ENGINEER'S NOTEBOOK II

A HANDBOOK OF INTEGRATED CIRCUIT APPLICATIONS

BY

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CONTRIBUTING EDITOR
POPULAR ELECTRONICS

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READ THIS...

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Due to the large volume of mail received by Radio Shack and the author, it is impossible to answer letters requesting custom circuit designs, technical advice, troubleshooting assistance, etc. But though we cannot acknowledge individual letters, we will nevertheless be delighted to review carefully your comments, impressions and suggestions about this book.

Thanks in advance to those of you who write. We appreciate your comments. But please remember we will be unable to give you a personal reply.
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## CMOS/MOS

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### NOTE:
The CEX-1200 12-Key Tone Module and the PCIM-161 LCD Clock Module are located in the Linear section although both incorporate CMOS/MOS circuitry.

## TTL and LS Chips

TTL and LS chips are generally interchangeable. LS chips consume less power than TTL equivalents. Use LS chips, when possible, for battery powered circuits.

### NOTE:
Many of these chips are best categorized as analog. Linear is the popular term.
INTRODUCTION

Since the original Engineer's Notebook was published in 1979, Radio Shack has made many changes in its line of integrated circuits. Engineer's Notebook II reflects these changes with the addition of 22 new chips and modules and some 84 new circuits. Chips no longer sold by Radio Shack have been deleted.

Dave Wolf, Radio Shack's parts buyer, and Dave Gunzel, Radio Shack's publications director, have invested many hours reviewing draft versions of the new circuits. I'm appreciative of their many helpful suggestions and the freedom they have allowed me in the selection of circuits.

Speaking of circuits, unless otherwise acknowledged, the circuits in this notebook were designed by me specifically for this publication or were adapted from these sources:

1. Applications information published by the manufacturers of the various integrated circuits.

2. My engineering notebooks.

3. "Experimenter's Corner" and "Project of the Month," two columns I write each month for Popular Electronics magazine.

Thanks to Radio Shack's solderless breadboards, you can assemble most of the circuits very quickly. I hope you have as much fun experimenting with them as I have!

Forrest M. Mims, III

HOW TO USE THIS BOOK

To squeeze the maximum number of circuits into this notebook, only essential information is provided. Therefore you will want to use this notebook in conjunction with Radio Shack's "Semiconductor Reference Handbook" and other data books.

For a quickie review of important components and construction tips, read the next few pages. The remainder of the notebook is divided into two major sections: digital and linear. The digital section is further divided into two major IC families: MOS/CMOS and TTL/LS. The chips in each section are organized according to function, not numerical sequence.

Though most circuits in this book can function on their own, consider them as building blocks you can connect to other circuits to accomplish new applications. Experiment! Change resistors and capacitors in RC circuits to alter frequencies and timing. Add new functions. Above all, work with as many different chips as you can. If you've always used TTL, you'll be impressed with the operating flexibility of CMOS. If your forte is digital logic, you'll be amazed at what you can do with an op-amp. Finally, keep a record of your experiments and circuit designs. A notebook with a grid ruling like this one is best, but a 50¢ spiral notebook is OK.

For beginners only....Be sure to read the next few pages! Begin with simple chips (gate packages, timers, op-amps, etc.), and you'll soon be ready for more advanced circuits and projects. Have fun!
REVIEWING THE BASICS

INTRODUCTION

"Can I use a 0.22 uF capacitor instead of a 0.10 uF unit?"

"Is it OK 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:

\[ R = \frac{E}{I} \text{ (or) } I = \frac{E}{R} \text{ (or) } E = IR \]

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

Resistors are identified by a color code:

<table>
<thead>
<tr>
<th>COLOR</th>
<th>1</th>
<th>2</th>
<th>3 (Multiplier)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BLACK</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>BROWN</td>
<td>1</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>RED</td>
<td>2</td>
<td>2</td>
<td>100</td>
</tr>
<tr>
<td>ORANGE</td>
<td>3</td>
<td>3</td>
<td>1000</td>
</tr>
<tr>
<td>YELLOW</td>
<td>4</td>
<td>4</td>
<td>10,000</td>
</tr>
<tr>
<td>GREEN</td>
<td>5</td>
<td>5</td>
<td>100,000</td>
</tr>
<tr>
<td>BLUE</td>
<td>6</td>
<td>6</td>
<td>1,000,000</td>
</tr>
<tr>
<td>VIOLET</td>
<td>7</td>
<td>7</td>
<td>10,000,000</td>
</tr>
<tr>
<td>GRAY</td>
<td>8</td>
<td>8</td>
<td>100,000,000</td>
</tr>
<tr>
<td>WHITE</td>
<td>9</td>
<td>9</td>
<td>(none)</td>
</tr>
</tbody>
</table>

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

Since no resistor has a perfect tolerance, it's often OK to substitute resistors. For example, it's almost always OK to use a 1.8K resistor in place of a 2.0K 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 OK 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:

\[ +10V \]
\[ \begin{array}{c}
R1 \\
1K
\end{array} \]
\[ \begin{array}{c}
R2 \\
1K
\end{array} \]

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

Note that the total resistance of R1 and R2 is simply R1 + R2. This rule provides a handy trick for making custom resistances.
Voltage dividers are used to bias transistors:

![Voltage Divider Diagram](image)

They're also a convenient source of variable voltage:

![Potentiometer Diagram](image)

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

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.

![Electrolytic Capacitor Diagram](image)

These leads must go to the most positive connection point.

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.)

![Capacitor Application Diagram](image)
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 uF.

**SEMI-CONDUCTORS**

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

**DIODES**

Log 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:

\[
R_s = \frac{V_{CC} - V_{LED}}{I_{LED}}
\]

Example: \(V_{LED}\) of red LED is 1.7 volts. For a forward current \((I_{LED})\) of 20 mA at \(V_{CC} = 5\) volts, \(R_s = 330\) ohms. Don't exceed \(I_{LED}\)!!
Infrared LEDs are much more powerful than visible LEDs, but their radiation is totally invisible. Use them for object detectors and communications.

**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:

![Diagram of IC pin 1]

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

**MANUFACTURER** (Motorola) **PART NUMBER**

![Diagram of IC with manufacturer and part number]

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

![Date code example]

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. See p. 12.

**CIRCUIT BUILDING**

Build your circuits on a solderless breadboard to make changes and find bugs. Then make permanent versions. Radio Shack plastic modular sockets (276-173, etc.) are ideal. They include two socket rows for power supply connections and snap rails for attaching sockets together. Parts and wires can be inserted directly into the holes in the socket.

For permanent circuits, use Radio Shack PC boards. Catalog numbers 276-024 and 276-151 are ideal for simple IC projects. Use larger universal PC boards for more complex projects (276-152 & 276-157). You can cut them into smaller sections with a nibbler tool or small saw.

I prefer to use wrapping wire for IC projects. Insert wrapping sockets in board and make connections with a Wire-Wrapping tool (such as 276-1570). Apply wrapping wire directly to leads of transistors, resistors, etc. and solder in place.
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:

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<tbody>
<tr>
<td>0</td>
<td>L L L L</td>
<td>8</td>
<td>H L L L</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>L L L H</td>
<td>9</td>
<td>H L L H</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>L L H L</td>
<td>10</td>
<td>H L H L</td>
<td></td>
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<tr>
<td>3</td>
<td>L L H H</td>
<td>11</td>
<td>H H L L</td>
<td></td>
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<tr>
<td>4</td>
<td>L H L L</td>
<td>12</td>
<td>H H L H</td>
<td></td>
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<td>5</td>
<td>L H L H</td>
<td>13</td>
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<tr>
<td>6</td>
<td>L H H L</td>
<td>14</td>
<td>H H H H</td>
<td></td>
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<tr>
<td>7</td>
<td>L H H H</td>
<td>15</td>
<td>H H H H</td>
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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

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<td>OUT</td>
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<td>L L H L</td>
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<td>L H H L</td>
<td>L H H L</td>
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<td></td>
<td></td>
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YES (BUFFER)

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NOT (INVERTER)

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3-STATE LOGIC

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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:

```
+ (VDD)
```

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 VDD! (Two exceptions: the 4049 and 4050.)

2. Avoid, if possible, slowly rising and falling input signals since they can cause excessive power consumption. Rise times faster than 15 microseconds are best.

3. All unused inputs must be connected to VDD (+) or VSS (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 SiO2 (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:

ZAP!

PREVENT STATIC DISCHARGE!

1. Never store MOS IC's in non-conductive 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:

Rpu: +5 (Vdd)
Rpu: 470-4.7K
PULLUP RESISTOR.

FOR TTL, 1K - 10K
FOR LS.

TTL OR LS

CMOS

2. DIFFERENT SUPPLY VOLTAGES:

+5

10K

1K

R5000

TTL OR LS

CMOS

3. CMOS LED DRIVERS:

Vdd (+3-5V)

GLOWS
WHEN
LOW.

Vdd = +3-15V

GLOWS
WHEN
HIGH.

R = Vdd - 1.7

.01

FOR 10 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 = 100 kΩ, C = 0.01 – 0.1 µF
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.

