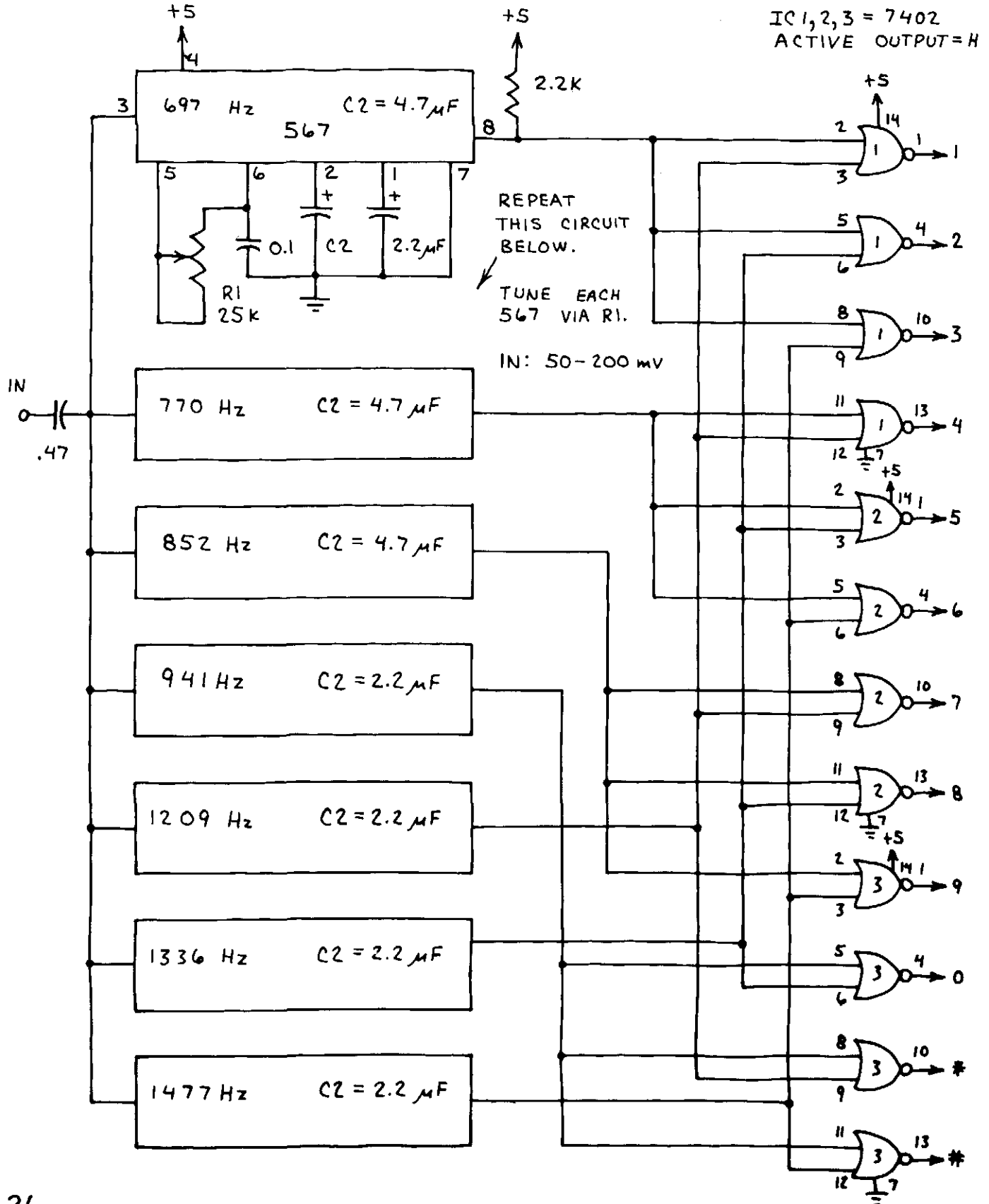


ADJUST R_1 AND R_2 TO RESPOND TO CLOSELY SPACED FREQUENCIES. LED₁ AND LED₃ WILL GLOW IF FREQUENCY IS HIGH OR LOW. LED₂ WILL GLOW WHEN THE INPUT FREQUENCY IS CENTERED.

TONE DECODER (CONTINUED)

567

TOUCH-TONE® DECODER



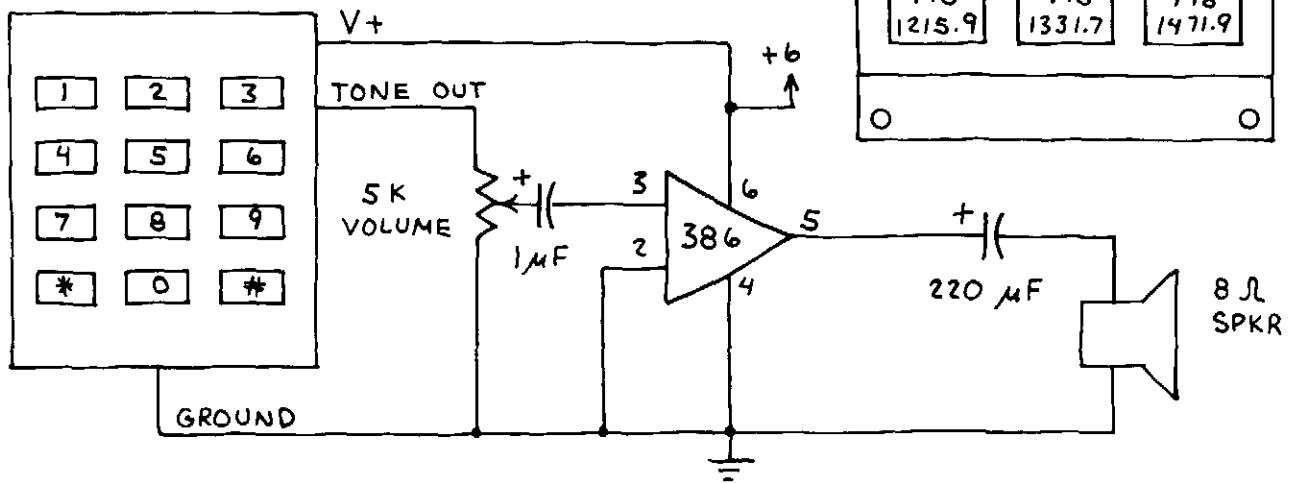
12-KEY PUSHBUTTON TONE MODULE CEX-4000

GENERATES THE 12 STANDARD TELEPHONE TONE DIALING FREQUENCY PAIRS. $V+$ SHOULD NOT EXCEED 6 VOLTS. REQUIRES 3.58 MHz CRYSTAL. OK TO USE FROM 1 TO 12 KEYS FOR REMOTE CONTROL.

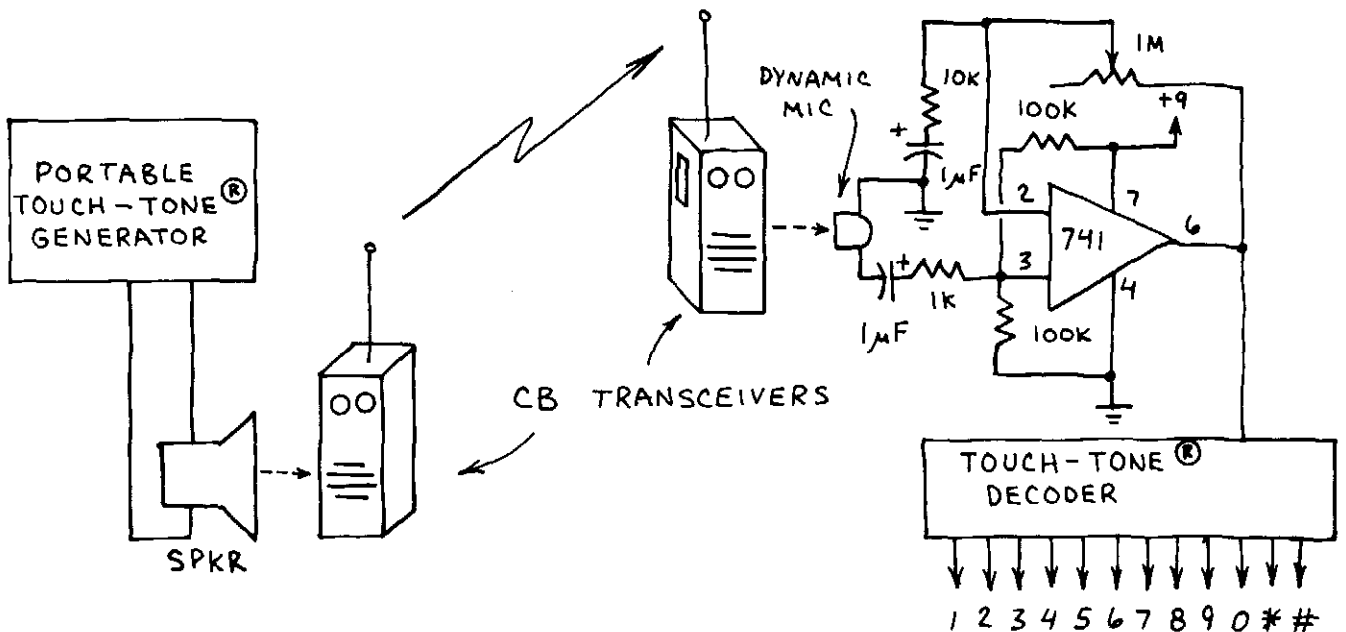
TOUCH-TONE® IS A REGISTERED TRADEMARK OF AT&T.

O (FREQUENCIES IN Hz) O		
1 699.1 1215.9	2 699.1 1331.7	3 699.1 1471.9
4 766.2 1215.9	5 766.2 1331.7	6 766.2 1471.9
7 847.4 1215.9	8 847.4 1331.7	9 847.4 1471.9
* 948 1215.9	0 948 1331.7	# 948 1471.9

PORTABLE TOUCH-TONE® GENERATOR

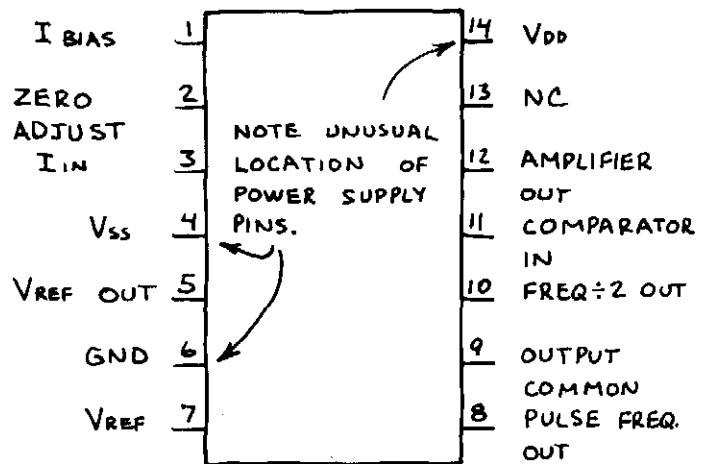


REMOTE CONTROL



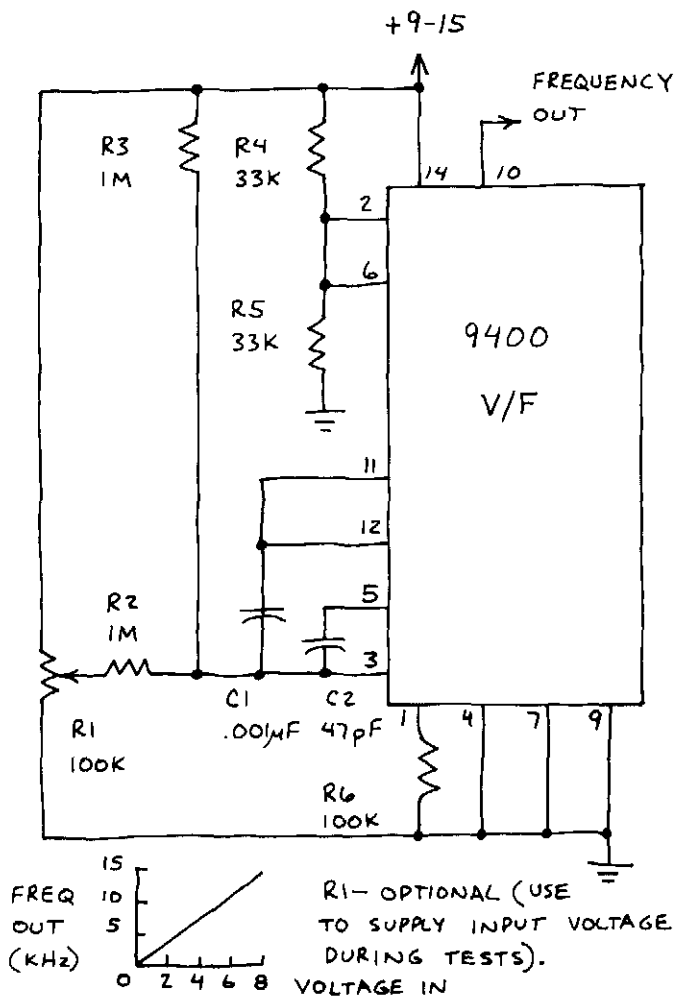
VOLTAGE-TO-FREQUENCY FREQUENCY-TO-VOLTAGE CONVERTER 9400

IN VOLTAGE-TO-FREQUENCY (V-F) MODE, AN INPUT VOLTAGE WHICH HAS BEEN CONVERTED INTO A CURRENT BY A RESISTOR AT PIN 3 IS TRANSFORMED INTO A PROPORTIONAL FREQUENCY. IN FREQUENCY-TO-VOLTAGE MODE A FREQUENCY AT PIN 11 IS CONVERTED INTO A PROPORTIONAL VOLTAGE. THIS CHIP CAN BE OPERATED FROM A SINGLE OR DUAL POLARITY POWER SUPPLY.

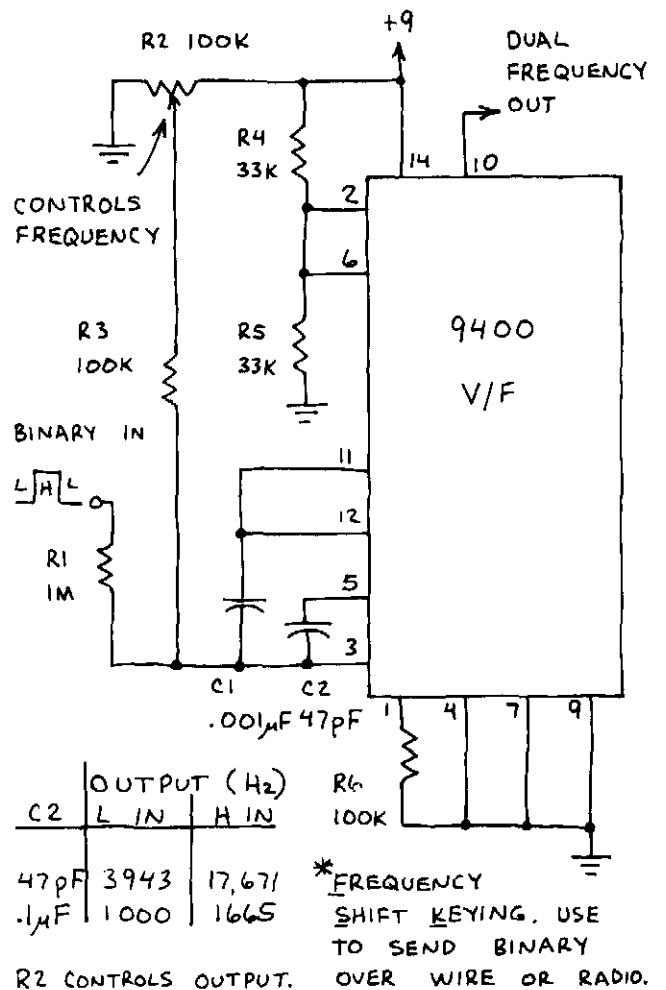


CAUTION: THIS CHIP INCORPORATES BOTH BIPOLAR AND CMOS CIRCUITRY. THEREFORE CMOS HANDLING PRECAUTIONS MUST BE FOLLOWED TO AVOID PERMANENT DAMAGE.

