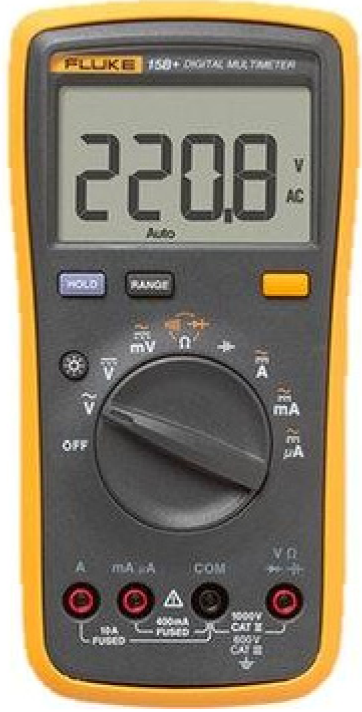
万用表**Fluke Model15B**使用

测试的过程中经常会用到万用表，以Fluke Model15B为例，常用有3个用途：

1） 测量交流和直流电压；
2） 测量交流和直流电流；
3） 测量电阻、电容、通断。



Fluke Model15B

按钮栏：

1） HOLD按钮:按下该按钮保持当前度数，显示屏出现“HOLD”字样，再按则恢复。

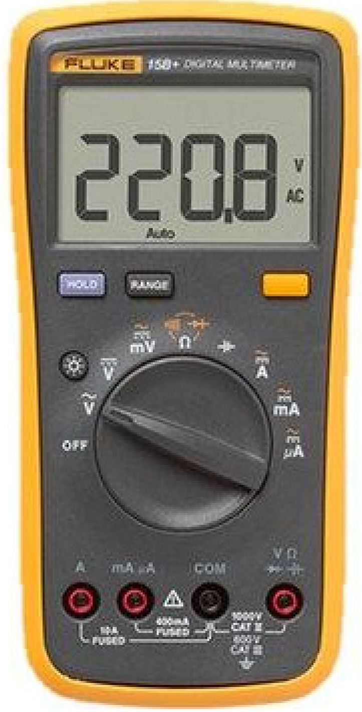
2） RANGE按钮:默认值是自动量程，显示屏出现“Auto Range”字样，按下按钮进入手动量程模式，每次按均增加量程，达到最大量程时回到最低量程，按下并保持2秒则退出手动量程模式。

3）“黄色”按钮：旋转开关对应的挡位功能中切换。

4）“太阳”按钮：显示屏背光

中间的旋转开关

关、交流电压V、直流电压V、交直流电压mV、测通断/二极管/电阻、电容、交直流电流A、交直流电流mA、交直流电流微安。



Fluke Model15B

底部的接线端

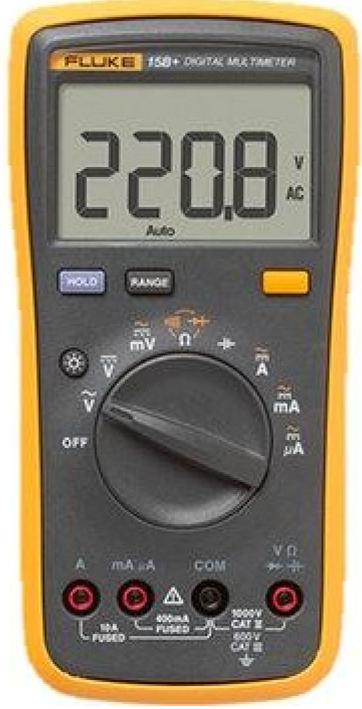
红色内圈接红表笔，黑色内圈接黑表笔。

1） A: 测量该数量级的电流，包括直流电电流、交流电电流。

2） 毫安 微安：测量该数量级的电流。

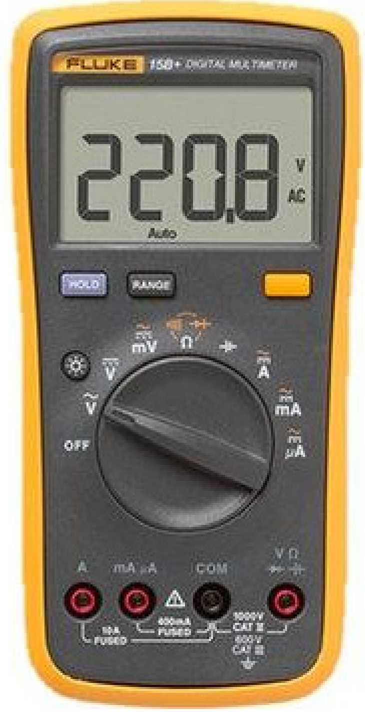
3） COM：黑表笔接这里。

4） V Ω …：测量电压、电阻、通断性、二极管、电容时，红色表笔接这里。测试通断性时，旋转开关选择电阻模式，按下“黄色”按钮2次，激活蜂鸣器，显示屏出现“）））”。如果电阻低于50Ω，蜂鸣器响表明短路，读数为0L表明电路断路。



Fluke Model15B

注意事项：
1）端子间或每个端子与接地点之间施加的电压不能超过额定值。
2）测量一个已知电压，以确定产品操作是否正常。
3）测量时，必须使用正确的端子、功能档和量程档。
4）测量时，请先连接零线或地线，再连接火线；断开时，请先切断火线，再断开零线和地线。