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AND-OR GATE

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EXCLUSIVE-OR GATE

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QUAD NAND GATE (CONTINUED)

4011

GATED OSCILLATOR

GATED FLASHER

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

GATE OSCILLATOR

OUTPUT FREQUENCY IS
1 KHz SQUARE WAVE.

SIMPLE OSCILLATOR

OUTPUT NOT AS SYMMETRICAL
AS ABOVE CIRCUIT.

GATED FLASHER

TOUCH SWITCH

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

ONE-SHOT TOUCH SWITCH

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

INCREASED OUTPUT DRIVE

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.

BOUNCLESS SWITCH

\[ V_{DD} \]

14
3
1
2

100K

5
4
6

100K

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.

RS LATCH

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<th>R</th>
<th>S</th>
<th>Q</th>
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QUAD AND GATE 4081

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

AND GATE BUFFER

\[ \text{IN} \rightarrow \text{4081} \rightarrow \text{OUT} \quad \text{IN} = \text{OUT} \]

NAND GATE

\[
\begin{array}{ccc}
\text{A} & \text{B} & \text{OUT} \\
\text{L} & \text{L} & \text{H} \\
\text{L} & \text{H} & \text{H} \\
\text{H} & \text{L} & \text{H} \\
\text{H} & \text{H} & \text{L} \\
\end{array}
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NOR GATE

\[
\begin{array}{ccc}
\text{A} & \text{B} & \text{OUT} \\
\text{L} & \text{L} & \text{L} \\
\text{L} & \text{H} & \text{L} \\
\text{H} & \text{L} & \text{L} \\
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\end{array}
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4-INPUT NAND GATE

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\begin{array}{cccc}
\text{A} & \text{B} & \text{OUT} \\
\text{L} & \text{L} & \text{L} \\
\text{L} & \text{H} & \text{H} \\
\text{H} & \text{L} & \text{H} \\
\text{H} & \text{H} & \text{H} \\
\end{array}
\]

4-INPUT AND GATE

\[
\begin{array}{cccc}
\text{A} & \text{B} & \text{C} & \text{D} & \text{OUT} \\
\text{H} & \text{H} & \text{H} & \text{H} & \text{H} \\
\text{H} & \text{H} & \text{H} & \text{L} & \text{H} \\
\text{L} & \text{L} & \text{L} & \text{L} & \text{L} \\
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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.

1-BIT COMPARATOR

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

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4-BIT COMPARATOR

DETERMINES IF TWO 4-BIT WORDS ARE EQUAL.

HINT: USE 4011 (P. 14)

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.

PHASE DETECTOR

LED STOPS GLOWING WHEN THE INPUT FREQUENCIES ARE EQUAL.
QUAD EXCLUSIVE-OR GATE (CONTINUED)

4070

EXCLUSIVE-NOR

3-INPUT EX-OR

IC1 = 4070

10 MHz OSCILLATOR

VDD = 3 to 15 volts

FREQUENCY VARIES WITH VDD:

<table>
<thead>
<tr>
<th>VDD</th>
<th>FREQUENCY</th>
<th>AMPLITUDE</th>
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<tbody>
<tr>
<td>5</td>
<td>2.4 MHz</td>
<td>3.5 V</td>
</tr>
<tr>
<td>10</td>
<td>9.4 MHz</td>
<td>8.0 V</td>
</tr>
<tr>
<td>15</td>
<td>11.0 MHz</td>
<td>12.0 V</td>
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</tbody>
</table>

8-INPUT EX-OR

IC1, 2 = 4070

SQUARE WAVE GENERATOR

VDD = 3 to 15 volts

RISETIME = 50 nanoseconds

FREQUENCY = 2 MHz when

VDD = 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.)

CLOCK PULSE GENERATOR

\[ V_{DD} \]

\[ 1, 2 = \frac{1}{3} \, 4049 \]  
Pulse rate = \( \frac{1}{1.4RC} \)

BOUNCELESS SWITCH

\[ V_{DD} \]

\[ 1, 2 = \frac{1}{3} \, 4049 \]

PHASE SHIFT OSCILLATOR

\[ V_{DD} \]

\[ \text{Output frequency} = \frac{1}{3.3RC} \]

\[ 1, 2, 3 = \frac{1}{3} \, 4049 \]

TRIANGLE WAVE SOURCE

\[ V_{DD} \]

\[ 1, 2, 3 = \frac{1}{2} \, 4049 \]

\[ \text{Frequency} = 1.4 \times \frac{1}{RC} \]

SQUARE WAVE GENERATOR

\[ V_{DD} \]

\[ 1, 2 = \frac{1}{5} \, 4049 \]

LINEAR 10X AMPLIFIER

\[ V_{DD} \]

\[ 1, 2, 3 = \frac{1}{2} \, 4049 \]

Note that the inverters are used in a linear mode. Gain = \( \frac{R_2}{R_1} \).
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.

Output Expander

Logic Probe

Note unusual location of power supply pins.

Output Buffer

Increased output drive

CMOS to CMOS at lower VDD

CMOS to TTL/LS at lower VCC

VDD 1 exceeds VDD 2.
1 = VDD 1

1 = \frac{1}{6} \text{4050}
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} = 9 V). Use to drive 4046 VCO or produce unusual waveforms. R = 47K and 2R = 100K.

Use 4518 counter for automatic operation.
**QUAD BILATERAL SWITCH (CONTINUED)**

**PROGRAMMABLE GAIN AMPLIFIER**

![Amplifier Circuit Diagram](attachment:amplifier_circuit.png)

**R**

- D: DCBA
- C: 0000
- B: 1111
- A: 1111

**V<sub>IN</sub>**

**V<sub>OUT</sub>**

**V<sub>OUT</sub> = R<sub>F</sub> / R<sub>IN</sub>**

---

**PROGRAMMABLE FUNCTION GENERATOR**

![Function Generator Circuit Diagram](attachment:function_generator_circuit.png)

- **IC1, 2, 3 = 4066**
- **V<sub>DD</sub> = 5 - 15V**
- **R<sub>I</sub> - R<sub>10</sub> = 10k TRIMMER POTS**

**Produces Repetitive 10-Step Waveform.**

**Program Height of Each Step via R<sub>I</sub> - R<sub>10</sub>.**

**Vary Rate via R<sub>II</sub> and C<sub>1</sub>**
1024-BIT STATIC RAM

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

<table>
<thead>
<tr>
<th>CE</th>
<th>R/W</th>
<th>OPERATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>L</td>
<td>WRITE (LOADS BIT AT PIN 11)</td>
</tr>
<tr>
<td>L</td>
<td>H</td>
<td>READ (OUTPUTS BIT AT PIN 12)</td>
</tr>
<tr>
<td>H</td>
<td>X</td>
<td>HI Z (OUTPUT ENTERS THIRD STATE)</td>
</tr>
</tbody>
</table>

2102L ADDRESSING CIRCUIT

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

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

+5
CLOCK

2102L

THE ADDRESS INPUTS MUST BE STABLE DURING R/W OPERATIONS.
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

SA

SJ

74LS193

10

74193/

11

74LS193

9

S J

SI

SH

SG

SF

SE

SD

SC

SB

SA

LOAD

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

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.
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.

2114L ADDRESSING CIRCUIT

+5 A7 A6 A5 A4 A3 A2 A1 A0 C D WE
18 17 16 15 14 13 12 11 10

INPUT/OUTPUT
PINS

AO-A9: ADDRESS INPUTS
WE: WRITE ENABLE

A6 A5 A4 A3 A0 A1 A2 CE GND
(CS)

CLEAR
WHEN H)

ADDRESS
LINES TO
OTHER
2114L'S.

THE ADDRESS INPUTS
MUST REMAIN STABLE
DURING R/W OPERATIONS.
1024 x 4-BIT RAM (CONTINUED)
2114L/4045

1024-NIBBLE DATA LOADING CIRCUIT
(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. SWİTCH S5 TO H.
   3. CLOSE, THEN OPEN, S1.
   4. SELECT CLOCKED OR MANUAL OUTPUT (S2).

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

S4 - CHIP ENABLE

S3 - WRITE

CE (CS)

+5

$5$ - WRITE ENABLE

DATA INPUT SWITCHES (SPDT WITH NEUTRAL CENTER)
DUAL D FLIP-FLOP 4013

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

I-OF-4 SEQUENCER

OUTPUTS GO HIGH IN SEQUENCE. 1, 2, 3, 4: 4001
ALL OTHERS STAY LOW.

DIVIDE-BY-2

MODULO-8 COUNTER

COUNTS LLLLLLLL AND RECycles 5

SERIAL IN/OUT, PARALLEL OUT SHIFT REGISTER

VDD

SERIAL DATA IN
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-3 COUNTER

DIVIDE-BY-4 COUNTER

DIVIDE-BY-5 COUNTER

4-BIT SERIAL SHIFT REGISTER

VDD (+3-15V)
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

DATA BUS

VDD

CLOCK POLARITY

1

0

0

0

D LATCH

D LATCH

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

STEPPEWAVE GENERATOR

TYPICAL VALUES: R1 = R3 = 22K
R2 = 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 ± IN ARE TRIGGER INPUTS.

POSITIVE ONE-SHOT

PULSE DELAYER

RI CONTROLS DELAY TIME. R2 CONTROLS DELAYED PULSE WIDTH.