BASIC V/F CONVERTER



FSK* DATA TRANSMITTER

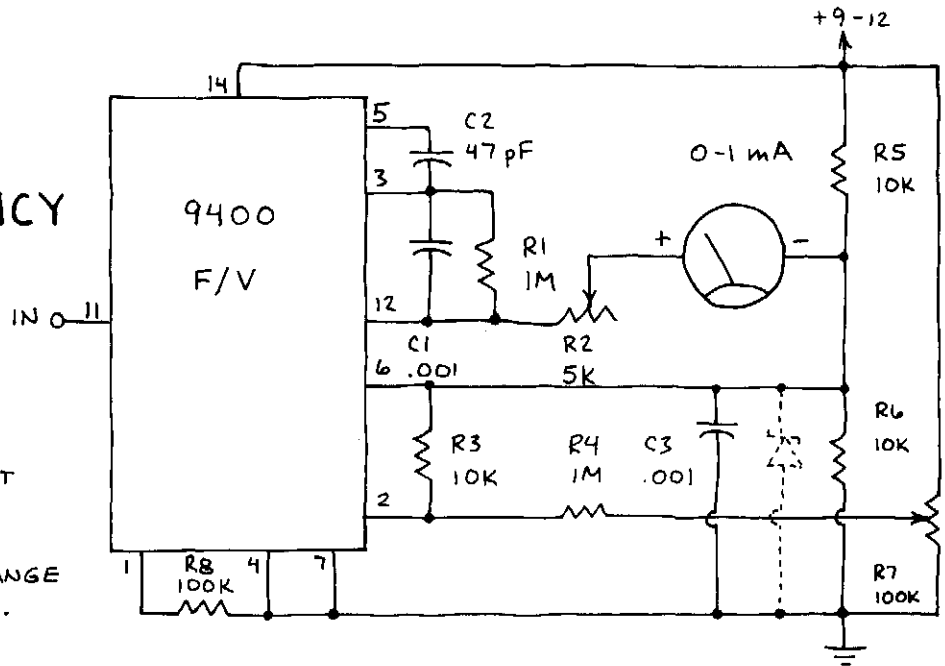


VOLTAGE-TO-FREQUENCY (CONTINUED) FREQUENCY-TO-VOLTAGE CONVERTER

9400

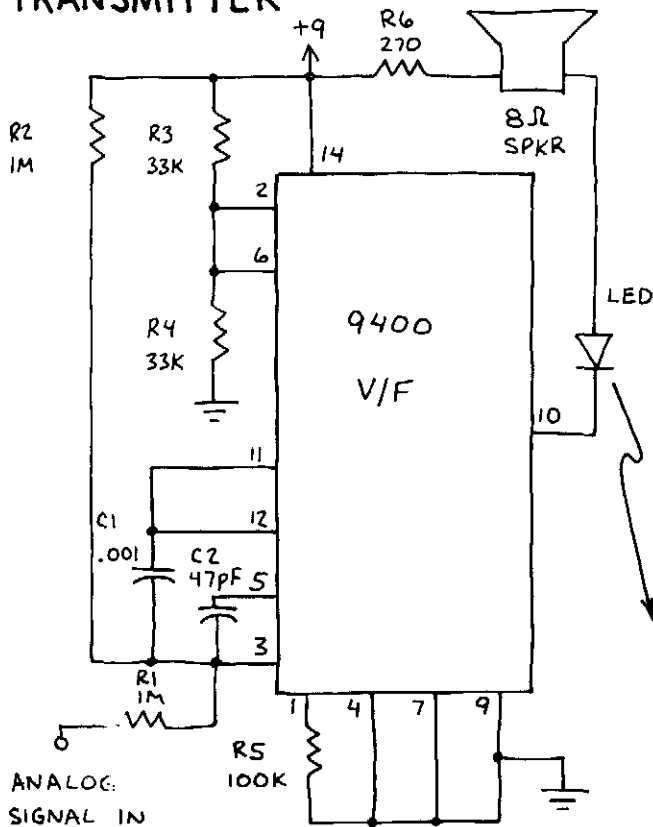
AUDIO FREQUENCY METER

INPUT FREQUENCY MUST CROSS 0 VOLT. WORKS UP TO 25 KHz. R2 IS ZERO ADJUST FOR METER. ADJUST R7 TO GIVE MAXIMUM READING AT 25 KHz IN. FOR MORE STABILITY, CHANGE R6 TO 6-V ZENER DIODE.

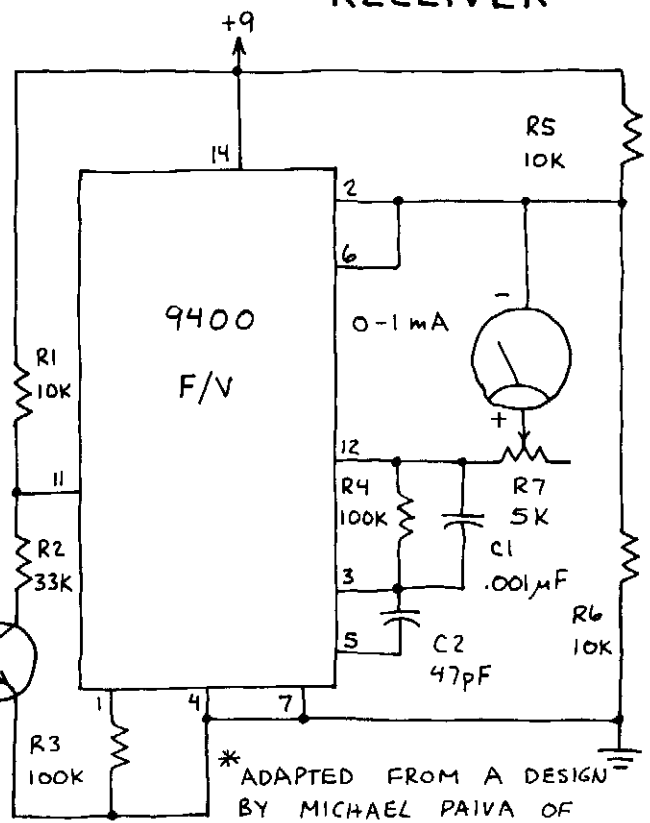


ANALOG DATA TRANSMISSION SYSTEM*

TRANSMITTER



RECEIVER



* ADAPTED FROM A DESIGN BY MICHAEL PAIVA OF TELEDYNE.

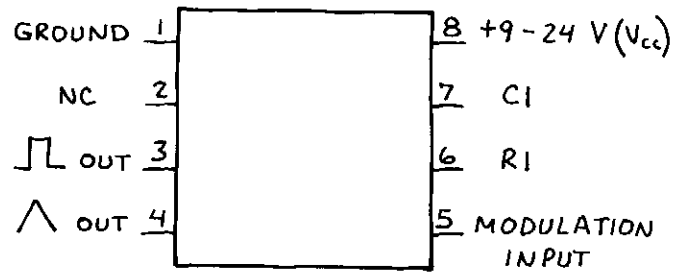
THE SPKR IS OPTIONAL BUT MAY PROVE HELPFULL DURING INITIAL TESTING. USE AN INFRARED LED, THE LED,

Q1 CAN BE THE PHOTOTRANSISTOR SUPPLIED WITH R7 IN THE RECEIVER IS ZERO ADJUST.

VOLTAGE CONTROLLED OSCILLATOR (VCO)

566

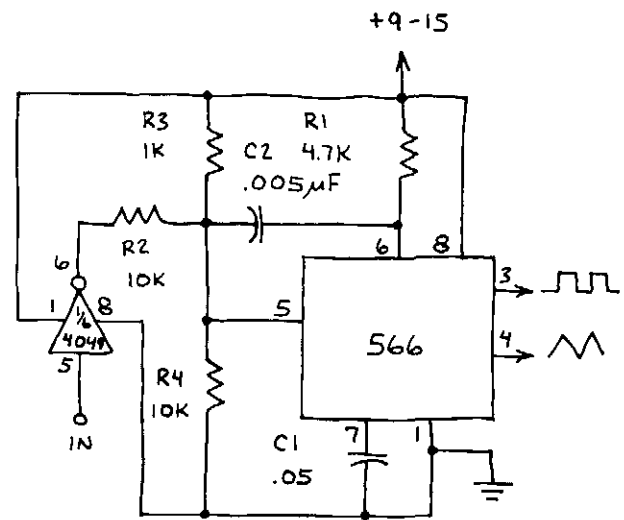
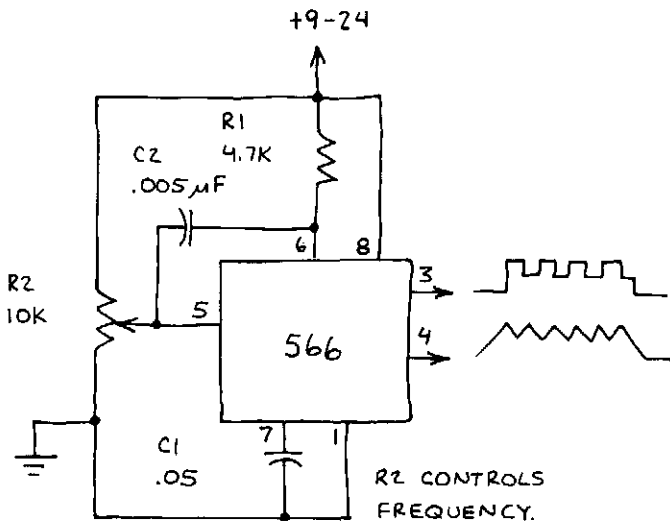
VERY STABLE, EASY TO USE TRIANGLE AND SQUARE WAVE OUTPUTS. R_1 AND C_1 CONTROL CENTER FREQUENCY. VOLTAGE AT PIN 5 VARIES FREQUENCY. **IMPORTANT:** OUTPUT WAVE DOES NOT FALL TO 0 VOLT! AT 12 VOLTS (PIN 8), FOR EXAMPLE, TRIANGLE OUTPUT CYCLES BETWEEN +4 AND +6 VOLTS. SQUARE OUTPUT CYCLES BETWEEN +6 AND +11.5 VOLTS.



$$\text{CENTER FREQUENCY} = \frac{2 (V_{CC} - \text{INPUT VOLTS})}{R_1 C_1 V_{CC}}$$

FSK GENERATOR *

FUNCTION GENERATOR



* FSK MEANS FREQUENCY SHIFT KEYING.

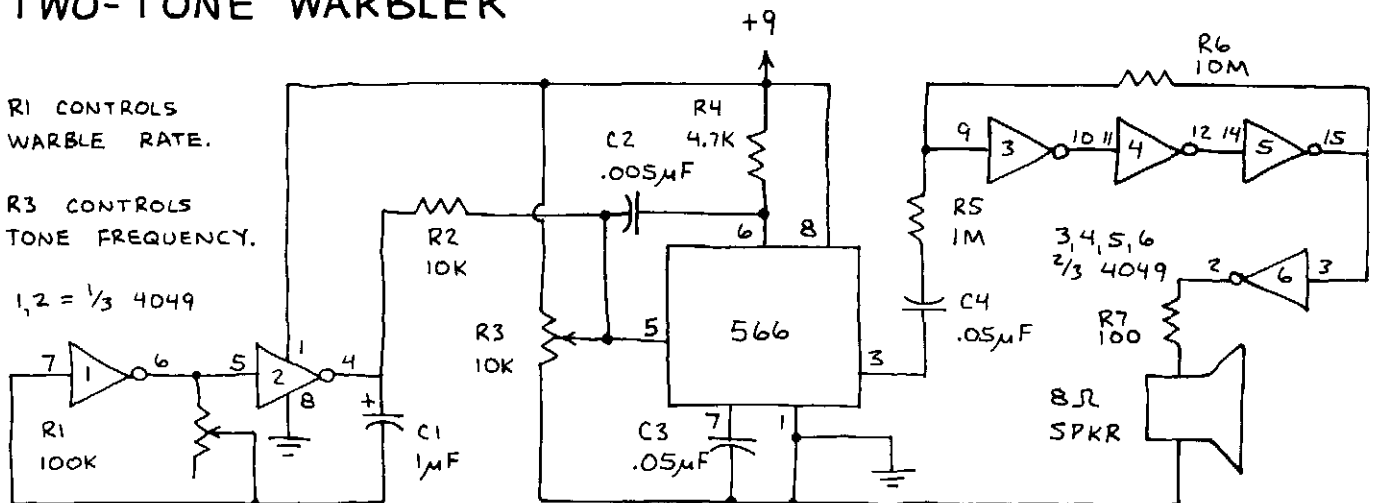
IN	OUTPUT	USE TO TRANSMIT BINARY DATA OVER TELEPHONE LINES OR STORE BINARY DATA ON MAGNETIC TAPE.
L	1.5 KHz	V _{CC} = 9 VOLTS.
H	3.0 KHz	

TWO-TONE WARBLER

R_1 CONTROLS WARBLE RATE.

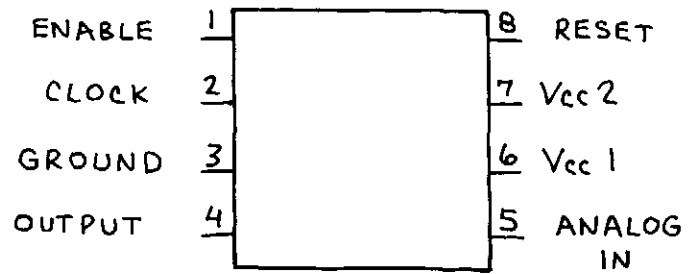
R_3 CONTROLS TONE FREQUENCY.

1, 2 = $\frac{1}{3}$ 4049



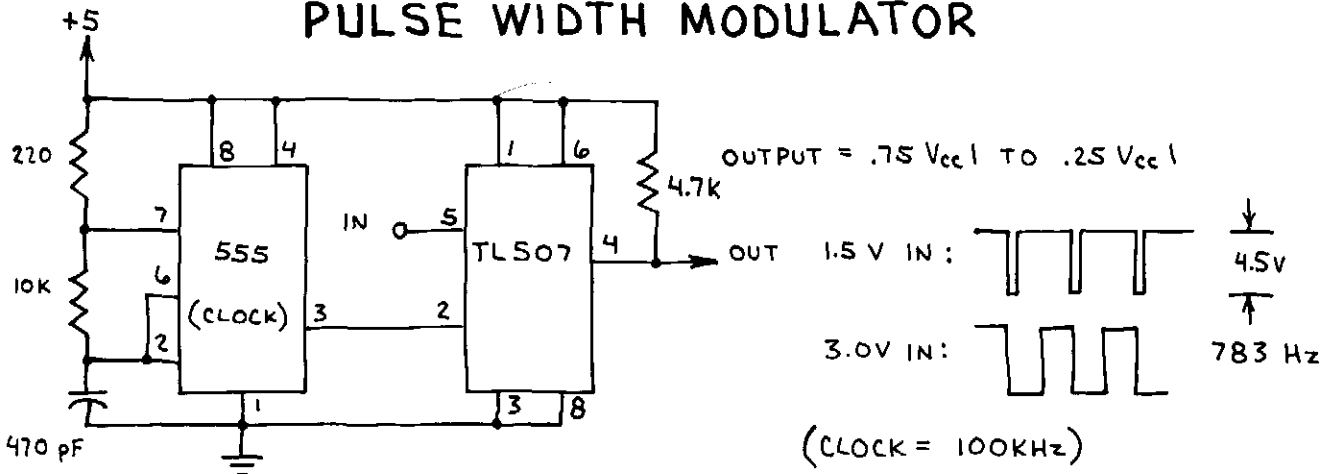
ANALOG-TO-DIGITAL CONVERTER TL507

PROVIDES ANALOG-TO-DIGITAL CONVERSION FOR MICROPROCESSORS. CAN PROVIDE 4-BIT OR 8-BIT OUTPUT WITH EXTERNAL COUNTER PLUS STEERING LOGIC. MAKES GOOD PULSE WIDTH MODULATOR. NOTE: USE V_{cc1} OR V_{cc2} .