STEPPED TONE GENERATOR

TO CONTROL WITH LIGHT, USE CdS PHOTOCELL FOR R1. ADJUST R1 TO CREATE UNIQUE STEPPED TONE. R2 CONTROLS FREQUENCY. OK TO EXPERIMENT WITH C1 AND C2. R3 CONTROLS GAIN.
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

COUNT TO N AND HALT

COUNT TO N AND RECYCLE

FOR N = 9,
GROUND
PIN 15.
4017

OK TO ADD
MORE 4017's

VDD

16 15 14 13 12 11 10 9
RESET CLOCK ENABLE
CARRY

INPUTS

DECODED OUTPUTS

1 2 3 4 5 6 7 8

0-99 COUNTER

CLOCK

VDD

16 15 14 13

1 2 3 4 5 6 7 8

A B

S1

CARRY OUT

CLOCK IN

4017 4 2 0

10 4 1 5 6 7 8

11 9

3 0 0 1 0 1 0

13 15 16

13

10 4 0 1 5 6

16

5 6 7 8 9 0

VDD

16 8 13 14 15

CLOCK
DECADEx COUNTER/DIVIDER  (CONTINUED)

4017

BCD KEYBOARD ENCODER

+5

8

3 2 4 7 10 1 5 6 9 11

5V

100k

1

+5

0.1uF

IC1 = 4049  IC2 = 4011

TOGGLE S10, THEN PRESS S0-S9.

FREQUENCY DIVIDER

VDD

IN

14

3 2 4 10 1 5 6 9 11

IC1 = 4001

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

LATCH (LE)...
RESET (MR)...
EVENTS (CLOCK)...
DISABLE (DIS)...
C1...

OK TO USE LIQUID CRYSTAL DISPLAY OR COMMON CATHODE LED DISPLAY. SEE 14543 FOR DETAILS.

6-DIGIT FREQUENCY COUNTER

LATCH: STORES TOTAL COUNT IN ONE COUNT CYCLE.
RESET: CLEARS COUNT TO 000000 PRIOR TO NEW COUNT CYCLE.
COUNT: COUNT INPUT

FREQUENCY INPUT
6-DIGIT COUNTER

THIS CIRCUIT SHOWS HOW TO CASCADE TWO 3-DIGIT COUNTERS. MAXIMUM COUNT Q3 IS 9999.999. DISPLAYS ARE COMMON CATHODE (COMMON ANODE CONFIGURATION SHOWN ON PREVIOUS PAGE) NOTE THAT PIN 6 OF 1453 (OR 4543) GOES TO GND INSTEAD OF VDD WHEN COMMON CATHODE DISPLAY IS USED.

FREQUENCY COUNTER:

USE INPUT AND CONTROL CIRCUIT ON PREVIOUS PAGE. INPUT FREQUENCY SHOULD NOT EXCEED VDD. NON-SQUARE WAVE INPUTS MAY REQUIRE INPUT TAILORING. USE COMPARATOR TO SHARPEN SLOW RISING WAVES.
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. H flashes L off.

DECIMAL COUNTING UNIT (DCU)

Count in 1
Enable 2
Reset 7
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.

V_{DD} (+3-15V)
f g a b c d e

LATCH ENABLE BLANKING INPUT LAMP TEST

V_{DD}

8
9
10
11
12
13
14

8
9
10
11
12
13
14

100K

4.7uF

V_{DD}

1/2 4518
D 6
C 5
B 4
A 3

1/2 4011

1/2 4011

R1 Ri

R2 R2

R3 R3

R4 R4

R5 R5

R6 R6

R7 R7

R1-R7=220\Omega

V_{DD} = +5-9V

IMPORTANT: All inputs must go somewhere!

COMMON CATHODE LED DISPLAY
60-Hz TIMEBASE

MM5369 (276-1769)

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.

**Motorola specifies that C1 = 30pF 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 3.579545 Hz. Accuracy fairly good even if you don't tune C2.**

10-Hz TIMEBASE

1-Hz TIMEBASE

DIGITAL STOPWATCH

**Operation:**
1. Toggle SI from clear to ready.
2. Switch S2 from stop to start.
3. Switch S2 from start to stop.

1 Hz = 00-99 sec
10 Hz = 0.0-9.9 sec
Ok to add more stages.
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 TOSSER

PRESS SI; BOTH LEDS GLOW. RELEASE SI 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 SI TO OPERATE, INCREASE C2 AND C3 TO LOWER OUTPUT FREQUENCY.
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:

```
IN4001
+--
|   |
|   |
|   +--
+      |
   6-VOLTS
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   |
   1-10uF
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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 (CONTROL)

INVERTER

A

AND GATE

A

B

OR GATE

A

B

AND-OR GATE

A

B

C

D

NOR GATE

A

B

C

D

4-INPUT NAND GATE

A

B

C

D

EXCLUSIVE-OR GATE

A

B

C

D

EXCLUSIVE-NOR GATE

A

B

C

D

NOTE: PIN NUMBERS CAN BE REARRANGED IF DESIRED.
QUAD NAND GATE (CONTINUED)
7400/74LS00

HALF ADDER

RS LATCH

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

FLASH RATE IS 2 Hz. WHEN C1 AND C2 ARE 47 μF.

TOGGLE SI TO OPERATE.

PROVIDES NOISE FREE OUTPUT FROM STANDARD SPDT TOGGLE SWITCH.
QUAD NAND GATE (CONTINUED)
7400/74LS00

8-INPUT NAND GATE

BCD DECODER

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

IC1, 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

IN 7408 OUT IN=OUT

USE FOR INTERFACING WITHOUT
CHANGING LOGIC STATES.

NAND GATE

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

NOR GATE

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

4-INPUT NAND GATE

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

4-INPUT AND GATE

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

DIGITAL TRANSMISSION GATE

ENABLE
H L L
H L L
L L L
L L L

AND-OR-INVERT GATE

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

43
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

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.

<table>
<thead>
<tr>
<th>ADDRESS</th>
<th>DATA IN</th>
<th>OUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>B</td>
<td>A</td>
</tr>
<tr>
<td>L</td>
<td>X</td>
<td>L</td>
</tr>
<tr>
<td>L</td>
<td>X</td>
<td>H</td>
</tr>
<tr>
<td>H</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td>H</td>
<td>X</td>
<td>H</td>
</tr>
</tbody>
</table>

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

\[
\begin{array}{c|c|c}
A & B & OUT \\
\hline
L & L & L \\
L & H & H \\
H & L & H \\
H & H & L \\
\end{array}
\]

THIS CIRCUIT IS EQUIVALENT TO A BINARY HALF-ADDER.

ONE-SHOT

\[
\begin{array}{c}
\text{IN} \\
\hline
\text{OUT} \\
\end{array}
\]

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 Q\cdot R\cdot C.

RS LATCH

\[
\begin{array}{c|c|c}
R & S & Q \\
\hline
L & L & NO CHANGE \\
L & H & H \\
H & L & L \\
H & H & NOT ALLOWED \\
\end{array}
\]

AND GATE

\[
\begin{array}{c|c|c}
A & B & OUT \\
\hline
L & L & L \\
L & H & L \\
H & L & L \\
H & H & H \\
\end{array}
\]

OR GATE

\[
\begin{array}{c|c|c}
A & S & OUT \\
\hline
L & L & L \\
L & H & H \\
H & L & H \\
H & H & L \\
\end{array}
\]

4-INPUT NOR GATE

\[
\begin{array}{c|c}
A & B \\
\hline
L & L \\
X & X \\
\end{array}
\]

45
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

OUTPUT FOLLOWS SWITCH POSITION.

$1, 2 = \frac{1}{2} \times 7404/74LS04$

UNIVERSAL EXPANDER

ALLOWS ONE SIGNAL TO OUT(=IN) CONTROL 2 OR MORE INPUTS.

1-OF-2 DEMULTIPLEXER

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

THIS TECHNIQUE CAN BE USED TO MAKE MULTIPLE OUTPUT DEMULTIPLEXERS.

<table>
<thead>
<tr>
<th>DATA</th>
<th>ADDRESS</th>
<th>OUT A</th>
<th>OUT B</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>L</td>
<td>L</td>
<td>H</td>
</tr>
<tr>
<td>H</td>
<td>L</td>
<td>H</td>
<td>H</td>
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<tr>
<td>L</td>
<td>H</td>
<td>H</td>
<td>L</td>
</tr>
<tr>
<td>H</td>
<td>H</td>
<td>L</td>
<td>H</td>
</tr>
</tbody>
</table>
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:

<table>
<thead>
<tr>
<th>G</th>
<th>IN</th>
<th>OUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>H</td>
<td>X</td>
<td>HI-Z</td>
</tr>
<tr>
<td>L</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td>L</td>
<td>H</td>
<td>H</td>
</tr>
</tbody>
</table>

1-OF-2 DATA SELECTOR

1-OF-2 DATA SELECTOR

Input words selects 1-of-2 2-bit words.

Output word

Adding 3-state output to TTL

Bidirectional data bus

Two-way (bidirectional) data bus

Write

Read
BCD-TO-7 SEGMENT DECODER/DRIVER
7447 / 74LS47

Converts BCD data into format suitable for producing decimal digits on common anode LED 7-segment display. When lamp test input is low, all outputs are low (on). When B1/R80 (blanking input) is low, all outputs are high (off). When DCHA input is LLLL (decimal 0) and RB1 (ripple blanking input) is low, all outputs are high (off). This permits unwanted leading 0's in a row of digits to be blanked.

MANUALLY SWITCHED DISPLAY

DISPLAY FLASHER

0-9 SECOND /MINUTE TIMER

CLOSE SI TO START TIMING CYCLE. CALIBRATE 555 FOR 1 PULSE (COUNT) PER SECOND OR 1 COUNT PER MINUTE BY ADJUSTING R1.
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

TO PIN 4
7448

O-99 TWO DIGIT COUNTER

LOWEST ORDER DISPLAY

HIGHEST ORDER DISPLAY

R1
R2
R3
R4
R5
R6
R7

7448

7490 / 74LS90

7490 / 74LS90

Vcc

Vcc

Vcc

R8
R9
R10
R11
R12
R13
R14

R1 - R14: 330 Ω

COMMON CATHODE LED DISPLAY
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.)

I-TO-8 DEMULTIPLEXER

Data out

74LS138

Data in

Input: Data (H or L) is passed to selected output.

2-TO-8 STEP SEQUENCER

Outputs

To desired sequence (e.g. connect to output 4 and circuit will cycle from 0 to 3).

Use to flash LEDs, control relays, etc.

RI controls cycle rate.
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

Data out is low when data in is low. If data in is high, selected output is high.

BACK AND FORTH FLASHER

These LEDs flash back and forth, visually appealing.

Increase R1 to slow flash rate.
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. SEE RADIO SHACK DATA BOOK FOR INFORMATION ABOUT R AND C.

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 PHOTORESISTORS 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:

<table>
<thead>
<tr>
<th>PRESET</th>
<th>CLEAR</th>
<th>CLOCK</th>
<th>D</th>
<th>Q</th>
<th>Q1</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>H</td>
<td>X</td>
<td>X</td>
<td>H</td>
<td>L</td>
</tr>
<tr>
<td>H</td>
<td>L</td>
<td>X</td>
<td>X</td>
<td>L</td>
<td>H</td>
</tr>
<tr>
<td>H</td>
<td>H</td>
<td>↑</td>
<td>H</td>
<td>H</td>
<td>L</td>
</tr>
<tr>
<td>H</td>
<td>H</td>
<td>↑</td>
<td>L</td>
<td>L</td>
<td>H</td>
</tr>
</tbody>
</table>

ϕ IS CLOCK INPUT.
↑ IS RISING EDGE OF CLOCK PULSE.

2-BIT STORAGE REGISTER

PHASE DETECTOR

THE LED GLOWS WHEN INPUT FREQUENCIES F1 AND F2 ARE UNEQUAL OR OUT OF PHASE. F1 AND F2 SHOULD BE SQUARE WAVES.

WAVE SHAPER

DIVIDE-BY-TWO COUNTER
DUAL J-K FLIP-FLOP
7473

Two J-K 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:

<table>
<thead>
<tr>
<th>Clear</th>
<th>Clock</th>
<th>J</th>
<th>K</th>
<th>Q</th>
<th>Q</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>L</td>
<td>H</td>
</tr>
<tr>
<td>H</td>
<td>L</td>
<td>L</td>
<td>H</td>
<td>H</td>
<td>L</td>
</tr>
<tr>
<td>H</td>
<td>L</td>
<td>L</td>
<td>H</td>
<td>L</td>
<td>H</td>
</tr>
<tr>
<td>H</td>
<td>L</td>
<td>H</td>
<td>H</td>
<td>TOGGLE</td>
<td></td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Outputs:</th>
<th>A</th>
<th>B</th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td>H</td>
<td>L</td>
<td>H</td>
<td>L</td>
<td>H</td>
</tr>
</tbody>
</table>

Divide-by: three

<table>
<thead>
<tr>
<th>Outputs:</th>
<th>A</th>
<th>B</th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td>H</td>
<td>H</td>
<td>H</td>
<td>H</td>
<td>H</td>
</tr>
</tbody>
</table>

Divide-by: four

<table>
<thead>
<tr>
<th>Outputs:</th>
<th>A</th>
<th>B</th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td>H</td>