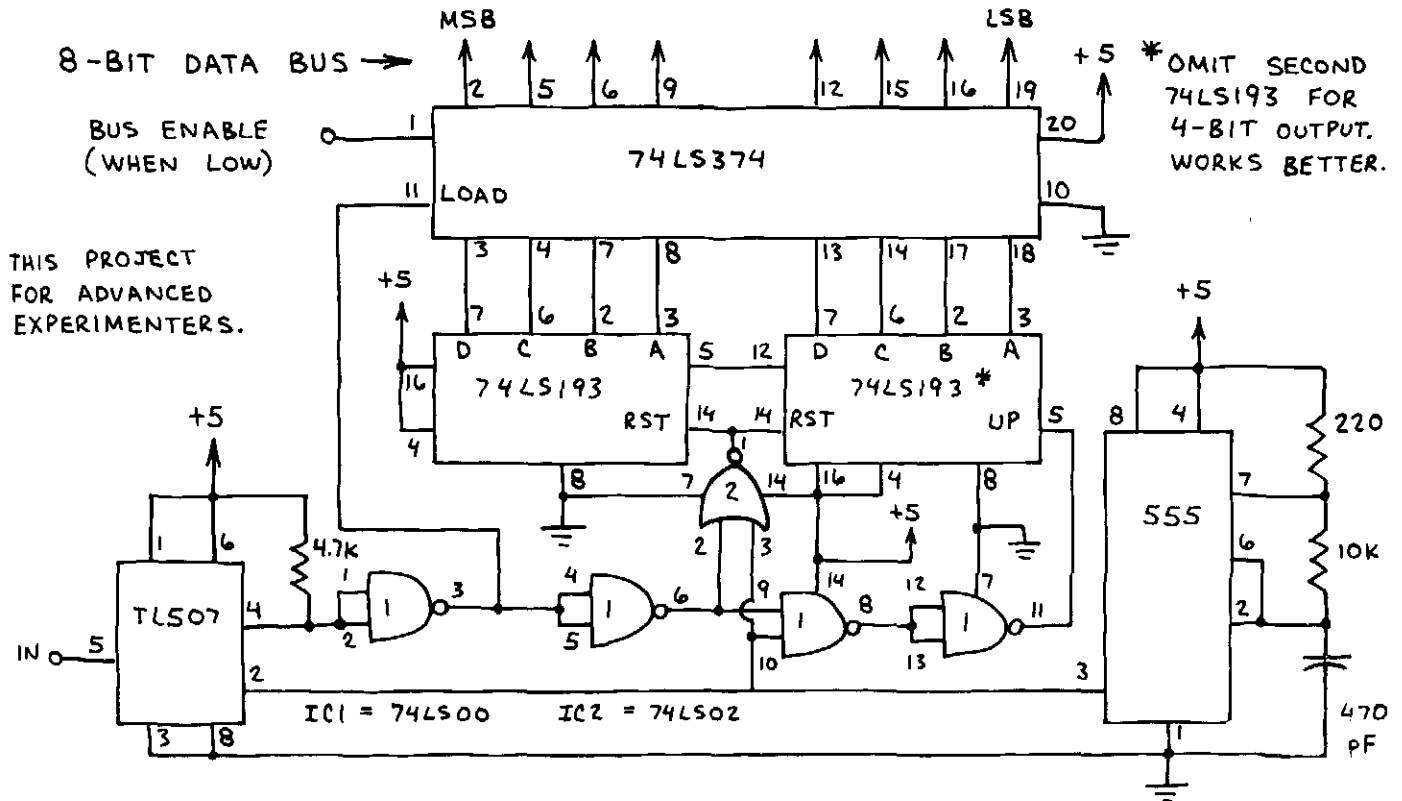


V_{cc1} - 3.5 TO 6 VOLTS
 V_{cc2} - 8 TO 18 VOLTS

PULSE WIDTH MODULATOR



8-BIT ANALOG-TO-DIGITAL CONVERTER



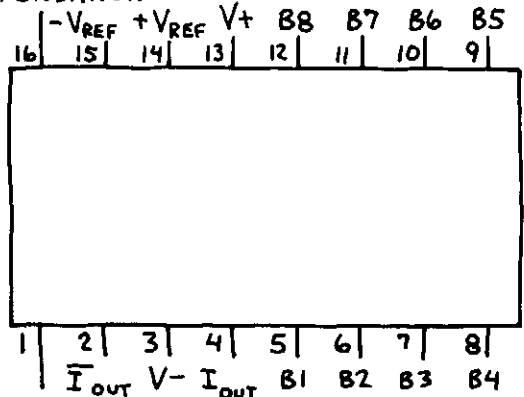
THIS PROJECT FOR ADVANCED EXPERIMENTERS.

8-BIT DIGITAL-TO-ANALOG CONVERTER DAC 801

PROVIDES VERY FAST 8-BIT DIGITAL-TO-ANALOG CONVERSION. WILL ACCEPT TTL LEVELS AT INPUTS B1 TO B8. CAN PROVIDE \pm OUTPUT. USE TO INTERFACE MICROCOMPUTER TO ANALOG DEVICES.

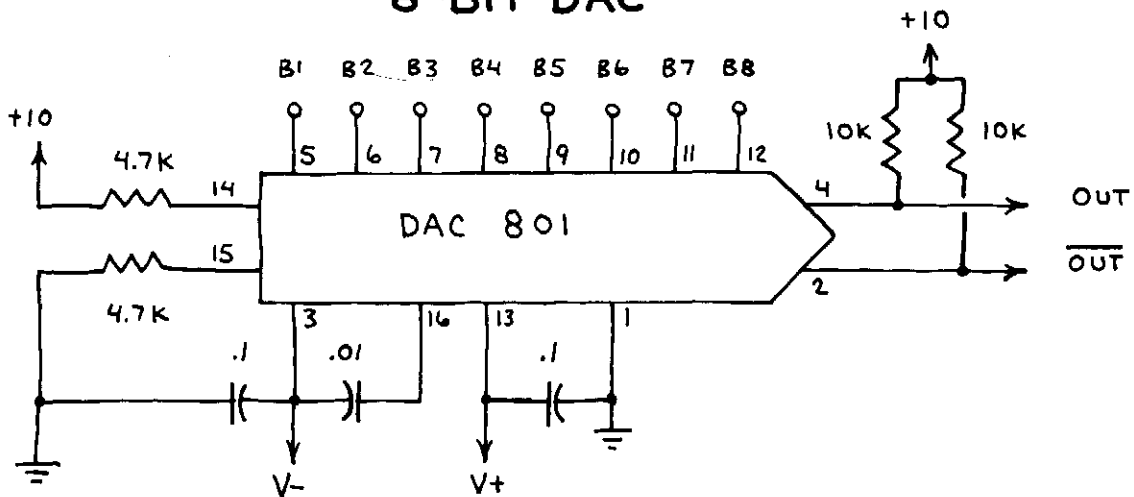
B1 - MOST SIGNIFICANT BIT.
B8 - LEAST SIGNIFICANT BIT.
 V_{\pm} - ± 4.5 TO 18 V.

COMPENSATION



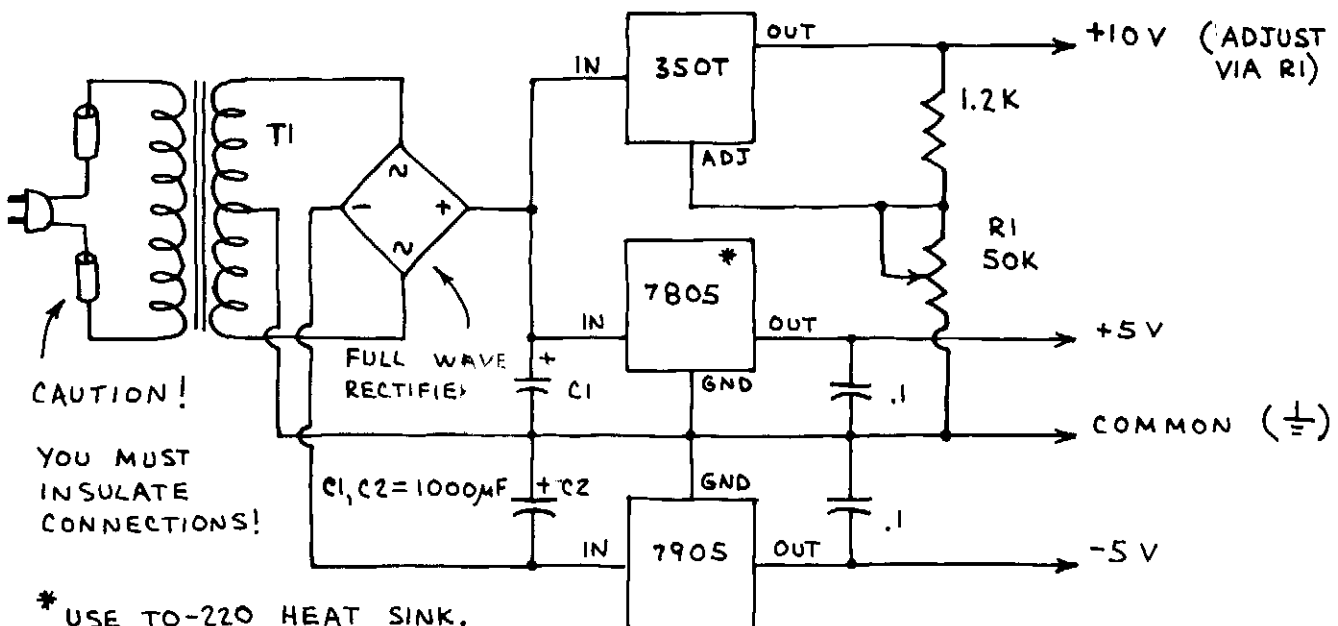
THRESHOLD CONTROL

8-BIT DAC



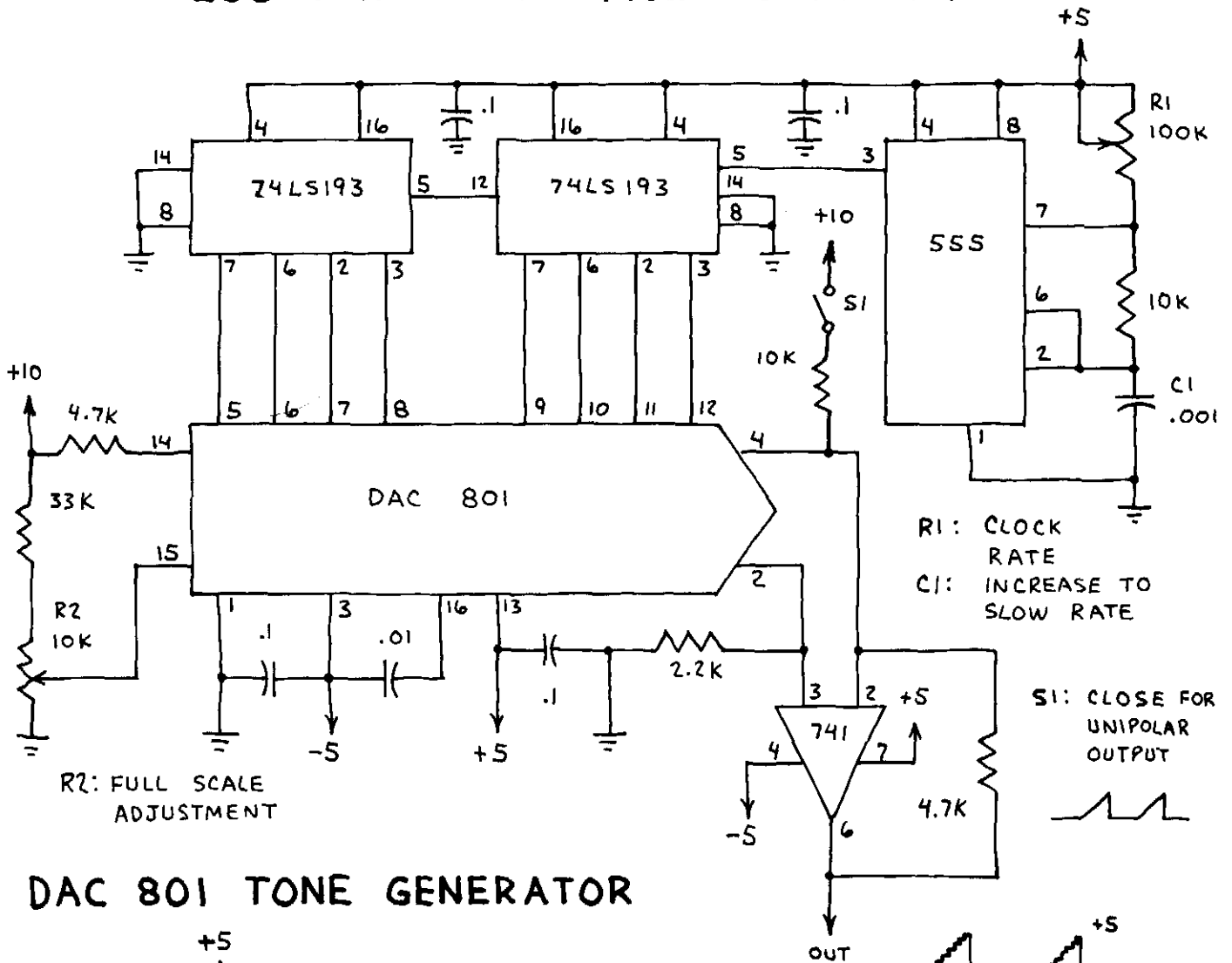
DAC 801 POWER SUPPLY

T1: 120VAC / 25.2 VAC CT

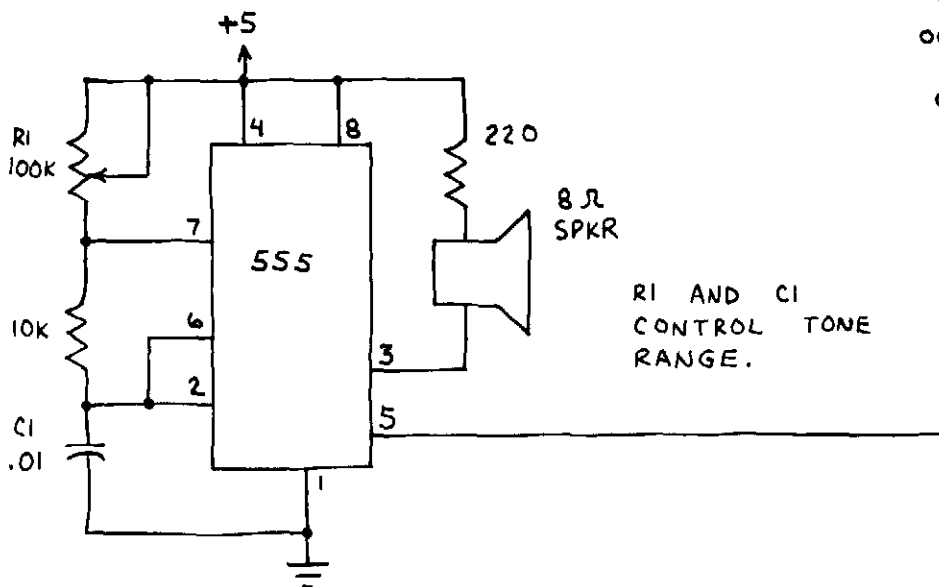


8-BIT DIGITAL-TO-ANALOG CONVERTER DAC 801 (CONTINUED)

256-STEP STAIRCASE GENERATOR



DAC 801 TONE GENERATOR



CHANGE OR OMIT ONE OR MORE INPUTS TO DAC 801 TO MAKE UNIQUE WAVEFORMS.

NOTE: +10V REFERENCE CAN BE +5 TO +10V IN NON-PRECISION ROLES (e.g. TONE GENERATION).

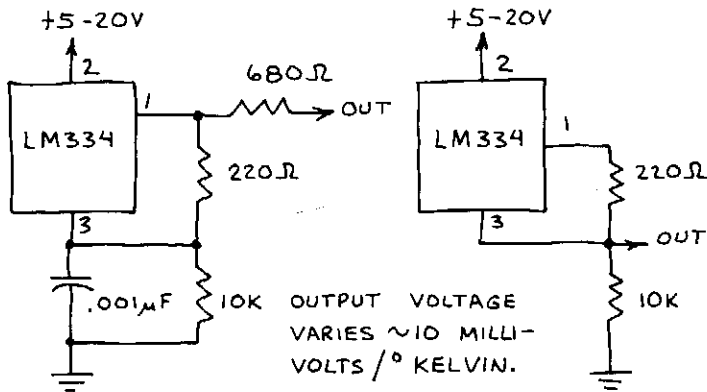
TEMPERATURE SENSOR AND ADJUSTABLE CURRENT SOURCE LM334

VERSATILE 3-LEAD COMPONENT THAT LOOKS MORE LIKE A TRANSISTOR THAN AN IC. CAN BE USED AS A TEMPERATURE SENSOR, CURRENT SOURCE FOR LEDs AND OTHER COMPONENTS OR CIRCUITS, VOLTAGE REFERENCE, ETC.