<td>L</td>
<td>H</td>
<td>L</td>
<td>H</td>
</tr>
</tbody>
</table>

54
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:

<table>
<thead>
<tr>
<th>PRE</th>
<th>CLR</th>
<th>CLK</th>
<th>J</th>
<th>K</th>
<th>Q</th>
<th>Q'</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>H</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>H</td>
<td>L</td>
</tr>
<tr>
<td>H</td>
<td>H</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>L</td>
<td>H</td>
</tr>
<tr>
<td>H</td>
<td>H</td>
<td>L</td>
<td>H</td>
<td>L</td>
<td>L</td>
<td>H</td>
</tr>
<tr>
<td>H</td>
<td>H</td>
<td>L</td>
<td>H</td>
<td>L</td>
<td>TOGGLE</td>
<td></td>
</tr>
</tbody>
</table>

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

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

4-BIT SERIAL SHIFT REGISTER

PARALLEL OUT (A B C D)

4-BIT BINARY UP COUNTER

DCBA BINARY OUT → A(2^0) B(2^1) C(2^2) D(2^3)
QUAD LATCH
7475/74LS75

A 4-BIT BISTABLE LATCH. PRIMARILY USED TO STORE THE COUNT IN DECIMAL COUNTING UNITS. NOTE THAT BOTH Q AND 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 $\overline{Q}$ OUTPUTS HIGH.

DATA BUS

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-6 COUNTER

DIVIDE-BY-7 COUNTER

DIVIDE-BY-8 COUNTER

DIVIDE-BY-9 COUNTER

DIVIDE-BY-10 COUNTER

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.
**BCD UP-DOWN COUNTER 74192**

Fully programmable BCD counter. Operation is identical to 74193/7415193 except count is 10-step BCD (LLLL-HHHH) instead of 16-step binary. Many applications for 74192/7415192 and 74193/7415193 are interchangeable.

**CASCADED COUNTERS**

![Cascaded Counters Diagram]

**SINGLE UP-DOWN INPUT**

![Single Up-Down Input Diagram]

**PROGRAMMABLE COUNT DOWN TIMER**

![Programmable Count Down Timer Diagram]

Calibrate R1 and C1 to provide desired number of clock pulses per minute. Set desired N into S1-S4 (Closed switch = low and open switch = high). Press S5 to load N and start (or reset) count. LED glows at halt.
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

RAMP SYNTHESIZER

OUTPUT A IS LOWEST ORDER BIT.

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 D-CBA 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

Press S1 (normally closed) to reset.
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.

The 7490 divides the clock pulses by 8 and loads data in 74LS164 into the 74LS374 at 8-bit intervals.

PSEUDO-RANDOM VOLTAGE GENERATOR

Output is pseudo-random stepped voltage. Change pattern by moving pin 2 of 7400 to pins 3, 4, 5, 6, 7, 8, 9, 10 or 11 of 74LS164.
OCTAL BUFFER
74LS240

Ideal for interfacing external circuits to home computers. Inverts data.

<table>
<thead>
<tr>
<th>CONTROL (E1, E2)</th>
<th>OUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>IN</td>
</tr>
<tr>
<td>H</td>
<td>HI-Z</td>
</tr>
</tbody>
</table>

4-BIT BUS TRANSFER

TO BUS

FROM BUS

8-BIT BUS BUFFER

Bus B

Enable

L = \overline{A} \rightarrow B
H = ISOLATED

\overline{A} = INVERTED

Bus A
OCTAL BUFFER
74LS244

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

<table>
<thead>
<tr>
<th>CONTROL (E1, E2)</th>
<th>OUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>IN</td>
</tr>
<tr>
<td>H</td>
<td>HI-Z</td>
</tr>
</tbody>
</table>

4-BIT BUS TRANSFER

TO BUS

FROM BUS

8-BIT BUS BUFFER
OCTAL D-TYPE LATCH
74LS373

EIGHT "TRANSPARENT" D-TYPE LATCHES. OUTPUTfollows 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:

<table>
<thead>
<tr>
<th>OUTPUT</th>
<th>D</th>
<th>Q</th>
</tr>
</thead>
<tbody>
<tr>
<td>H</td>
<td>H</td>
<td>H</td>
</tr>
<tr>
<td>L</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td>L</td>
<td>L</td>
<td>X</td>
</tr>
<tr>
<td>H</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

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

REG. 1 (74LS373)

REG. 2 (74LS373)

H: Disconnects REG. 1 FROM BUS.
L: Connects REG. 1 TO BUS.
H: Outputs FOLLOW INPUTS.
L: Input DATA (ON BUS) Loaded.

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

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

A → B WHEN H
B → A WHEN L

ENABLE WHEN L
HI-Z WHEN H

BUS A
BUS B
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:

Output (VOLTS) ----> 4
2
1

Input (VOLTS) ----> .02 .04 .06 .08

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 susceptibility 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 (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-bar graph 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)

1 - INPUT
2 - OUTPUT
3 - GROUND
ATTACH HEAT SINK IF REQUIRED.

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

TI - 117-12.6 V, 1.2A OR 3A TRANSFORMER (273-1505 OR 273-1511).
BI - 1A-4A FULL WAVE BRIDGE RECTIFIER (276-1111, 276-1151 OR 276-1171).
(RADIO SHACK CATALOG NUMBERS IN PARENTHESES.)

VOLTAGE REGULATOR  CURRENT REGULATOR

C_IN - OPTIONAL; USE 0.33 μF OR SO IF REGULATOR FAR FROM POWER SUPPLY.
C_OUT - OPTIONAL; USE 0.1μF OR MORE TO TRAP SPIKES THAT BOTHER LOGIC ICs.
-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**

![Fixed -5 Volt Regulator Diagram]

-5.5 to -35 Volts

IN

1 - GROUND
2 - OUTPUT
3 - INPUT

*Working voltage must exceed Vin.*

**Adjustable Negative Power Supply**

![Adjustable Negative Power Supply Diagram]
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.

1.25-25 VOLT REGULATOR 6-VOLT NICAD CHARGER

Vin should be filtered. Ok to omit C1 if Vin very close to LM317. R1 controls output voltage. *Add if output > 25 V and C2 > 25 μF.

Bi is battery of 4 nickel cadmium storage cells in series. This circuit charges Bi at a current of 51.2 mA. Increase R1 to reduce current. For example, current is 43 mA when R1 is 24 ohms.

PROGRAMMABLE POWER SUPPLY

Vin (≥ 28V)

 limits maximum Vout to ~27V when input is 28 V.

DCBA inputs: connect to pin 2 to select.

<table>
<thead>
<tr>
<th>Rd</th>
<th>Vout</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>1.8</td>
</tr>
<tr>
<td>330</td>
<td>3.0</td>
</tr>
<tr>
<td>470</td>
<td>4.0</td>
</tr>
<tr>
<td>1K</td>
<td>7.3</td>
</tr>
<tr>
<td>2.2K</td>
<td>13.5</td>
</tr>
<tr>
<td>3.3K</td>
<td>18.0</td>
</tr>
</tbody>
</table>
-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

METAL TAB

ADJUSTABLE NEGATIVE REGULATOR

Vin > Vout

1.5 TO -38 VOLTS IN

Vout = -1.25V \left(1 + \frac{R2}{120}\right)

* WORKING VOLTAGE MUST EXCEED Vin.

PRECISION LED REGULATOR

SUPPLIES CONSTANT CURRENT (I) TO LED.

LED I = 1.5 V/R1.
R2 GIVES ±15% ADJUSTMENT.
LED I = 15 mA WHEN R = 100 Ω.
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

7-37 VOLT REGULATOR

TYPICAL VALUES

<table>
<thead>
<tr>
<th>Vout</th>
<th>R1</th>
<th>R2</th>
<th>R3</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.0</td>
<td>4.12 K</td>
<td>3.01 K</td>
<td>1.74 K</td>
</tr>
<tr>
<td>3.6</td>
<td>3.57 K</td>
<td>3.65 K</td>
<td>1.80 K</td>
</tr>
<tr>
<td>5.0</td>
<td>2.15 K</td>
<td>4.99 K</td>
<td>1.50 K</td>
</tr>
<tr>
<td>6.0</td>
<td>1.15 K</td>
<td>6.04 K</td>
<td>966</td>
</tr>
</tbody>
</table>

FOR ANY VOLTAGE BETWEEN 2-7 VOLTS:

\[ V_{\text{out}} = (V_{\text{ref}}^*) \times \left( \frac{R2}{R + R2} \right) \]

\[ V_{\text{ref}}^* = 6.8 - 7.5 V \text{ (MEASURE AT PIN 6)} \]

\[ R3 = \frac{R1 \times R2}{R1 + R2} \]

TYPICAL VALUES

<table>
<thead>
<tr>
<th>Vout</th>
<th>R1</th>
<th>R2</th>
<th>R3</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>1.87 K</td>
<td>7.15 K</td>
<td>4.6 K</td>
</tr>
<tr>
<td>12</td>
<td>4.87 K</td>
<td>7.15 K</td>
<td>2.9 K</td>
</tr>
<tr>
<td>15</td>
<td>7.87 K</td>
<td>7.15 K</td>
<td>3.75 K</td>
</tr>
<tr>
<td>28</td>
<td>21.0 K</td>
<td>7.15 K</td>
<td>5.33 K</td>
</tr>
</tbody>
</table>

FOR ANY VOLTAGE BETWEEN 7-37 VOLTS:

\[ V_{\text{out}} = (V_{\text{ref}}^*) \times \left( \frac{R1 + R2}{R2} \right) \]

\[ R3 = R1 \times R2 \text{ (R3, WHICH IS OPTIONAL, GIVES TEMPERATURE STABILITY)} \]

74
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

VOUT = (1 + R1/R2) \( V_{REF} = 3-30V \)

VOLTAGE DETECTOR

USE TO DETECT TTL LOGIC LEVELS.

SIMPLE TIMER