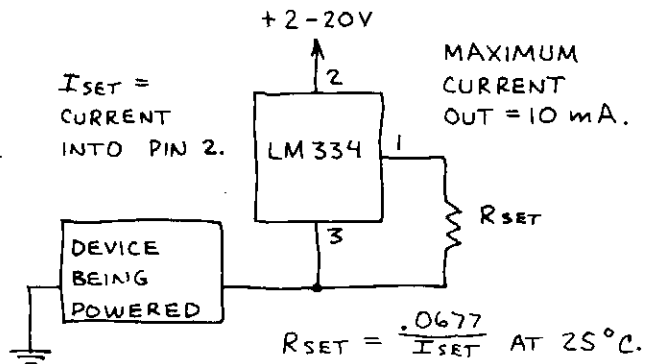


1 = R
2 = +V
3 = -V (GND)

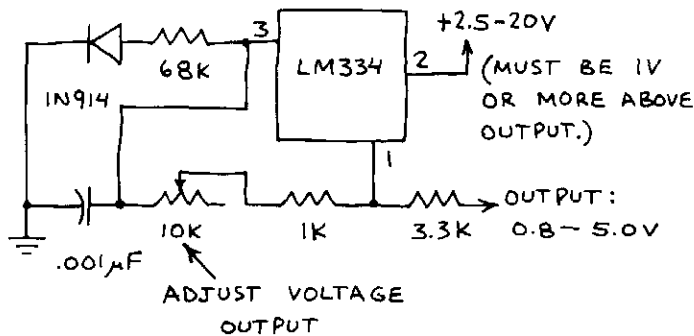
BASIC THERMOMETERS



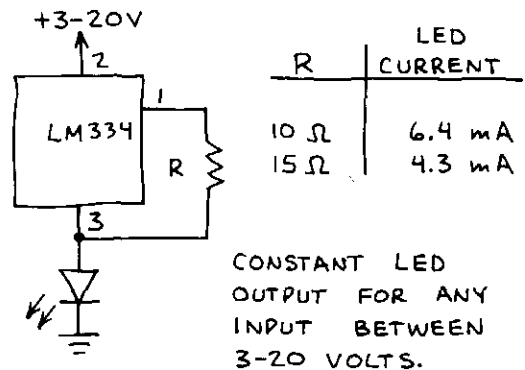
BASIC CURRENT SOURCE



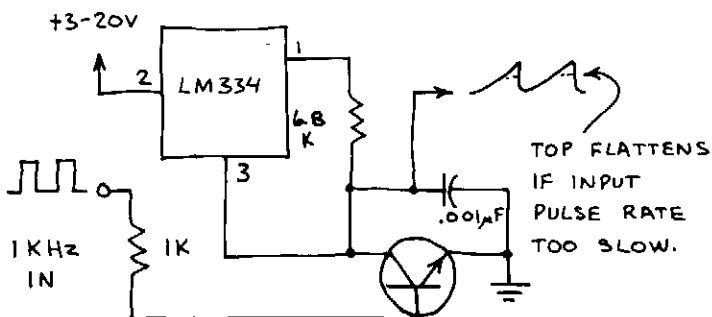
VOLTAGE REFERENCE



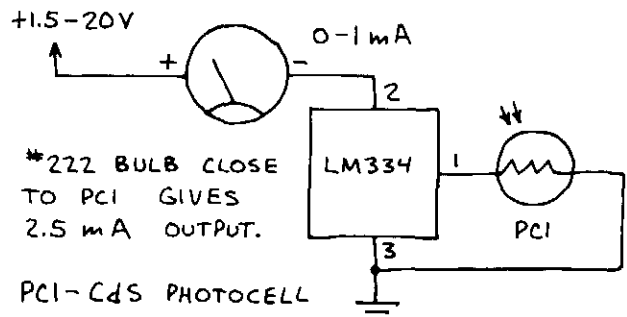
CALIBRATED LED



RAMP GENERATOR



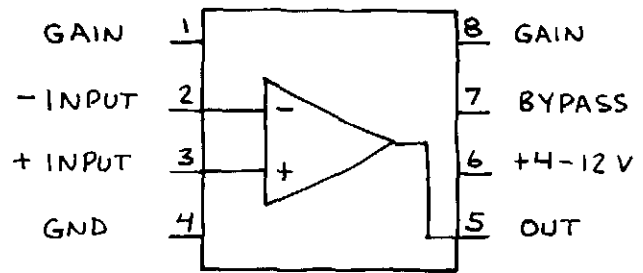
LIGHT METER



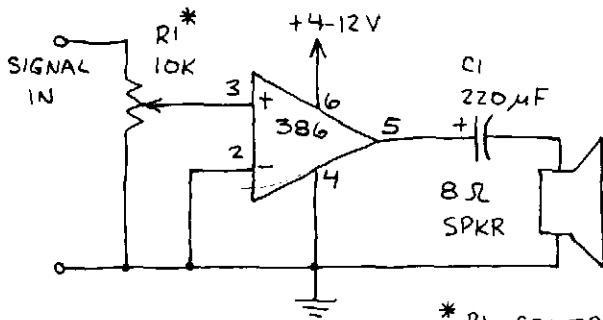
POWER AMPLIFIER

LM386

DESIGNED MAINLY FOR LOW VOLTAGE AMPLIFICATION. WILL DRIVE DIRECTLY AN 8-OHM SPEAKER. GAIN FIXED AT 20 BUT CAN BE INCREASED TO ANY VALUE UP TO 200.

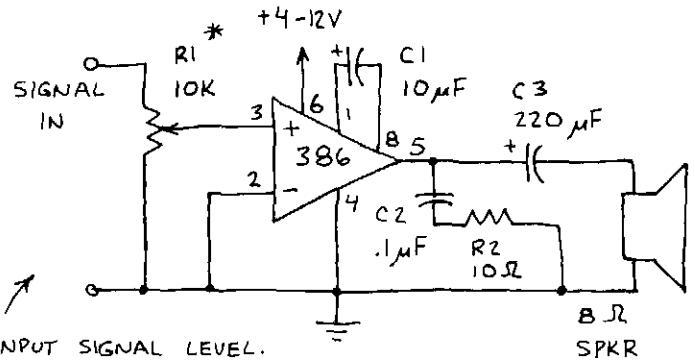


X20 AMPLIFIER

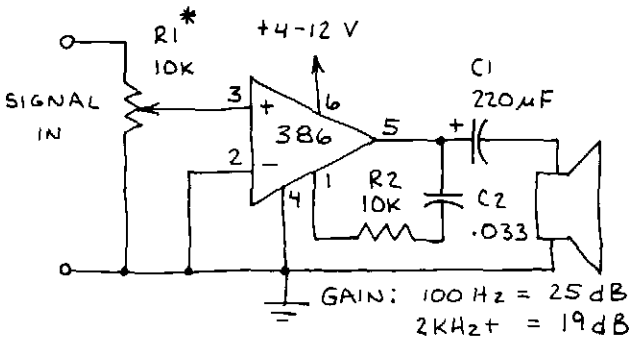


* R1 CONTROLS INPUT SIGNAL LEVEL.

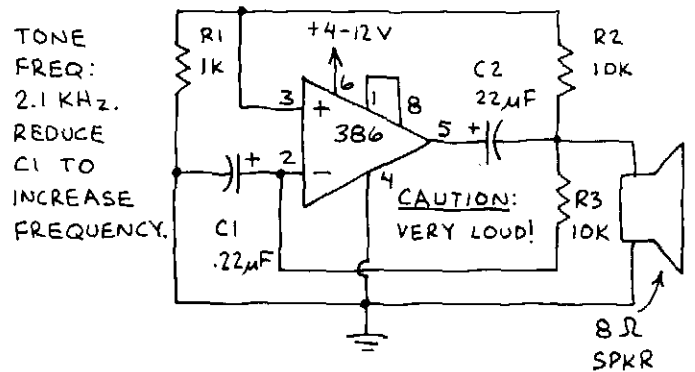
X200 AMPLIFIER



BASS BOOSTER



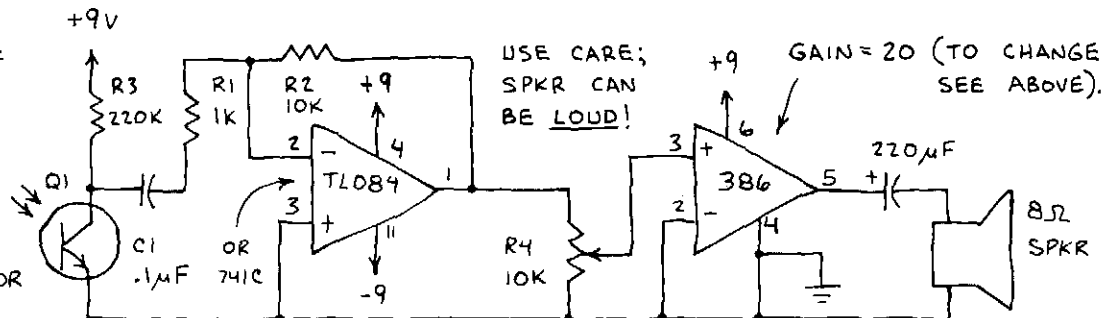
AUDIBLE ALARM



HIGH GAIN POWER AMPLIFIER

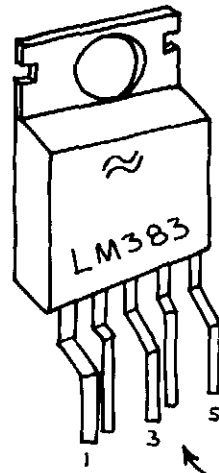
CIRCUIT SHOWN IS VERY SENSITIVE LIGHT WAVE RECEIVER. OK TO USE OTHER OP-AMPS FOR THE TLO84.

Q1 - PHOTOTRANSISTOR



8-WATT POWER AMPLIFIER LM383 / TDA2002

POWER AMPLIFIER DESIGNED SPECIFICALLY FOR AUTOMOTIVE APPLICATIONS — BUT IDEAL FOR ANY AUDIO AMPLIFICATION SYSTEM. DESIGNED TO DRIVE A 4-OHM LOAD (EQUIVALENT TO A SINGLE 4-OHM SPEAKER OR TWO 8-OHM SPEAKERS IN PARALLEL). THIS CHIP CONTAINS THERMAL SHUTDOWN CIRCUITRY TO PROTECT ITSELF FROM EXCESSIVE LOADING. THIS WILL CAUSE SEVERE DISTORTION DURING OVERLOAD CONDITIONS. YOU MUST USE AN APPROPRIATE HEAT SINK.

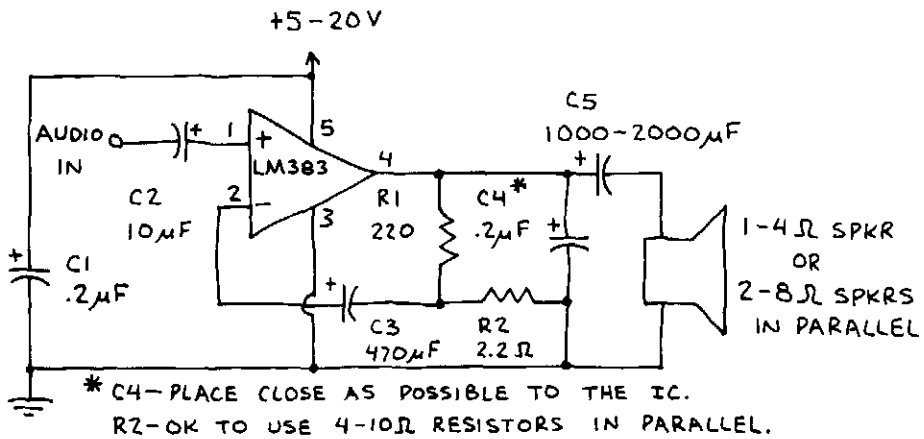


NOTE PRE-FORMED LEADS.

SOME HEAT SINK COMPOUND ON THE LM383 TAB BEFORE ATTACHING THE HEAT SINK.



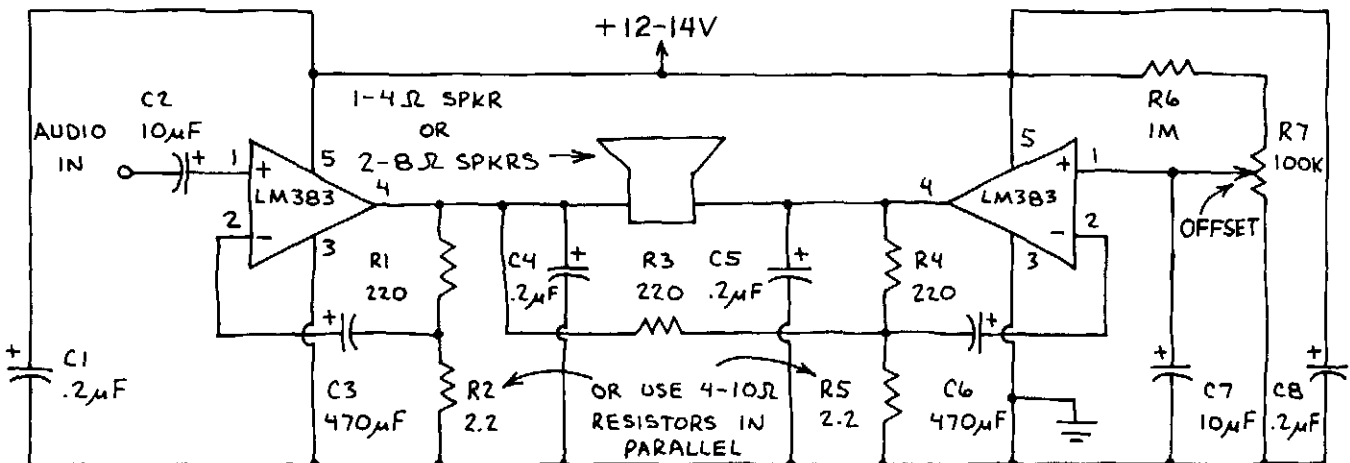
8-WATT AMPLIFIER



OPERATION:

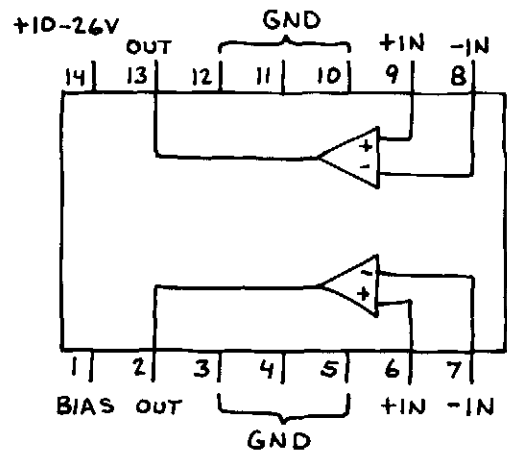
1. USE HEAT SINK.
2. REDUCE POWER SUPPLY VOLTAGE TO 6-9 VOLTS (AS IN CIRCUIT BELOW) IF SEVERE DISTORTION OCCURS.
3. DON'T APPLY EXCESSIVE INPUT SIGNAL.

16-WATT BRIDGE AMPLIFIER



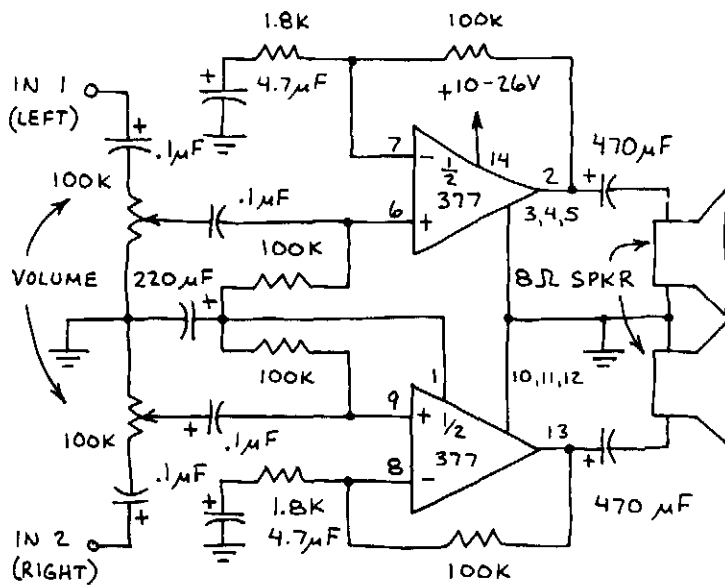
DUAL 2-WATT AMPLIFIER LM1877/LM377

HIGH QUALITY, EASY TO USE POWER AMPLIFIER. IDEAL FOR DO-IT-YOURSELF STEREO, P.A. SYSTEMS, INTERCOMS, ETC. AUTOMATIC THERMAL SHUTDOWN PROTECTS AGAINST OVERHEATING. 70dB CHANNEL SEPARATION MEANS VIRTUALLY NO CROSSTALK. ONLY 3 MICROVOLTS NOISE INPUT. HEATSINKING: UNNECESSARY IN MANY APPLICATIONS SINCE AVERAGE POWER IS USUALLY WELL BELOW BRIEF PEAKS. IN ANY CASE, PINS 3, 4, 5, 10, 11 AND 12 SHOULD BE CONNECTED TOGETHER. IF LOAD EXCEEDS DEVICE RATING, THERMAL SHUTDOWN WILL OCCUR... AND WILL CAUSE SEVERE DISTORTION. USE HEATSINK (UP TO 10 SQUARE INCHES OF COPPER FOIL ON PC BOARD OR METAL FIN) IF THIS OCCURS.

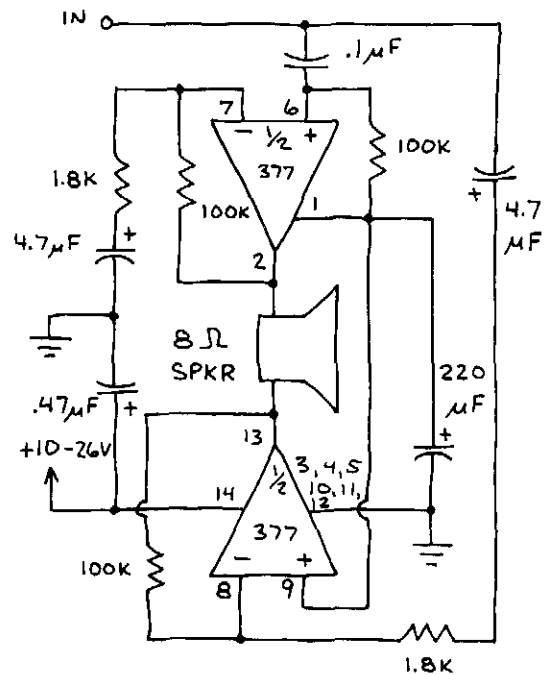


NOTE: GND PINS SHOULD BE HEAT SUNK FOR MAXIMUM POWER.

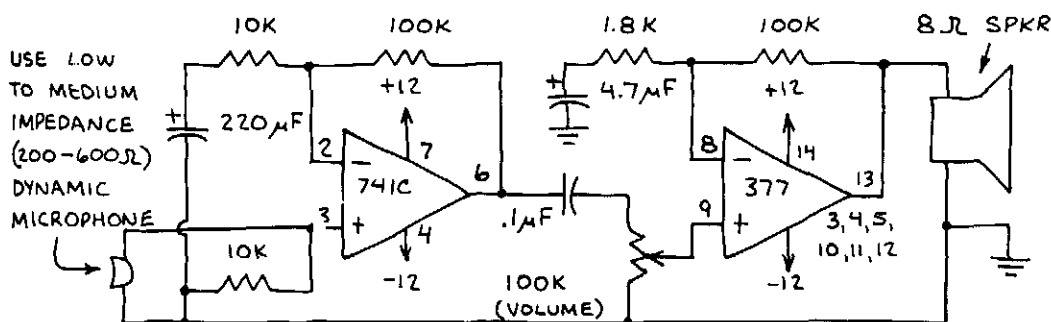
STEREO AMPLIFIER



4-WATT AMPLIFIER



PUBLIC ADDRESS SYSTEM



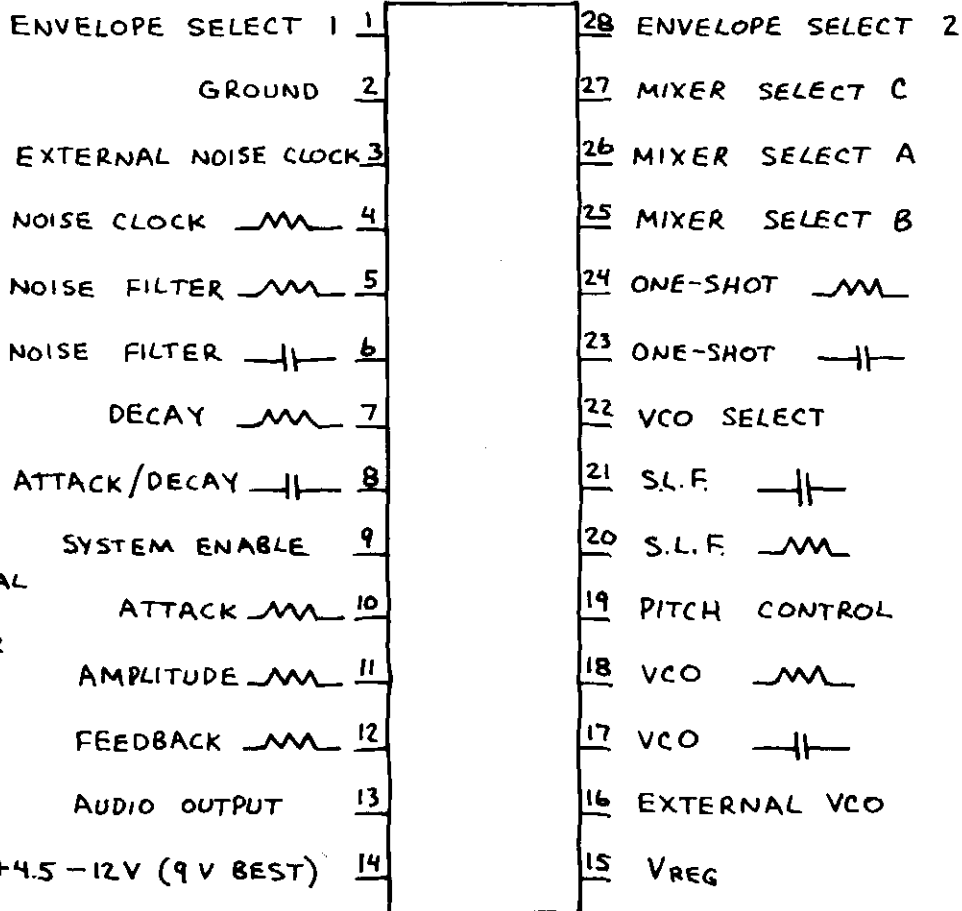
THIS CIRCUIT WORKS WELL. NOTE FEWER PARTS IN LM1877/LM377 STAGE... THANKS TO SPLIT POWER SUPPLY.

COMPLEX SOUND GENERATOR

SN76477N

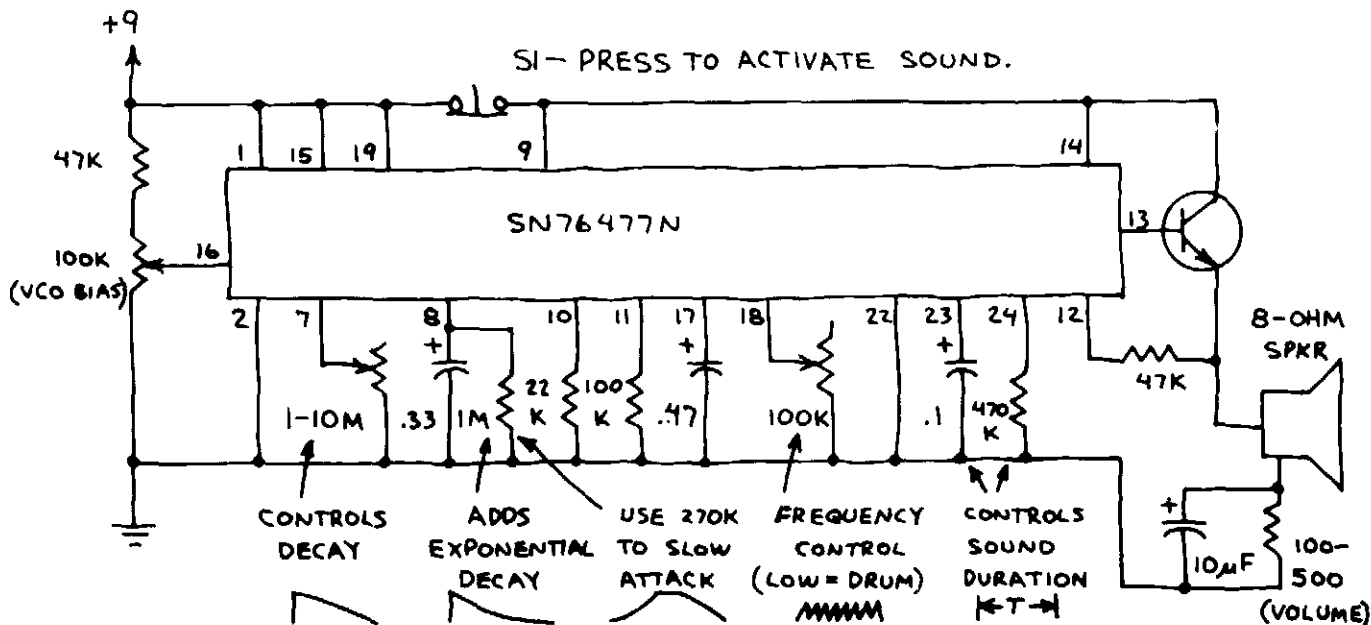
NOTE: THE SN76488 INCLUDES BUILT-IN SPEAKER AMPLIFIER. THE SN76477 DOES NOT.

INCORPORATES S.L.F. (SUPER LOW FREQUENCY OSCILLATOR), VCO (VOLTAGE CONTROLLED OSCILLATOR), NOISE GENERATOR AND A MIXER THAT ALLOWS THE OUTPUTS FROM ONE OR MORE OF THE ABOVE TO BE COMBINED. CAN BE OPERATED TOGETHER WITH APPROPRIATE RESISTORS AND CAPACITORS TO PRODUCE MANY KINDS OF SOUNDS. CAN BE CONTROLLED BY EXTERNAL LOGIC. SEE DATA SUPPLIED WITH CHIP FOR MORE INFO.



THIS CHIP IS EASY TO USE IF YOU FOLLOW DATA SHEET INSTRUCTIONS. +4.5 - 12V (9V BEST)

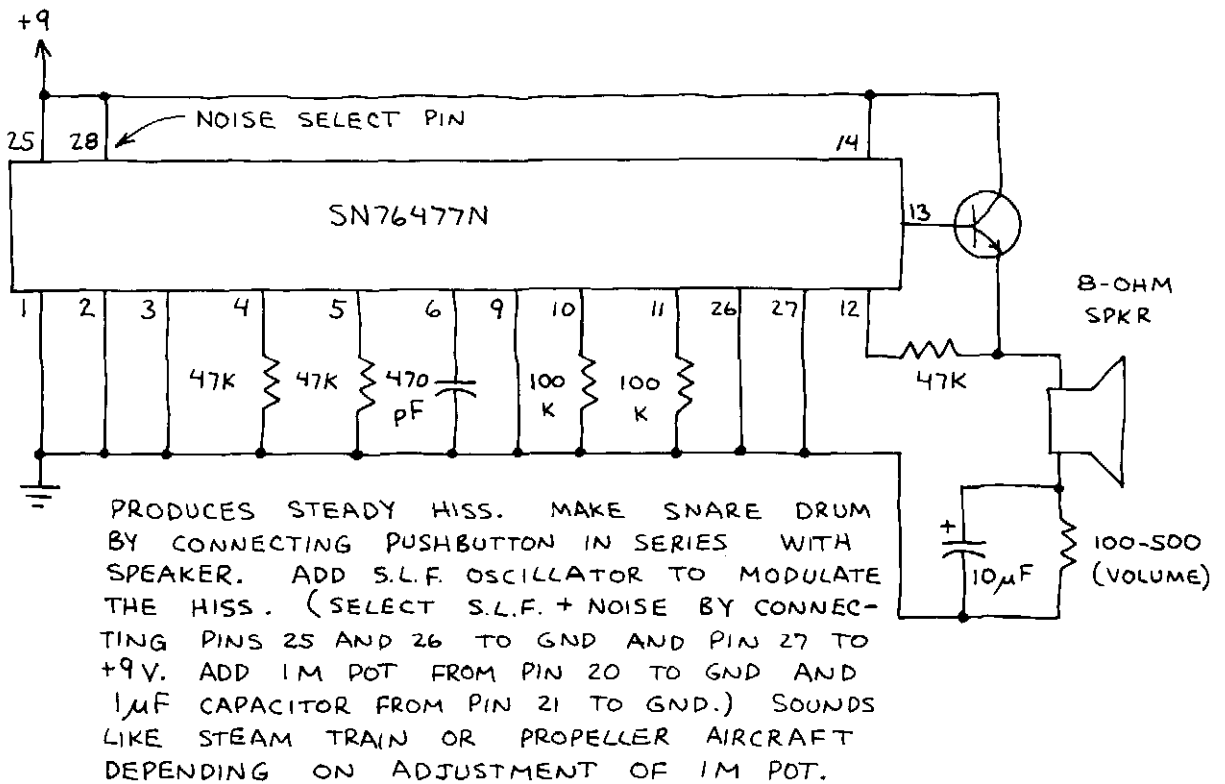
PERCUSSION SYNTHESIZER



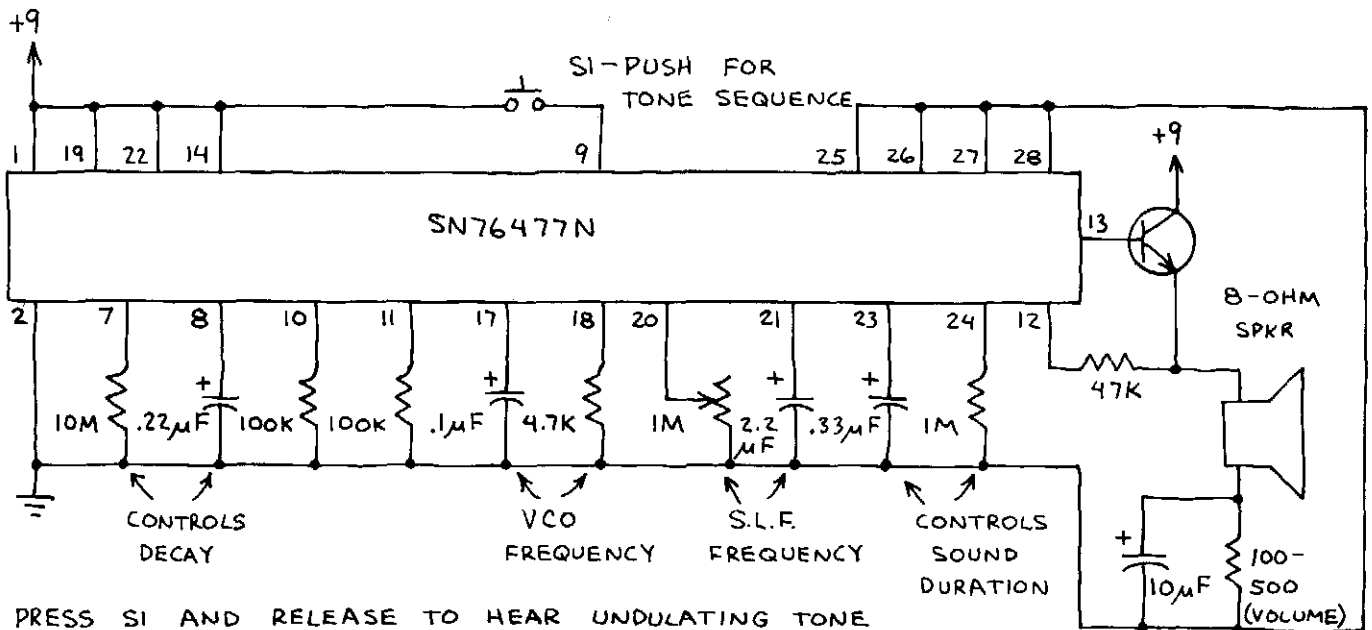
COMPLEX SOUND GENERATOR (CONTINUED)

SN76477N /

NOISE GENERATOR



UNIVERSAL UP-DOWN TONE GENERATOR



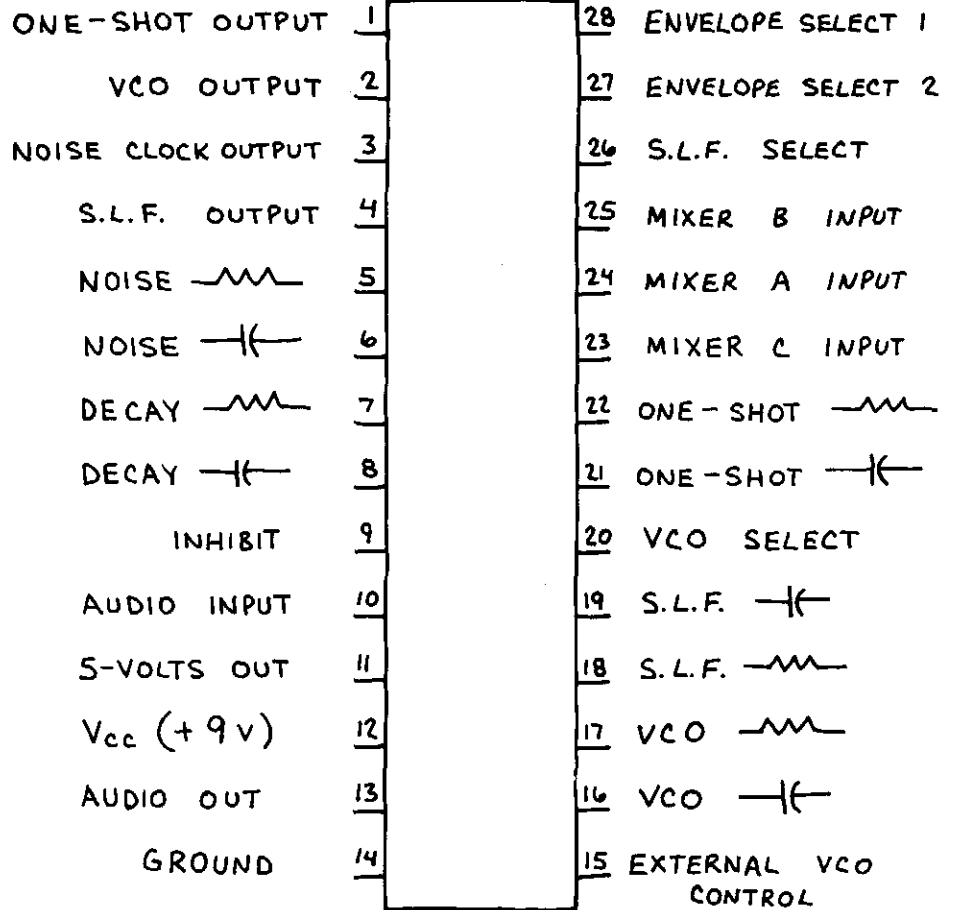
COMPLEX SOUND GENERATOR SN76488N

MODIFIED VERSION OF SN76477N. INCLUDES BUILT-IN AMPLIFIER FOR DIRECT SPEAKER DRIVE. NOTE THAT SN76488N AND SN76477N HAVE DIFFERENT PINOUTS.