1.5 TO 5V POWER SUPPLY

DELAY = (RI CI) \left( \ln \frac{q}{q-V_{REF}} \right)
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

V_{cc} = 5 to 15 VDC

R1 controls output
R2 10k
C1 .01 - 10µF

R4 220
R5 10k
RS sets amplitude, R1 controls rate.
Use to flash inandescent lamp, vary d.c. motor speed, etc.
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

\[ V = \pm 5-18V \]

\[ V_{OUT} = -V_{IN} \left( \frac{R_2}{R_1} \right) \]

NON-INVERTING AMPLIFIER

\[ V = \pm 5-18V \]

\[ V_{OUT} = V_{IN} \left( 1 + \frac{R_2}{R_1} \right) \]

UNITY GAIN FOLLOWER

USE TO COUPLE HIGH IMPEDANCE TO LOW IMPEDANCE.

\[ V = \pm 5-18V \]

\[ V_{OUT} = V_{IN} \]

COMPARATOR

\[ V = \pm 5-18V \]

\[ V_{OUT} = \begin{cases} +V & \text{if } V_{IN} > V_{REF} \\ -V & \text{if } V_{IN} < V_{REF} \end{cases} \]

TYPICAL APPLICATION SHOWN BELOW.

LEVEL DETECTOR

\[ R_1 \] SETS THE VOLTAGE DETECTION THRESHOLD (UP TO +9). \[ V_{IN} \] EXCEEDS THE THRESHOLD (ALSO CALLED THE REFERENCE), THE LED GLOWS.

TYPICAL USES:
AMPLIFICATION OF DC VOLTAGE AND PULSES.
OPERATIONAL AMPLIFIER (CONTINUED)

741C

BASIC INTEGRATOR

\[ V = \pm 5 \text{ to } 18 \text{V} \]

\[ V_{\text{out}} = - \frac{V_{\text{in}} (R_2)}{R_1} \]

\[ \text{OUT} \]

WHEN \( V = \pm 9 \text{V} \)
AND \( V_{\text{in}} = \pm 2.5 \text{V} \),
OUT = \( \pm 1 \text{V} \).

BASIC DIFFERENTIATOR

\[ V = \pm 5 \text{ to } 18 \text{V} \]

\[ \text{IN} \]

\[ V_{\text{out}} = V_{\text{in}} - \frac{V_{\text{in}}}{R_2} \]

\[ \text{OUT} \]

WHEN \( V = \pm 9 \text{V} \)
AND \( V_{\text{in}} = \pm 0.25 \text{V} \),
OUT = \( \pm 0.25 \text{V} \).

CLIPPING AMPLIFIER

\[ V = \pm 5 \text{ to } 18 \text{V} \]

\[ V_{\text{out}} = -V_{\text{in}} (\frac{R_2}{R_1}) \] \( \text{UP TO } V_{\text{IN}} + 0.7 \text{V} \).

DI AND D2 = ZENER DIODES.
IF \( V_{\text{IN}} = 6.7 \text{V} \),
THEN OUTPUT CANNOT EXCEED \( 6.7 \text{V} \).

BRIDGE AMPLIFIER

\[ V = \pm 5 \text{ to } 18 \text{V} \]

\[ \text{IN} \]

\[ V_{\text{out}} = V_{\text{IN}} - \frac{V_{\text{IN}}}{R_2} \]

\[ \text{OUT} \]

\( R_1 \) IS UNKNOWN RESISTOR.
USE 450 CELL FOR \( R_1 \) TO MAKE A VERY SENSITIVE LIGHT METER.

SUMMING AMPLIFIER

\[ V = \pm 5 \text{ to } 18 \text{V} \]

\[ \text{IN} \]

\[ V_{\text{out}} = - (V_{\text{IN}1} + V_{\text{IN}2}) \]

\[ \text{OUT} \]

NOTE: \( V_{\text{out}} \) CANNOT EXCEED \( \pm V \).

DIFFERENCE AMPLIFIER

\[ V = \pm 5 \text{ to } 18 \text{V} \]

\[ \text{IN} \]

\[ V_{\text{out}} = V_{\text{IN}2} - V_{\text{IN}1} \]

\[ \text{OUT} \]
LIGHT WAVE RECEIVER

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

HIGH PASS ACTIVE FILTER

LOW PASS ACTIVE FILTER

4-BIT D/A CONVERTER

ADD CIRCUIT BELOW FOR IMPROVED OPERATION.
OPERATIONAL AMPLIFIER (CONTINUED)

OPTICAL POWER METER

BARGRAPH LIGHT METER

CAUTION: THIS IS A VERY SENSITIVE CIRCUIT! TOO MUCH LIGHT WILL SLAM THE METER NEEDLE.

R3: OFFSET ADJUST

R4 100K

R1 1K

R5 150

R2 1M

R3 10K

R6 220

R7 330

R8 390

R9 470

Q1 IS A PHOTOTRANSISTOR (RADIO SHACK 276-130) CONNECTED AS A PHOTODIODE. A SILICON SOLAR CELL CAN ALSO BE USED. USE GREEN LEDS FOR READOUT.

ELECTRONIC BELL

AUDIBLE LIGHT SENSOR

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

LIGHT ON PCI 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

R2
10K

R4
10M

\[ \frac{1}{2} \]

1458

\[ \frac{1}{2} \]

1458

R3
10M

\[ \frac{1}{2} \]

VIN

R1
10K

IN914

C1
100\mu F

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

PULSE GENERATOR

R2
10K

R1
10M

\[ \frac{1}{2} \]

1458

\[ \frac{1}{2} \]

1458

C1
100\mu F

C1 STORES THE PEAK VOLTAGE AT VIN.

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

PULSES ARE DC AMPLITUDE WHEN C1 = 0.1 \mu F IS 5 VOLTS.

FUNCTION GENERATOR

R1
100K

R5
100K

R4
10K

R7
100K

R8
100K

R10
27K

R3
100K

C1
0.01

C2
0.1 \mu F

C3
0.0012

R6
10K

R9
10K

FREQUENCY = 1 KHz

SQUARE: ± 7.5V

TRIANGLE: ± 2V

SINE: ± 2V
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 TL084C. NOTE THAT PIN CONNECTIONS ARE THE SAME AS HUBB. THIS OP-AMP, HOWEVER, OFFERS MUCH BETTER PERFORMANCE.

SAMPLE AND HOLD

PEAK DETECTOR

TRACKS \( V_{IN} \) AND STORES PEAK \( V_{IN} \) IN \( C_1 \).

REDUCE \( C_1 \) FOR FASTER RESPONSE TO CHANGING \( V_{IN} \).

PROGRAMMABLE GAIN OP-AMP

CONNECT OUTPUTS OF PREAMPLIFIERS TO INPUTS 1-3. OK TO ADD MORE CHANNELS. WORKS WELL WITH TL084 MICROPHONE PREAMPLIFIERS.
QUAD OPERATIONAL AMPLIFIER

TL084C (JFET INPUT)

HIGH IMPEDANCE (10^12 OHMS) JUNCTION FET INPUTS. OUTPUT SHORT CIRCUIT PROTECTION. HIGH SLEW RATE (12 V/μSEC) PLUS LOW NOISE OPERATION. PERFORMANCE SIMILAR TO LF353N.

NOTE THAT PIN CONNECTIONS ARE SAME AS LM324.

MICROPHONE PREAMPLIFIER

USE LOW TO MEDIUM IMPEDANCE DYNAMIC MIKE

GAIN = R2 / R1

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

LOW-Z PREAMPLIFIER

OK TO USE 8Ω SPKR AS MICROPHONE. CONNECT DIRECTLY TO INPUTS (POOR TO FAIR) OR USE TRANSFORMER (GOOD):

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.

USE RADIO SHACK 276-130 PHOTOTRANSISTOR FOR Q1. 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

PULSE GENERATOR

BANDPASS FREQUENCY:
1 kHz

CAREFULLY ADJUST R3 FOR BEST VOICE QUALITY. FOR MORE POWER REDUCE R5 TO 50, R... BUT DO NOT ALLOW MORE THAN 30 mA THROUGH LED!

INTERFACE CIRCUITS

CHANGE R4 AND/OR CI TO VARY PULSE REPEITION RATE.
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.

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

ASTABLE MULTIVIBRATOR  
TOGGLE FLIP-FLOP

USE AS CLOCK, 
PULSE GENERATOR OR 
DUAL FLASHER (SHOWN).

FUNCTION GENERATOR  
X10 AMPLIFIER

FREQUENCY = 1.2 KHz
QUAD COMPARATOR
LM339 (276-1712)

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

OPTIMAL INPUT VOLTAGE

RI = 5k
R3 = 1k
R4 = 100k
R2 = 5k

LED glows when input voltage (pin 5) falls below reference voltage (pin 4).

INVERTING COMPARATOR WITH HYSTERESIS

NON-INVERTING COMPARATOR WITH HYSTERESIS

+ INPUT VOLTAGE

+ REFERENCE VOLTAGE

+ REFERENCE VOLTAGE

NOTE: HYSTERESIS PROVIDED BY FEEDBACK RESISTOR STOPS OSCILLATION.

TTL DRIVER

CMOS DRIVER

3-STATE OUTPUT

CONTROL
L = ENABLE
H = HIGH
V = 74LS367
QUAD COMPARATOR (CONTINUED)
LM339

LED BARGRAPH READOUT

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.

squarewave oscillator

adjust r1 to achieve sensitivity up to a few millivolts per led. see popular electronics (sept. 1978, pp. 92-97).
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

LIGHT CONTROLLED TONE

LAMP FLASHER
LED FLASHER/OSCILLATOR (CONTINUED) 3909

WHOOPER

CHIRPER

SUN POWERED OSCILLATOR

TOY ORGAN

TTL CONTROLLED 3909

H = FLASH LED
L = INHIBIT

H = TONE + LED GLOWS
L = INHIBIT
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:

**Diagram:**

- **R**
- **V**
- **LED**
- **IN**
- **REF**
- **OUT**
- **ADJUST**
- **R2**
- **100K**
- **+3-18**
- **LM3914**
- **LEDs**
- **R1**
- **1K**
- **R**
- **1K**
- **20K**
- **BUFFER**
- **2**
- **GND**
- **3**
- **+3-18V**
- **5**
- **IN**
- **7**
- **17**
- **11**
- **18**
- **10**
- **9**
- **8**
- **7**
- **6**
- **5**
- **4**
- **3**
- **2**
- **1**
- **R**
- **Loo**
- **IN**
- **R**
- **REF**
- **REF**
- **MODE**
- **17**
- **11**
- **7**
- **5**
- **10**
- **9**
- **8**
- **7**
- **6**
- **5**
- **4**
- **3**
- **2**
- **1**

**RI Controls LED Current.** Current through R1 is LED current. Since current (I) through 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 R2 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.

Ri and Rlo 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.
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 R1, R2 and R3.

S1 is the mode switch. Use a DPDT toggle. Position 1 selects bar and position 2 selects dot. Omit S1 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 C1 to slow flash rate.
**DOT/BAR DISPLAY DRIVER (CONTINUED)**

**LM3914N**

**SOLID-STATE OSCILLOSCOPE**

This is an experimental solid-state scope that will fit in a pocket size housing. The resolution is poor, but various waveforms can be visualized. Expand both the vertical and horizontal circuits for more resolution. For more information, see Popular Electronics, August 1979 (pp.78-79).