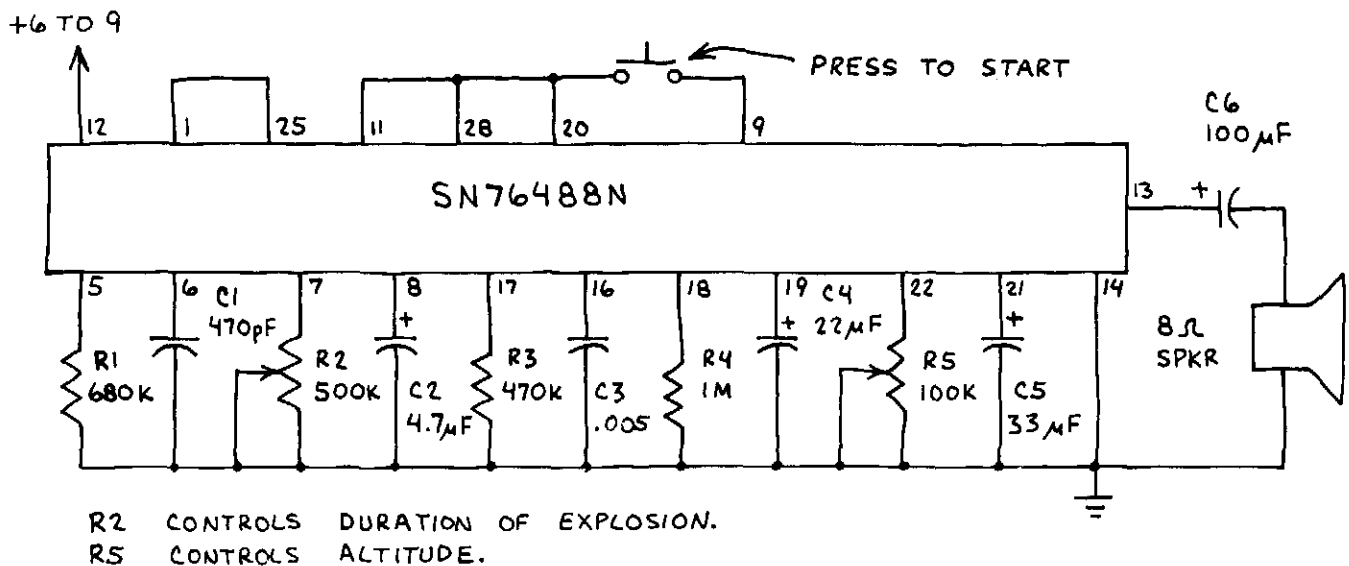
MANY DIFFERENT SOUNDS CAN BE CREATED. FOR BEST RESULTS, STUDY CAREFULLY THE TECHNICAL DATA SUPPLIED WITH CHIP.

VERY EASY TO DEVISE YOUR OWN UNIQUE SOUNDS!

NOTE: SOUND OUTPUT MAY CHANGE AS V_{cc} GOES FROM +6 TO +9V.



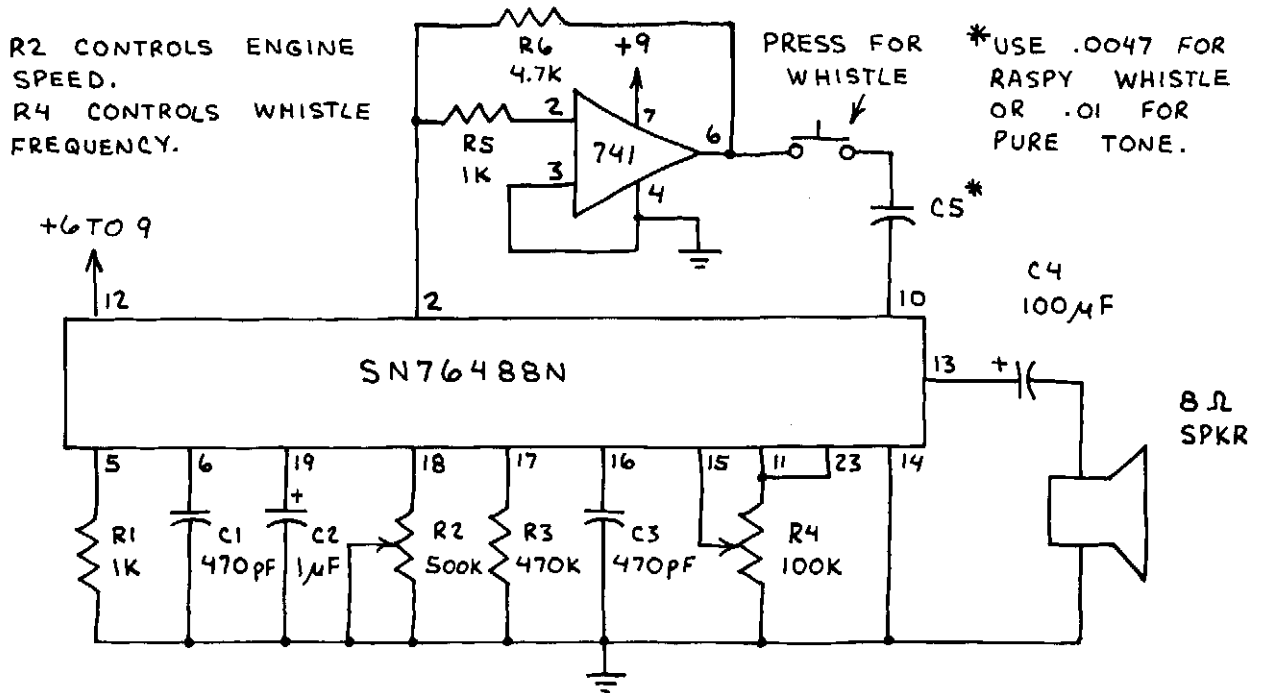
BOMB DROP PLUS EXPLOSION



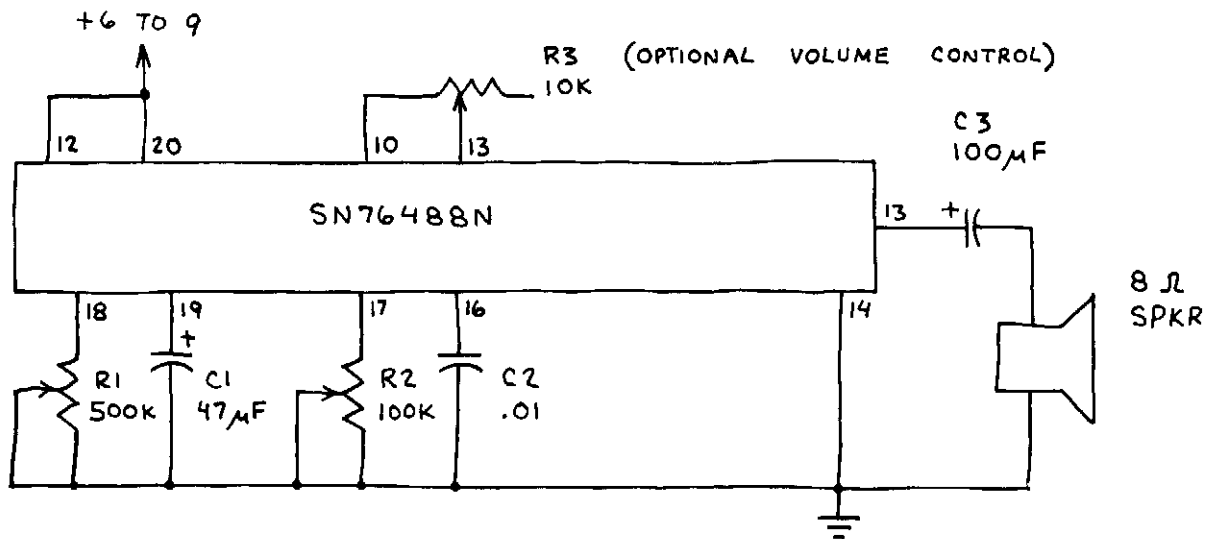
COMPLEX SOUND GENERATOR (CONTINUED)

SN76488N

IMPROVED STEAM ENGINE AND WHISTLE



THE ULTIMATE SIREN

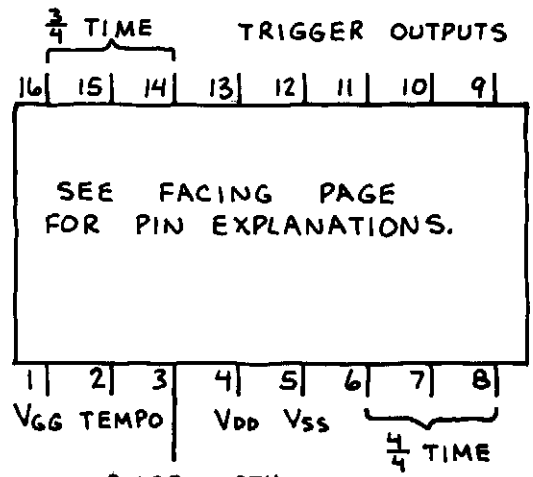


R1 CONTROLS CYCLE RATE.
R2 CONTROLS FREQUENCY.

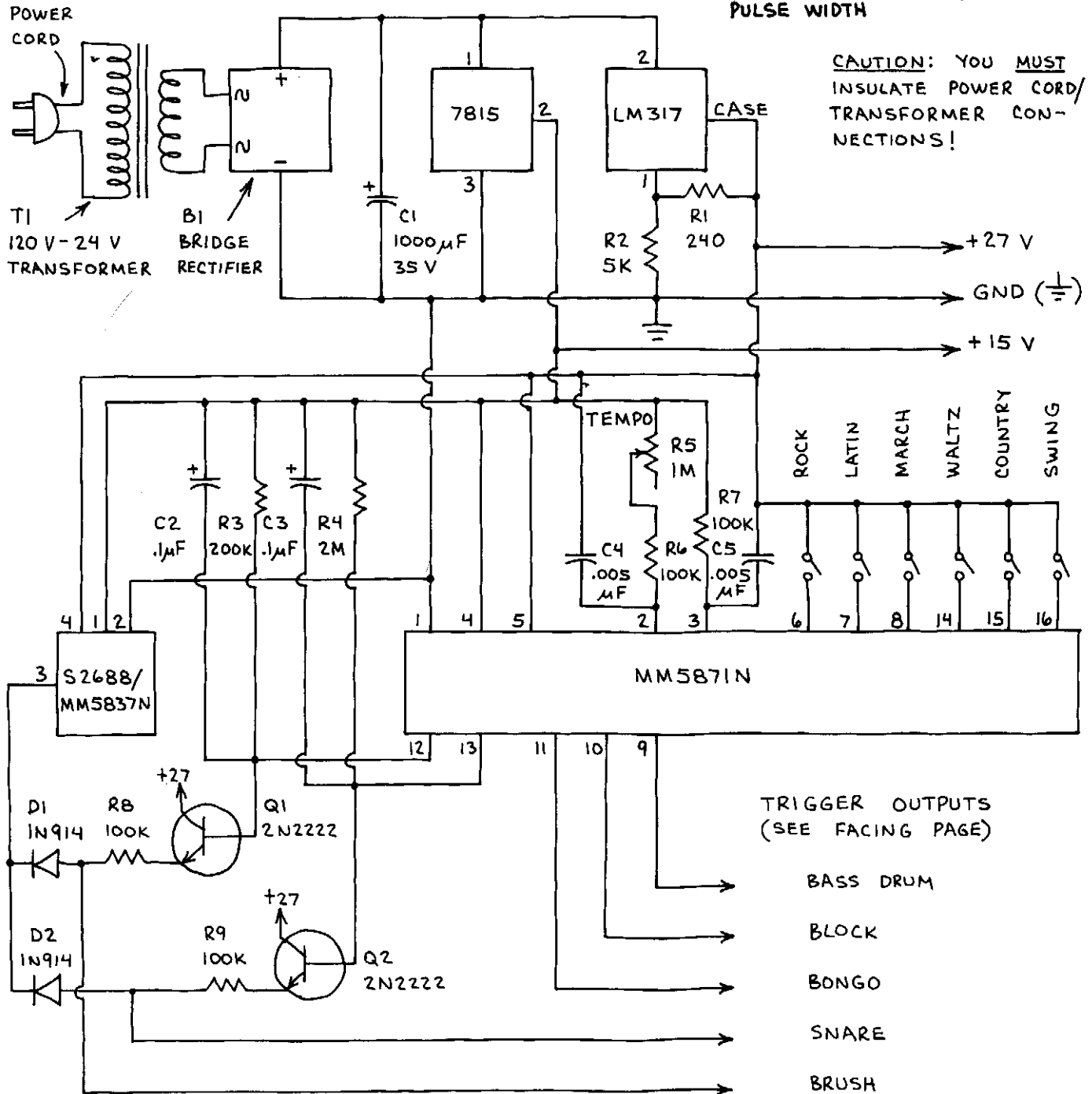
ADJUST R1 FOR HIGH RESISTANCE TO GIVE ULTRA SLOW SIREN.

RHYTHM PATTERN GENERATOR MM5871

PRODUCES SIX DIFFERENT RHYTHM PATTERNS AND TRIGGERS FIVE DIFFERENT INSTRUMENTS. ADJUSTABLE TEMPO. COMPLICATED TO USE, BUT WELL WORTH THE EFFORT.



RHYTHM BOX



RHYTHM PATTERN GENERATOR (CONTINUED)

MM5871

PERCUSSION SYNTHESIZERS:

OK TO TUNE BY MAKING SLIGHT CHANGES TO RC COMPONENTS.

MM5871 PIN EXPLANATIONS:

- 1 - V_{GG} (-27V ± 2V)
- 2 - TEMPO CONTROL (RC NETWORK)
- 3 - TRIGGER OUTPUT PULSE WIDTH CONTROL (RC NETWORK)
- 4 - V_{DD} (-14V ± 2V)
- 5 - V_{SS} (0V)

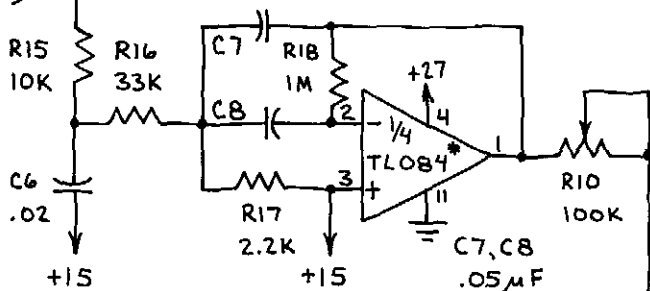
- PATTERN SELECT INPUTS -
- 6 - ROCK 8 - MARCH 15 - C/W
 - 7 - LATIN 14 - WALTZ 16 - SWING

- TRIGGER OUTPUTS -
- 9 - BASS 11 - BONGO 13 - SNARE
 - 10 - BLOCK 12 - BRUSH

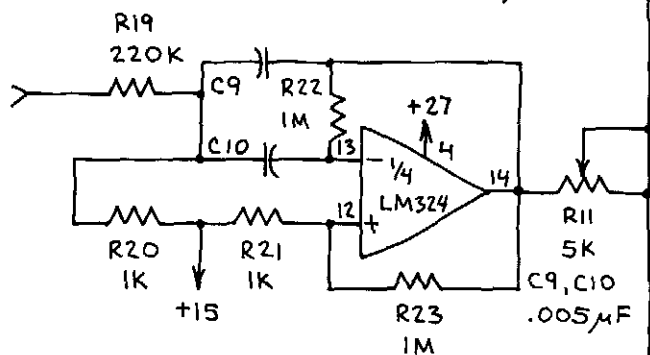
RHYTHM BOX OPERATION:

POTS R10-R14 CONTROL VOLUME OF EACH INSTRUMENT. EXPERIMENT WITH SETTINGS FOR BEST RESULTS. OK TO SELECT TWO OR MORE PATTERNS SIMULTANEOUSLY!

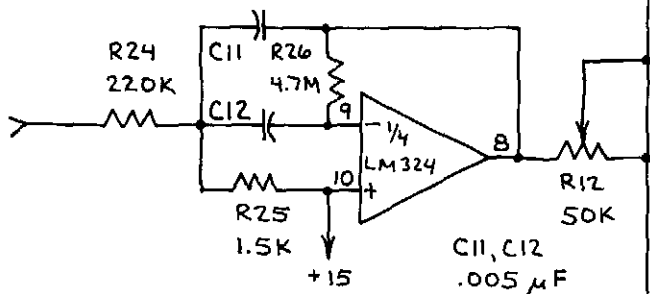
BASS DRUM



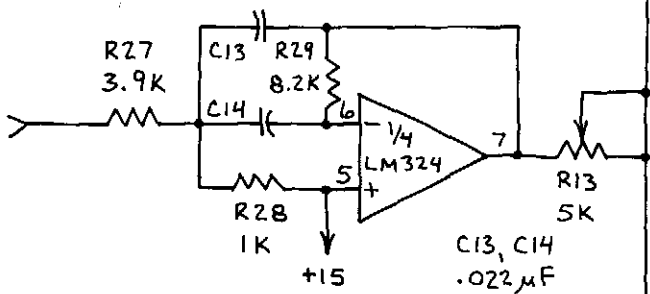
BLOCK



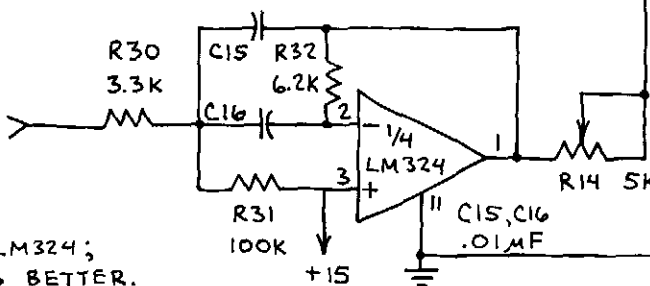
BONGO



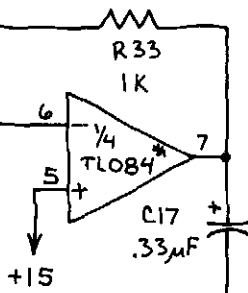
SNARE



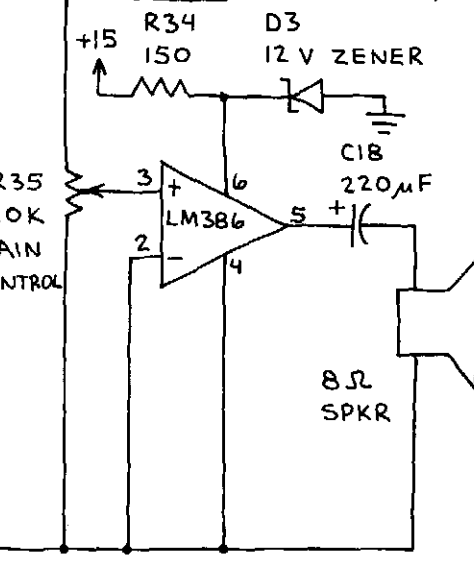
BRUSH



SUMMING AMPLIFIER/PREAMPLIFIER



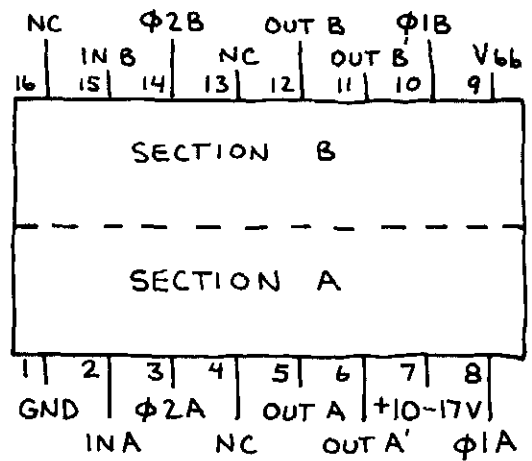
AUDIO POWER AMPLIFIER



* OK TO USE LM324; TLO84 WORKS BETTER.