**USING THE LM3914 AS A CONTROLLER:**

**RELAY**

**OPTICAL COUPLING**

CI - 47μF (Prevents Chatter)

DI - 1N914

RY1 - Radio Shack 275-004

Cl: Photo-Transistor

Q1: Use Radio Shack 276-130, etc.
DOT/BAR DISPLAY DRIVER
LM3915N

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

0 TO -27 dB DOT/BAR DISPLAY

LED DISPLAY

<table>
<thead>
<tr>
<th>dB</th>
<th>Bar Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>········· (FULLSCALE OR FS)</td>
</tr>
<tr>
<td>-3</td>
<td>········</td>
</tr>
<tr>
<td>-6</td>
<td>·······</td>
</tr>
<tr>
<td>-9</td>
<td>·······</td>
</tr>
<tr>
<td>-12</td>
<td>·······</td>
</tr>
<tr>
<td>-15</td>
<td>·······</td>
</tr>
<tr>
<td>-18</td>
<td>·······</td>
</tr>
<tr>
<td>-21</td>
<td>·······</td>
</tr>
<tr>
<td>-24</td>
<td>·······</td>
</tr>
<tr>
<td>-27</td>
<td>·······</td>
</tr>
</tbody>
</table>

* OK TO USE DOT MODE.

THE INPUT SIGNAL CAN BE CONNECTED DIRECTLY TO PIN 5 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 bargraph 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

R1 controls cycle rate. R4 controls range.

1 = 1/3 4049
(Ground unused inputs - pins 7, 9, 11, 14)
**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**

**ALARM CLOCK RADIO**

KEEP RADIO SWITCH ON.

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

---

**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.
**555**

**555 EQUIVALENT CIRCUIT**

The first and still the most popular IC timer chip operates as a one-shot timer or an astable multivibrator. The 555 is two 555 circuits on one chip.

**ONE-SHOT TIMER**

![Diagram of a one-shot timer circuit]

Values shown give 1 second output pulse.

**BISTABLE SWITCH**

Pressing S1 gives clean 0.1 second output pulse.

**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.
TOY ORGAN

**TYPICAL VALUES:**
- \( C_1 = 0.1 \text{ \( \mu \)F} 
- \( C_2 = 0.22 \text{ \( \mu \)F} 
- \( C_3 = 0.01 \text{ \( \mu \)F} 
- \( C_4 = 0.005 \text{ \( \mu \)F} 
- \( C_5 = 0.001 \text{ \( \mu \)F} 

**MISSING PULSE DETECTOR**

**LED TRANSMITTER**

CIRCUIT PULSES LED WITH 45 \( \mu \)SEC LONG, 120 mA PULSES AT A RATE OF 4.8KHz.

**PULSE GENERATOR**

USE TO SUPPLY CLOCK PULSES TO TTL AND LS LOGIC CIRCUITS. R1 CONTROLS PULSE REPETITION RATE

THIS CIRCUIT IS A ONE-SHOT THAT IS CONTINUALLY RETRIGGERED BY INCOMING PULSES. A MISSING OR DELAYED PULSE THAT PREVENTS RETRIGGERING BEFORE A TIMING CYCLE IS COMPLETE CAUSES PIN 3 TO GO LOW UNTIL A NEW INPUT PULSE ARRIVES. R1 AND C1 CONTROL RESPONSE TIME. USE IN SECURITY ALARMS, CONTINUITY TESTERS, ETC.
TIMER (CONTINUED)

ULTRA-LONG TIME DELAY

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

555

RI 1M
R2 1K
C1 10μF

555

R1 100K
C2 1μF
C1 4.7μF
C3 5μF
R2 1K

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

ADDITIONAL STAGES

4017

15 13 8

4017

12 14

4017

12 14

x10

x100

x1000

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

LIGHT DETECTOR

Cds PHOTOCELL (RADIO SHACK 276-114)

+9

555

R1 47K
R2 1K
C1 0.05μF

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

DARK DETECTOR

Cds PHOTOCELL (RADIO SHACK 276-114)

+9

555

R1 47K
R2 1K
C1 0.05μF

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

8Ω SPKR

8Ω SPKR

98
**TIMER (CONTINUED)**

**555**

**NEON LAMP POWER SOURCE**

- R1: 47K
- R2: 1K
- C1: .1µF

- RED: +9
- GREEN: IN914
- WHITE: 555

- T1: 8.2Ω-1K (Radio Shack 273-1380) .1µF
- C1: 0.1µF, 250V
- L1: Neon lamp

Works best with better quality neon lamps. Reduce R1 slightly for more output voltage.

**FREQUENCY DIVIDER**

- +5-15
- R1: 100K

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**

- +9
- R1: 100K
- R2: 1K
- C1: .1µF

Adjust R1 to provide up to 10kHz. Output frequency this high produces closely spaced triangle waves. The waves are separated at slower frequencies (V-V).
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 555s. This pin cross reference will simplify substituting two 555s for a 556 or half a 556 for a 555.

<table>
<thead>
<tr>
<th>Function</th>
<th>555</th>
<th>556(1)</th>
<th>556(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground</td>
<td>1</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Trigger</td>
<td>2</td>
<td>6</td>
<td>9</td>
</tr>
<tr>
<td>Output</td>
<td>3</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>Reset</td>
<td>4</td>
<td>4</td>
<td>11</td>
</tr>
<tr>
<td>Control V</td>
<td>5</td>
<td>3</td>
<td>12</td>
</tr>
<tr>
<td>Threshold</td>
<td>6</td>
<td>2</td>
<td>13</td>
</tr>
<tr>
<td>Discharge</td>
<td>7</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Vcc</td>
<td>8</td>
<td>14</td>
<td>14</td>
</tr>
</tbody>
</table>

3-STATE TONE SOURCE

+9

INTERVAL TIMER

+9

555/556 SCR OUTPUT

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.

To 555/556 output 3.3K

Load (small motor, lamp, etc.)

Reset (normally closed)

* Radio Shack 275-004

* Radio Shack 275-004

C1 100µF

C3 0.05

C4 0.05

C2 22µF
DUAL TIMER (CONTINUED)

556

SOUND SYNTHESIZER

TWO-STAGE TIMER

+5-15

R1 500K
R2 1K
C1 .01μF

R3 5K
(VOLUME)

R4 500K

C2 .005μF

C3 .05μF

C4 .05μF

C5 .05μF

C6 1-100μF

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

+5-15

R1 2.2K
R2 100K
Cl 33μF

R4 5K

R5 5K

R3 100K

R6 270Ω

This circuit is an oscillator followed by a frequency divider. Adjust R1 and R4 for very unusual sound effects.

MODE SELECT

<table>
<thead>
<tr>
<th>BA</th>
<th>OUTPUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>L L</td>
<td>TWO-TONE</td>
</tr>
<tr>
<td>L H</td>
<td>STEADY</td>
</tr>
<tr>
<td>H L</td>
<td>BURST</td>
</tr>
<tr>
<td>H H</td>
<td>METRONOME</td>
</tr>
</tbody>
</table>

L = GND
H = +5-15 (V08)

Change Cl 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

Outputs A, B, C, D go high, then low, sequentially. \( R1 - R4 \) and \( C1 - C4 \) control delay per step. \( RS \) controls rate.
QUAD TIMER (CONTINUED)

558

FULLY ADJUSTABLE PULSE GENERATOR

\[ V_{cc} \]

R1 controls pulse rate.
R2 controls pulse width.
R3 = R4 = 1.5 to 4.7K.

VERY USEFUL CIRCUIT! PULSE RATE AND WIDTH TOTALLY INDEPENDENT. SEE BELOW FOR MORE INFORMATION.

SIMPLE OSCILLATOR

\[ V_{cc} \]

R1 controls frequency.

FIXED DUTY CYCLE PULSER

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

LONG DURATION TIMER

RS = RG = R7 = 4.7K

SELECT R1 C1, R2 C2, R3 C3 AND R4 C4 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**

ALARM TONE SOUNDS IF SI IS NOT CLOSED WITHIN 5-30 SECONDS.
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. See Radio Shack Data Book for more information.

PULSE-FREQUENCY-MODULATED INFRARED COMMUNICATOR

TRANSMITTER

MIC: XTAL (270-095) OK. * ELECTRET (270-092) BEST. R3: TRY 1M FOR MORE GAIN.

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

Q1 PHOTOE TRANSISTOR

KEEP PWR LEADS ON BOTH UNITS SHORT. USE 0.1uF ACROSS PWR CONNECTIONS (AT CHIPS) IF OSCILLATION OCCURS. HAVE FUN.
TONE DECODER
567

Contains a Phase-Locked Loop.
Pin B 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 $(1.1) \times (RC)$. $R$ should be between 2kΩ-20kΩ. The 567 can be adjusted to detect any input between 0.01Hz 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.

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 1.3kHz.

INFRARED REMOTE CONTROL SYSTEM

TRANSMITTER

ADJUSTABLE TONE SOURCE (OPTIONAL)

RECEIVER

RANGE: SEVERAL INCHES. USE LENSES TO INCREASE.
TONE DECODER (CONTINUED)

567

2-FREQUENCY OSCILLATOR  2-PHASE OSCILLATOR

3.981 KHz
1.555 KHz

5-VOLT SQUARE WAVE (1KHz)

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.

NARROW BAND FREQUENCY DETECTOR

Adjust R1 and R2 to respond to closely spaced frequencies. LEDs 1 and 3 will glow if frequency is high or low. LED 2 will glow when the input frequency is centered.
TONE DECODER (CONTINUED)

TOUCH-TONE® DECODER

IC1, 2, 3 = 7402
ACTIVE OUTPUT = H

REPEAT THIS CIRCUIT BELOW.
TUNE EACH 567 VIA R1.

IN: 50 - 200 mV

IN

0.47

697 Hz  C2 = 4.7 μF

770 Hz  C2 = 4.7 μF

852 Hz  C2 = 4.7 μF