DUAL ANALOG DELAY LINE SAD-1024A

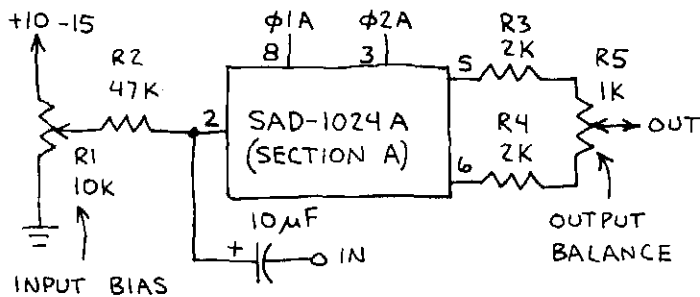
CONTAINS TWO INDEPENDENT 512 STAGE SERIAL ANALOG DELAY (SAD) LINES (ALSO CALLED ANALOG SHIFT REGISTERS). OK TO USE EACH 512 STAGE SAD SEPARATELY OR IN SERIES. ANALOG DELAYS OF UP TO $\frac{1}{2}$ SECOND CAN BE ACHIEVED. A 2-PHASE CLOCK IS REQUIRED TO DRIVE INPUTS $\phi 1$ AND $\phi 2$. INPUT DATA RIDES THROUGH THE SAD ON ALTERNATING CLOCK PULSES AND APPEAR AT THE TWO OUTPUTS AFTER PASSING THROUGH ALL 512 STAGES. CONNECT V_{bb} TO V_{DD} (PIN 7) OR, FOR OPTIMUM RESULTS, TO 1 VOLT BELOW V_{DD} . THIS CHIP CAN BE TRICKY TO USE SINCE SEVERAL EXTERNAL ADJUSTMENTS ARE REQUIRED. CIRCUITS ON THIS PAGE EXPLAIN OPERATING REQUIREMENTS WHILE A COMPLETE CIRCUIT IS SHOWN ON FACING PAGE.



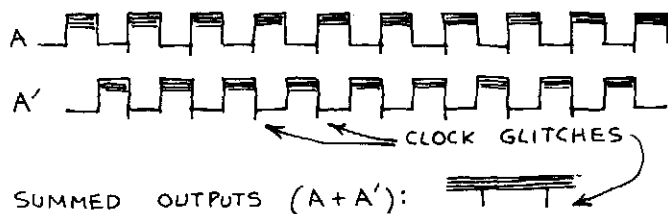
CAUTION: THIS NMOS CHIP IS VULNERABLE TO DAMAGE FROM STATIC DISCHARGE! FOLLOW CMOS HANDLING PROCEDURES.

SERIAL OPERATION

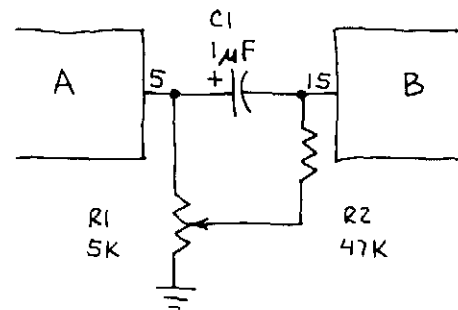
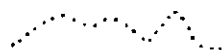
SAD IN/OUT CONTROLS



ADJUST R_1 (INPUT BIAS) FOR OPTIMUM AUDIO OUTPUT. OUTPUTS APPEAR LIKE THIS ON A SCOPE:

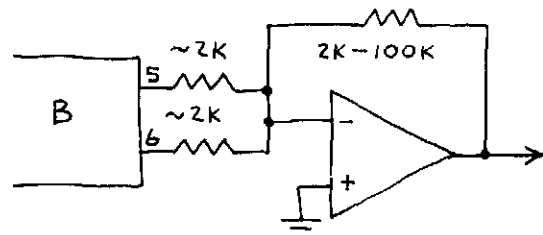


SET SCOPE TO VISUALIZE INPUT SIGNAL (COMPRESSING CLOCK RATE):



R_1 CONTROLS BIAS TO SECTION B. NOTE THAT ONLY ONE OUTPUT OF A IS CONNECTED TO INPUT OF B.

OUTPUT SUMMER

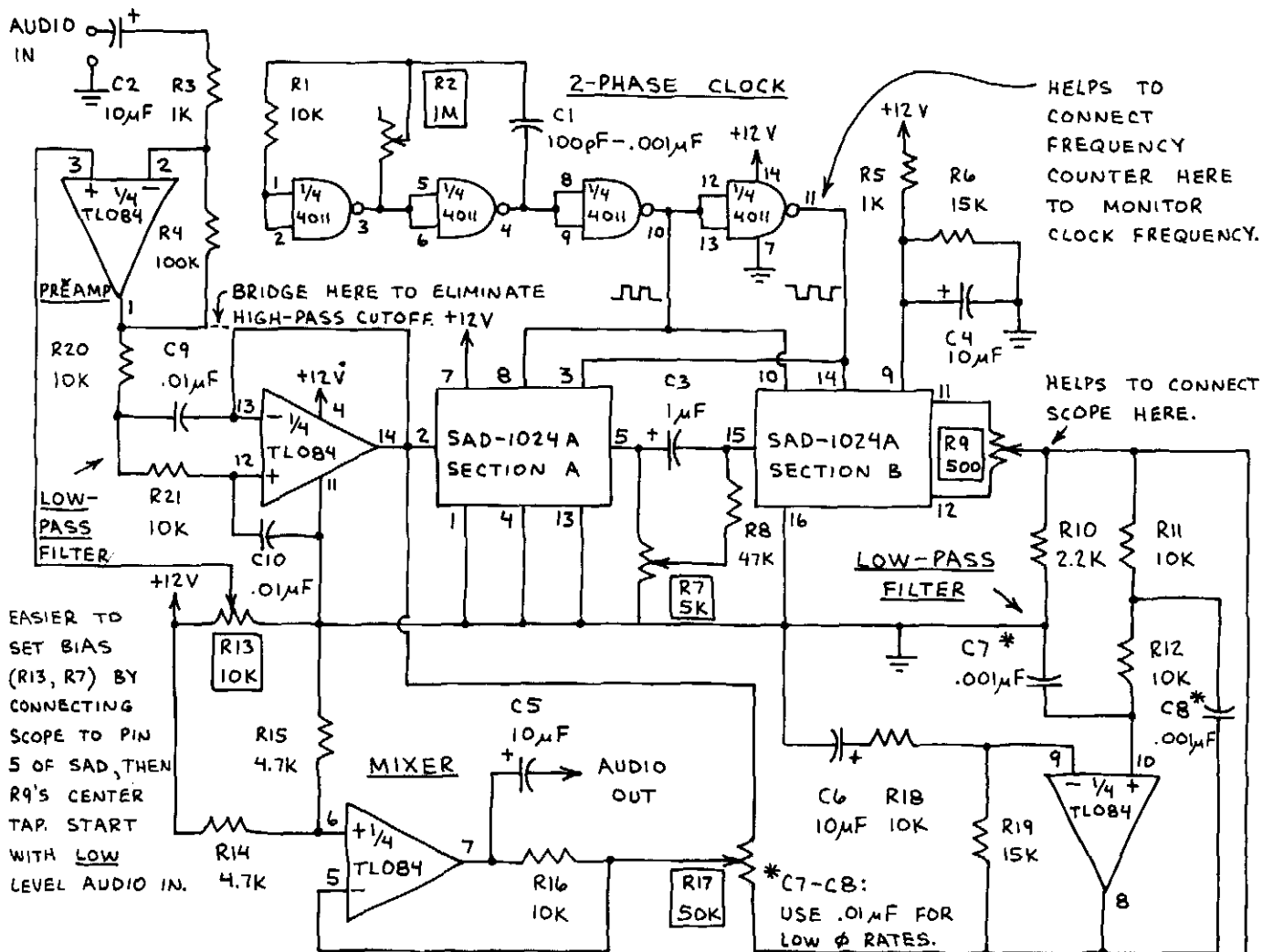


ANY OP-AMP CAN BE USED, BUT LOW NOISE FET INPUT TYPES ARE BEST.

DUAL ANALOG DELAY LINE (CONTINUED)

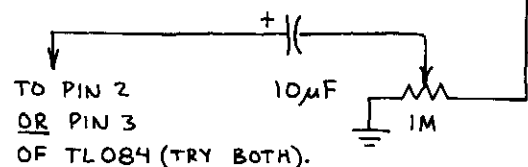
SAD-1024A

ADJUSTABLE FLANGER OR PHASER



ADJUST CIRCUIT FOR DESIRED EFFECT BY CONNECTING TRANSISTOR RADIO TO AUDIO INPUT. TUNE RADIO TO A TALK SHOW FOR BEST RESULTS. R13 AND R7 CONTROL BIAS TO SECTIONS A AND B OF THE SAD. R9 BALANCES THE SAD OUTPUTS. R2 CONTROLS THE CLOCK RATE. R17 IS THE MAIN BALANCE CONTROL. IT CONTROLS THE RELATIVE AMPLITUDES OF THE ORIGINAL AND DELAYED SIGNAL APPLIED TO THE MIXER. CONNECT THE OUTPUT TO A POWER AMPLIFIER. YOU MUST ADJUST BIAS CONTROLS PROPERLY FOR BEST RESULTS. SET R2 FOR LOW FREQUENCIES (3-KHz) FOR SINGLE ECHO. USE HIGHER CLOCK FREQUENCIES (20-100 KHz) FOR HOLLOW, SWISHY SOUNDS. NOTE: THIS CIRCUIT IS NOT FOR BEGINNERS.

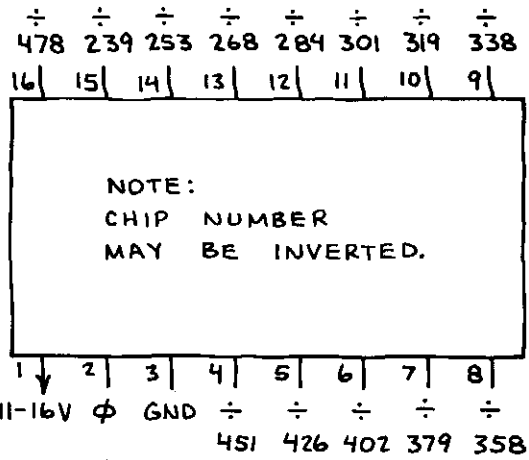
REVERBERATOR



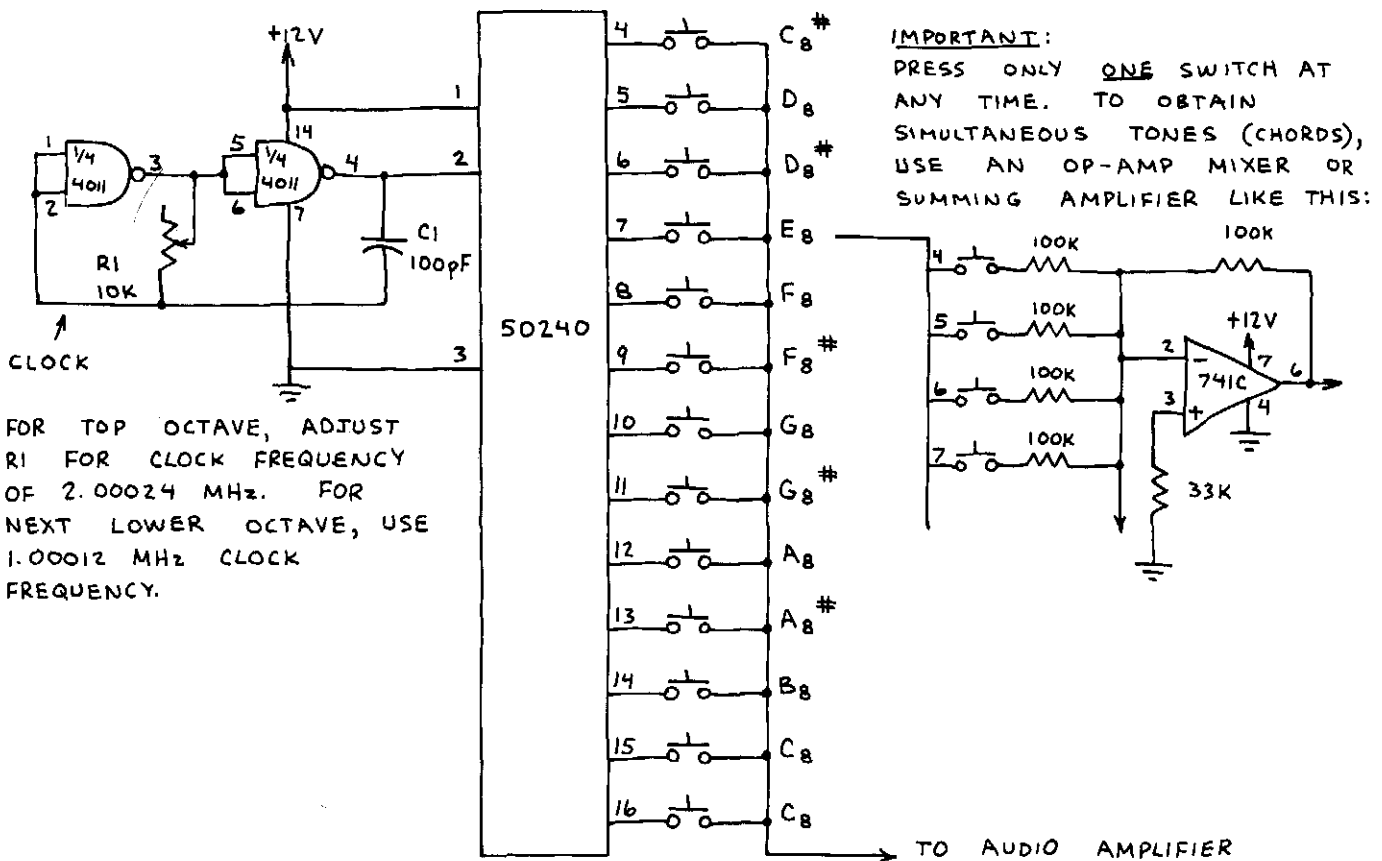
ADD THIS FEEDBACK CIRCUIT FOR UNUSUAL REVERBERATION EFFECTS. SLOW CLOCK FREQUENCIES GIVE MOST STRIKING REVERBERATIONS. TRY 5-20 KHz. FASTER CLOCK (20-100 KHz) AND CAREFUL ADJUSTMENT GIVES ROBOT-LIKE SOUND USED IN SOME SCIENCE FICTION MOVIES.

TOP OCTAVE SYNTHESIZER S50240

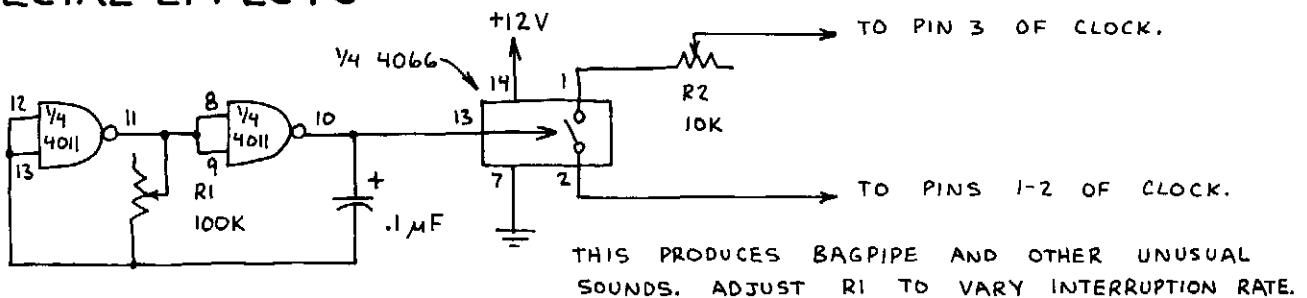
THIS PMOS CHIP ACCEPTS AN INPUT FREQUENCY (ϕ) AND THEN DIVIDES IT INTO A FULL OCTAVE PLUS ONE NOTE ON THE EQUALLY TEMPERED SCALE. THIS CHIP IS IDEAL FOR MUSIC SYNTHESIZERS, ORGANS, ETC. FOR TOP OCTAVE OPERATION, ϕ SHOULD BE 2.00024 MHz; LOWER FREQUENCIES GIVE LOWER OCTAVES.



ADJUSTABLE OCTAVE SYNTHESIZER



SPECIAL EFFECTS

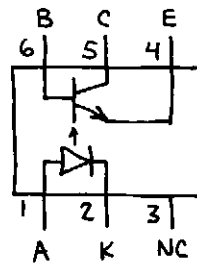


OPTOCOUPLERS

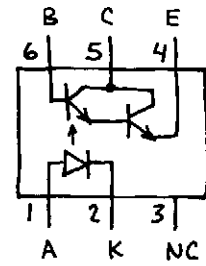
TIL 111 - PHOTOTRANSISTOR

TIL 119 - PHOTODARLINGTON

INFRARED LED TURNS ON PHOTOTRANSISTOR WHEN LED IS FORWARD BIASED. USE TO REDUCE ELECTRICAL NOISE AND SHOCK HAZARD. IDEAL FOR ISOLATING AND INTERFACING MICROCOMPUTER BUS LINES.



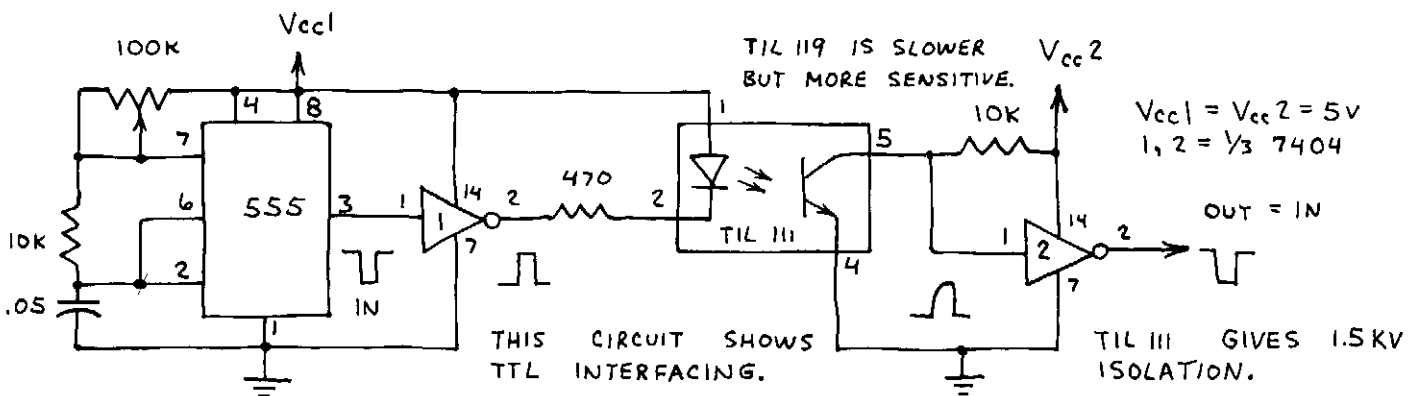
TIL 111



TIL 119

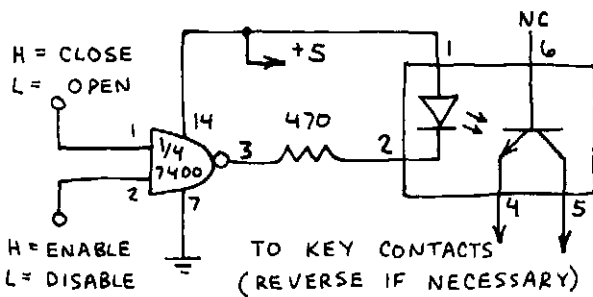
USE TIL 119 WHEN INPUT SIGNAL IS SMALL.

TIL 111 / TIL 119 TEST CIRCUIT



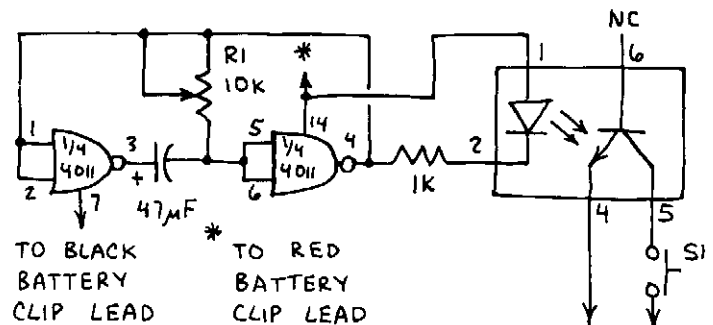
CALCULATOR / COMPUTER INTERFACING

KEYBOARD INPUT



IMPORTANT: THESE CIRCUITS MAY VOID YOUR CALCULATOR'S WARRANTY. I HAVE USED BOTH WITH A LOW COST CALCULATOR WITH LED READOUT. SEE POPULAR ELECTRONICS, DEC 1979 (PP. 85-87) FOR DETAILS. ALWAYS FOLLOW MOS HANDLING PROCEDURES WHEN WORKING WITH CALCULATORS! IF NOT, YOU MAY DAMAGE THE UNIT'S PROCESSING CHIP.

CALCULATOR TIMER



TO OPERATE:

1. SET R1 TO GIVE 10 Hz FREQUENCY.
2. ENTER
3. PRESS S1 FOR TIMING PERIOD.
4. READ TIME TO TENTH SECOND FROM DISPLAY.

TO KEY CONTACTS

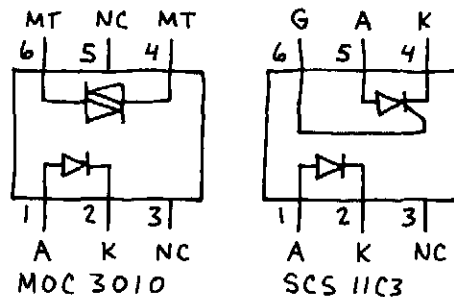
NOTE: THIS SHOWS CMOS INTERFACE.

OPTOCOUPERS

MOC3010 - SCR

SCS11C3 - TRIAC

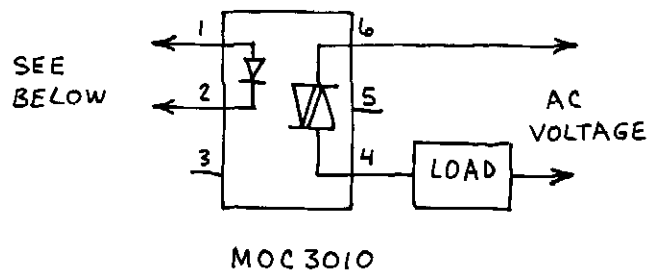
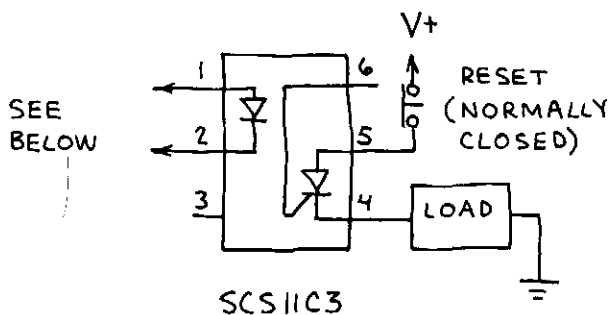
INFRARED LED SWITCHES
 TRIAC (MOC3010) OR SCR
 (SCS11C3). MOC3010 WILL
 SWITCH 120 VOLTS AC AT
 100 mA. SCS11C3 WILL
 SWITCH 200 VOLTS DC AT
 300 mA.



CALCULATOR OUTPUT PORTS

SCR (DC) PORT

TRIAC (AC) PORT

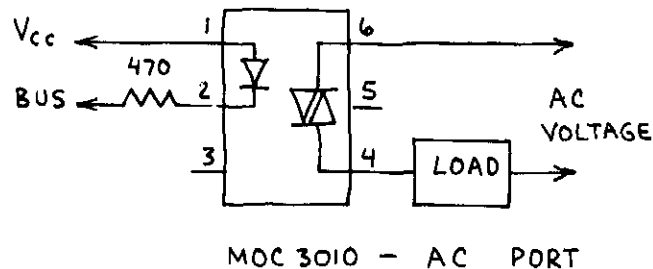
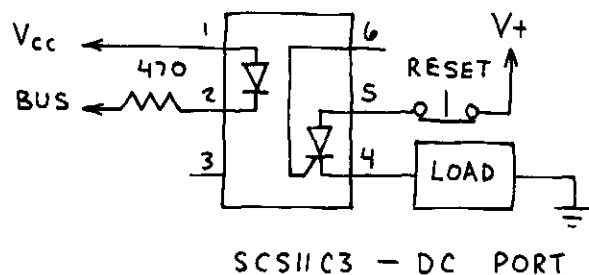


CONNECT PINS 1 AND 2 TO DECIMAL POINT OF LOWEST ORDER READOUT DIGIT. BE SURE TO OBSERVE POLARITY. USE ONLY WITH CALCULATOR HAVING LED READOUT. TYPICAL OPERATION: KEY IN NUMBER WHICH PLACES DECIMAL ANYWHERE BUT FINAL DIGIT. THEN PRESS \square \square \square \square . NUMBER IN DISPLAY WILL BE DECREMENTED EACH TIME \square IS PRESSED. WHEN COUNT REACHES 0, DECIMAL MOVES TO LAST DIGIT AND ACTUATES OUTPUT PORT. FOR MORE INFORMATION SEE POPULAR ELECTRONICS, DEC. 1979 (PP. 86-87).

THE LOAD FOR ALL THESE CIRCUITS MAY BE LAMP, MOTOR OR OTHER DEVICE WHICH DOES NOT EXCEED RATING OF OPTOCOUPLER.

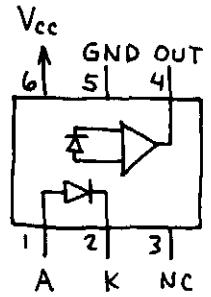
SOME CALCULATORS WILL REQUIRE DIFFERENT KEYSTROKE SEQUENCE. IMPORTANT: THESE CIRCUITS MAY VOID THE WARRANTY OF YOUR CALCULATOR OR COMPUTER. FOLLOW MOS HANDLING PROCEDURES TO AVOID DAMAGING CALCULATOR OR COMPUTER. COMPUTER PORTS DESIGNED TO INTERFACE WITH TTL OR LS BUS LINES.

COMPUTER OUTPUT PORTS

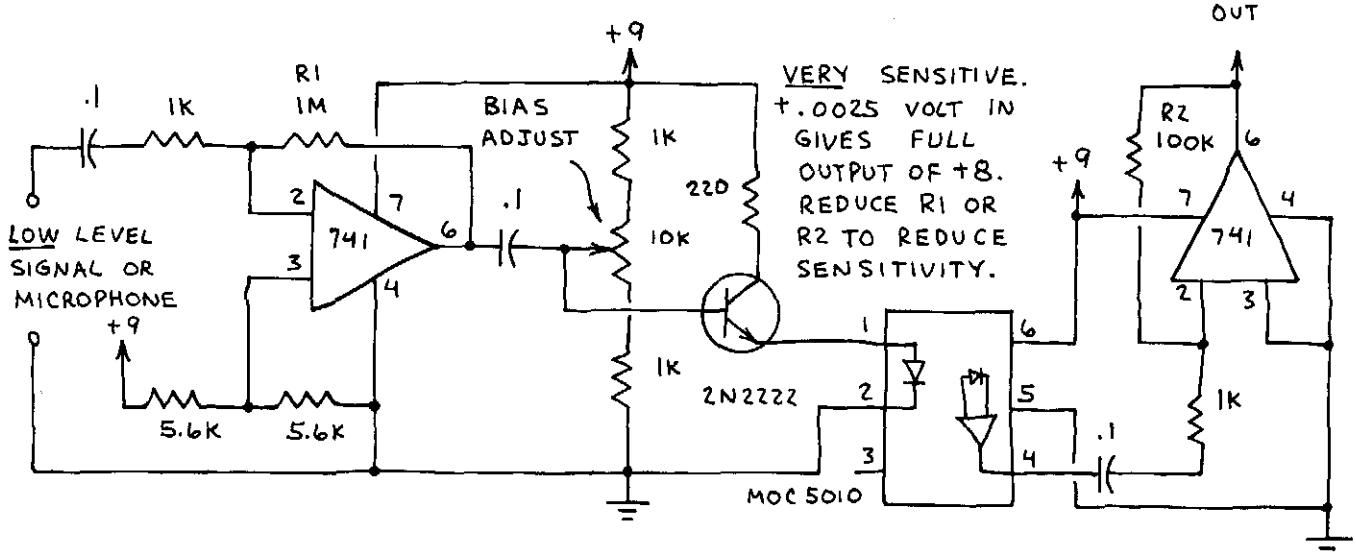


OPTOCOUPLER MOC5010 LINEAR AMPLIFIER

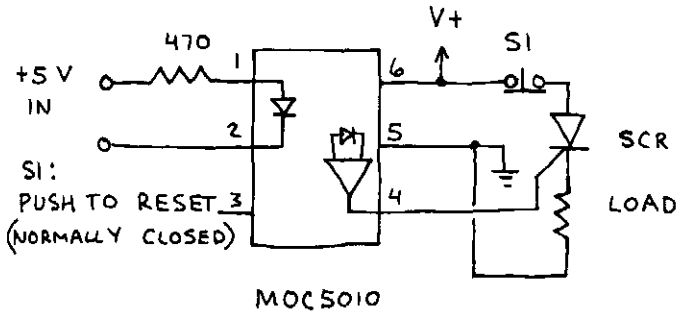
CONVERTS CURRENT FLOW THROUGH LED INTO OUTPUT VOLTAGE. IDEAL FOR TELEPHONE LINE COUPLING AND VARIOUS AUDIO APPLICATIONS.



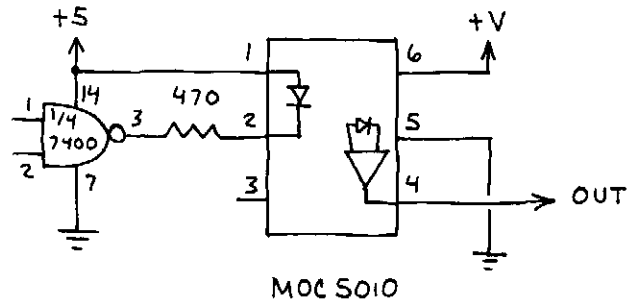
ISOLATED ANALOG DATA LINK



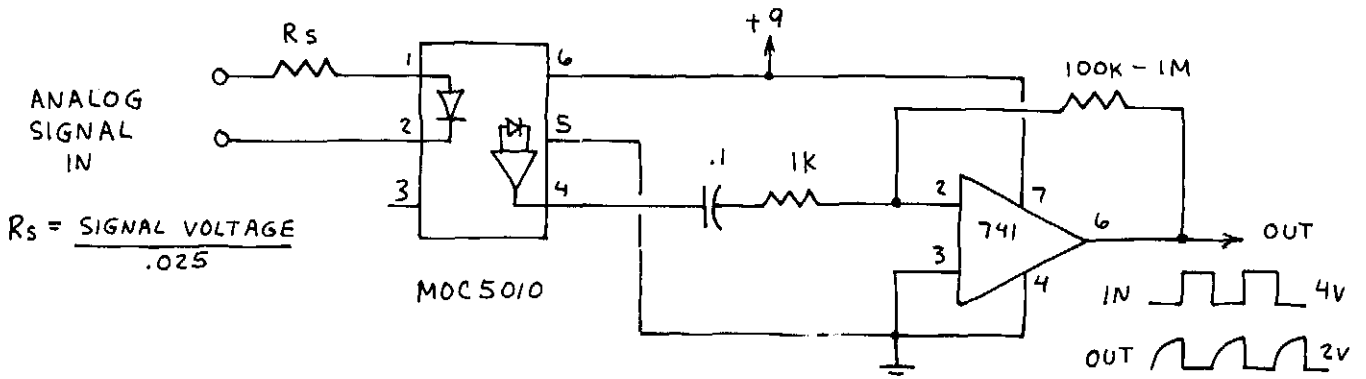
SCR DRIVER



TTL INTERFACING



AC SIGNAL ISOLATOR



NOTES

NOTES

INTEGRATED CIRCUIT INDEX

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NOTE: The Linear index includes some CMOS/MOS chips.

NOTE: TTL and LS chips are generally interchangeable. LS chips consume less power than TTL equivalents. Use LS chips for battery-powered circuits.

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