941 Hz  C2 = 2.2 μF

1209 Hz C2 = 2.2 μF

1336 Hz C2 = 2.2 μF

1477 Hz C2 = 2.2 μF

13
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.

Portable Touch-Tone® Generator

Remote Control

Portable Touch-Tone® Generator

CB Transceivers

Touch-Tone® Decoder
VOLTAGE-TO-FREQUENCY
FREQUENCY-TO-VOLTAGE
CONVERTER
9400 (276-1790)

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.

BASELINE V/F CONVERTER  FSK* DATA TRANSMITTER

In the dual frequency output, a frequency of 11.14 MHz is generated by the 14400 V/F and 22400 V/F.

R2 controls output over wire or radio.

47pF 3943 17,671
1µF 1000 1665
*Frequency shift keying, use to send binary.
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

THE SPKR IS OPTIONAL BUT MAY PROVE HELPFUL DURING INITIAL TESTING. USE AN
INFRARED LED (RADIO SHACK 276-42). Q1 CAN BE THE PHOTOTRANSISTOR SUPPLIED WITH
THE LED OR RADIO SHACK 276-130. R7 IN THE RECEIVER IS ZERO ADJUST.
VOLTAGE CONTROLLED OSCILLATOR (VCO)

VERY STABLE, EASY TO USE TRIANGLE AND SQUARE WAVE OUTPUTS. R1 AND C1 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.

FUNCTION GENERATOR

FSK GENERATOR

FSK MEANS FREQUENCY SHIFT KEYING.

TWO-TONE WARBLER

RI CONTROLS WARBLE RATE.

R3 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 Vcc 1 or Vcc 2.

Vcc 1 = 3.5 to 6 volts
Vcc 2 = 8 to 18 volts

PULSE WIDTH MODULATOR

8-BIT ANALOG-TO-DIGITAL CONVERTER

8-BIT DATA BUS → MSB

BUS ENABLE (WHEN LOW)

This project for advanced experimenters.

IC1 = 74LS00  IC2 = 74LS02
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 ± output, use to interface microcomputer to analog devices.

B1 = Most significant bit.
B8 = Least significant bit.
V± = ±4.5 to 18 V.

8-BIT DAC

DAC 801 POWER SUPPLY

TI: 120 VAC / 25.2 VAC CT (273-1512)
(OK to use 273-1505 for non-precision applications.)
256-STEP STAIRCASE GENERATOR

DAC 801 TONE GENERATOR

RI: CLOCK RATE
CI: INCREASE TO SLOW RATE
S1: CLOSE FOR UNIPOLAR OUTPUT

RI AND CI CONTROL TONE RANGE.

NOTE: +10V REFERENCE CAN BE +5 TO +10V IN NON-PRECISION ROLES (E.G. TONE GENERATION).
TEMPERATURE SENSOR AND ADJUSTABLE CURRENT SOURCE
LM334 (276-1734)

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.

BASIC THERMOMETERS

BASIC CURRENT SOURCE

\[ I_{set} = \frac{2}{R_{set}} \] at 25°C.

\[ R_{set} = \frac{0.0677}{I_{set}} \]

MAXIMUM CURRENT OUT = 10 mA.

VOLTAGE REFERENCE

CALIBRATED LED

OUTPUT: 0.8 - 5.0V

(10 Ω 4.3 mA)

(15 Ω 6.4 mA)

CONSTANT LED OUTPUT FOR ANY INPUT BETWEEN 3-20Volts.

RAMP GENERATOR

LIGHT METER

\[ I_{set} = \frac{2}{R_{set}} \] at 25°C.

\[ R_{set} = \frac{0.0677}{I_{set}} \]
POWER AMPLIFIER
LM386

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

X20 AMPLIFIER

X200 AMPLIFIER

* R1 CONTROLS INPUT SIGNAL LEVEL.

BASS BOOSTER

TONE FREQ: 2.1 KHz, REDUCE C1 TO INCREASE FREQUENCY.

AUDIBLE ALARM

CAUTION: VERY LOUD!

HIGH GAIN POWER AMPLIFIER

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

Q1 - PHOTOTRANSISTOR (RADIO SHACK 276-130)
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 (e.g., Radio Shack 276-1363). Spread some heat sink compound (276-1372) on the LM383 tab before attaching the heat sink.

8-WATT AMPLIFIER

+5 - 20V

1 - IN
2 - - IN
3 - GND
4 - OUT
5 - +5 - 20V

* C4 - Place close as possible to the IC.
R2 - Ok to use 4-10k resistors in parallel.

16-WATT BRIDGE AMPLIFIER

OR USE 4-10K RESISTORS IN PARALLEL

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.
DUAL 2-WATT AMPLIFIER
LM1877/LM377

HIGH QUALITY, EASY TO USE POWER AMPLIFIER. IDEAL FOR DD-IT-YOURSELF STEREO, P.A. SYSTEMS, INTERCOMS, ETC. AUTOMATIC THERMAL SHUTDOWN PROTECTS AGAINST OVERHEATING. 70 dB 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.

STEREO AMPLIFIER

4-WATT AMPLIFIER

PUBLIC ADDRESS SYSTEM

THIS CIRCUIT WORKS WELL. NOTE FEWER PARTS IN LM1877/LM377 STAGE... THANX TO SPLIT POWER SUPPLY.
COMPLEX SOUND GENERATOR
SN76477N

INTEGRATES 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.

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

ENVELOPE SELECT 1
GROUND
EXTERNAL NOISE CLOCK
NOISE CLOCK
NOISE FILTER
NOISE FILTER
DECAY
ATTACK/DECAY
SYSTEM ENABLE
ATTACK
AMPLITUDE
FEEDBACK
AUDIO OUTPUT
VCO
EXTERNAL VCO

ENVELOPE SELECT 2
MIXER SELECT C
MIXER SELECT A
MIXER SELECT B
ONE-SHOT
ONE-SHOT
VCO SELECT
S.L.F.
S.L.F.
PITCH CONTROL
VCO
VCO
VREG

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

PERCUSSION SYNTHESIZER

SI - PRESS TO ACTIVATE SOUND.
NOISE GENERATOR

Produces steady hiss. Make snare drum by connecting pushbutton in series with speaker. Add S.L.F. oscillator to modulate the hiss. (Select S.L.F. + noise by connecting pins 25 and 26 to GND and pin 27 to +9V. Add 1M pot from pin 20 to GND and 1µF capacitor from pin 21 to GND.) Sounds like steam train or propeller aircraft depending on adjustment of 1M pot.

UNIVERSAL UP-DOWN TONE GENERATOR

Press SI and release to hear undulating tone that gradually decays and stops. Change VCO and S.L.F. components for many different sound effects ranging from siren to science fiction movie sounds. For continuous sound, omit components at pins 7, 8, 23, 24 and ground pin 9.
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 Vcc goes from +6 to +9 V.

ONE-SHOT OUTPUT 1
VCO OUTPUT 2
NOISE CLOCK OUTPUT 3
S.L.F. OUTPUT 4
NOISE 5
NOISE 6
DECAY 7
DECAY 8
INHIBIT 9
AUDIO INPUT 10
S-VOLTS OUT 11
Vcc (+9 V) 12
AUDIO OUT 13
GROUND 14
ENVELOPE SELECT 1 28
ENVELOPE SELECT 2 27
S.L.F. SELECT 24
MIXER B INPUT 25
MIXER A INPUT 24
MIXER C INPUT 23
ONE-SHOT 22
ONE-SHOT 21
VCO SELECT 20
S.L.F. 19
S.L.F. 18
VCO 17
VCO 16
EXTERNAL VCO CONTROL 15

BOMB DROP PLUS EXPLOSION

+6 TO 9

SN76488N

R1 680K
C1 470pF
R2 500K
C2 4.7uF
R3 470K
C3 .005
R4 1M

C4 22uF
RS 100K
C5 33uF

PRESS TO START

C6 100uF

R2 controls duration of explosion.
RS controls altitude.
COMPLEX SOUND GENERATOR (CONTINUED)
SN76488N

IMPROVED STEAM ENGINE AND WHISTLE

R2 CONTROLS ENGINE SPEED.
R4 CONTROLS WHISTLE FREQUENCY.

+6 TO 9

R6 4.7K
RS 1K

PRESS FOR WHISTLE
USE .0047 FOR RASPY WHISTLE
OR .01 FOR PURE TONE.

C5

C4 100μF

SN76488N

5 6 19 + 18 17 16 15 11 23 14
R1 1K C1 470pF C2 1μF R2 500k R3 470k C3 470pF R4 100k

THE ULTIMATE SIREN

+6 TO 9

R3 (OPTIONAL VOLUME CONTROL)

R1 CONTROLS CYCLE RATE.
R2 CONTROLS FREQUENCY.

ADJUST R1 FOR HIGH RESISTANCE TO GIVE ULTRA SLOW SIREN.
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 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.

SAD IN/OUT CONTROLS

Adjust $R_1$ (input bias) for optimum audio output; outputs appear like this on a scope:

Adjust $R_1$ (input bias) for optimum audio output; outputs appear like this on a scope:

SUMMED OUTPUTS ($A + A'$): [Diagram]

Set scope to visualize input signal (compressing clock rate):

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 (3-8KHz) FOR SINGLE ECHO. USE HIGHER CLOCK FREQUENCIES (20-100KHz) 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.

125
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 TEST CIRCUIT

CIRCUIT SHOWS
TTL INTERFACING.

TIL 119 IS SLOWER
BUT MORE SENSITIVE.

TIL 111 GIVES 1.5KV
ISOLATION.

Vcc1 = Vcc2 = 5V
1, 2 = 1/3 7404

Vcc1

100K

Vcc1

TIL 119

TIL 111

10K

.05

TIL 111 / TIL 119 TEST CIRCUIT

CALCULATOR / COMPUTER INTERFACING

KEYBOARD INPUT

H = CLOSE
L = OPEN
H = ENABLE
L = DISABLE
TO KEY CONTACTS
(REVERSE IF NECESSARY)

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 BLACK
TO RED
BATTERY
BATTERY
CLIP LEAD
CLIP LEAD

TO OPERATE:

1. SET R1 TO GIVE 10HZ
FREQUENCY.
2. ENTER □ □ +
3. PRESS SI FOR TIMING PERIOD.
4. READ TIME TO TENTH SECOND FROM
DISPLAY.

NOTE:
THIS SHOWS
CMOS
INTERFACE.
OPTOCOUPLERS
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 \[ \boxed{1} \boxed{1} \boxed{0} \]. NUMBER
IN DISPLAY WILL BE DECREMENTED
EACH TIME \[ \boxed{1} \] 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).
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.

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

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

Rs = Signal Voltage

128