Fluke Model15B

万能表的使用方法图解

万用表

使用万用表前需了解标准符号

1.1国际电气符号

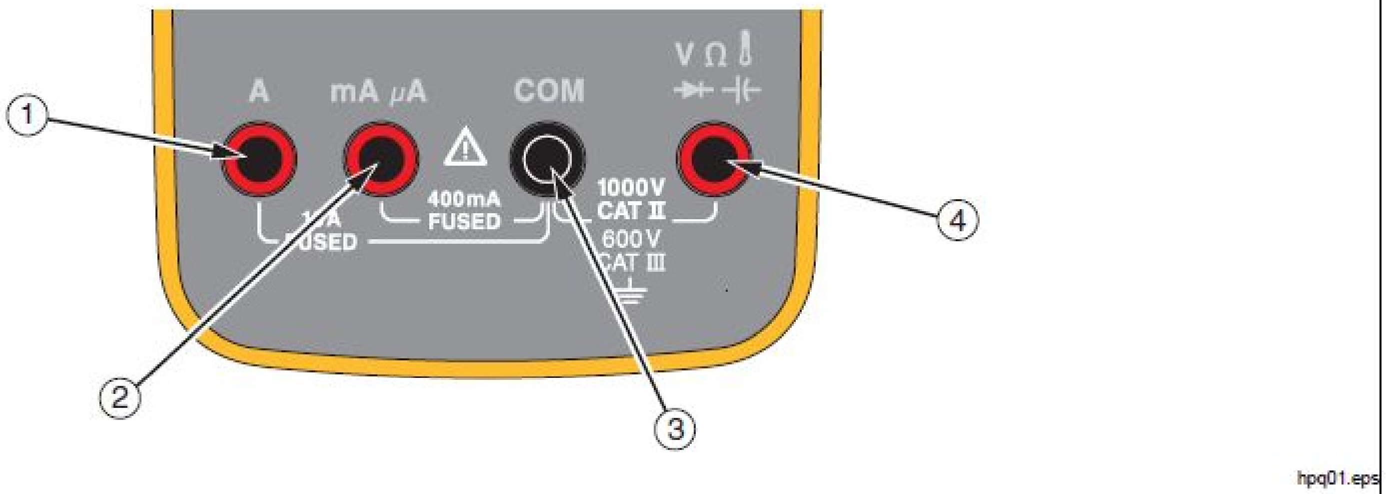
～	AC（交流电）	⏚	接地
⎓	DC（直流电）		保险丝
	二极管		电容
	危险电压。有触电危险。		电池
⚠	危险。重要信息。请参阅手册。	CAT II	II 类测量适用于测试和测量与低电压电源装置的用电点（插座和相似点）直接连接的电路。
CAT III	III 类测量适用于测试和测量与建筑物低电压电源装置配电部分连接的电路。	CAT IV	IV 类测量适用于测试和测量与建筑物低电压电源装置电源连接的电路。
CE	符合欧盟指令。		符合相关的北美安全标准。
	符合相关的韩国 EMC 标准		符合澳洲的相关标准。
	本产品符合 WEEE 指令 (2002/96/EC) 的标识要求。粘贴的标签指示不得将电气/电子产品作为家庭垃圾丢弃。产品类别：根据 WEEE 指令附录 I 中的设备类型，该产品被归类为第 9 类“监测和控制仪器”产品。请勿将本产品作为未分类的城市废弃物处理。请访问 Fluke 网站了解回收方面的信息。		

1.2 标准的安全等级

CAT Ⅱ	II 类测量适用于测试和测量与低电压电源装置的用电点（插座和相似点）直接连接的电路。
CAT Ⅲ	III 类测量适用于与建筑物低压电源装置配电部分连接的测试和测量电路。
CAT Ⅳ	IV 类测量适用于测试和测量与建筑物低电压电源装置电源部分连接的电路。
	本产品符合 WEEE 指令的标识要求。 粘贴的标签指示不得将本电气/电子产品作为家庭垃圾丢弃。 产品类别： 根据 WEEE 指令附录 I 中的设备类型，该产品被归类为第 9 类“监测和控制仪器”产品。 请勿将本产品作为未分类的城市废弃物处理。

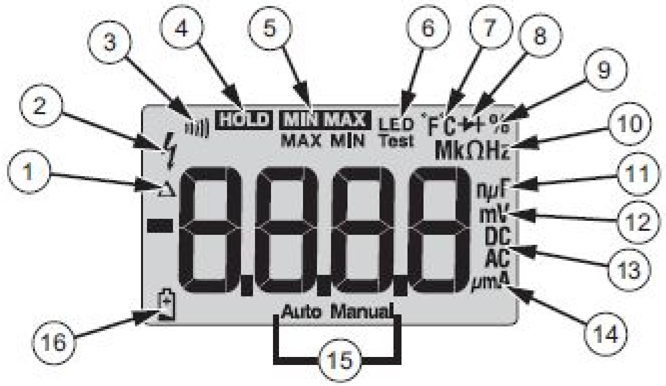
了解万用表的接线端与显示屏幕

2.1接线端



项目	说明
①	用于交流电和直流电电流测量（最高可测量 10 A）和频率测量 (17B+/18B+) 的输入端子。
②	用于交流电和直流电的微安以及毫安测量（最高可测量 400mA）和频率测量 (17B+/18B+)的输入端子。
③	适用于所有测量的公共（返回）接线端。
④	用于电压、电阻、通断性、二极管、电容、频率 (17B+/18B+)、占空比 (17B+/18B+)、温度（仅限 17B+）和 LED 测试（仅限 18B+）测量的输入端子。

2.2显示屏



hpq02.eps

项目	说明	项目	说明
①	已启用相对测量（仅限 17B+）。	⑨	已选中占空比 (17B+/18B+)。
②	高压	⑩	已选中电阻或频率 (17B+/18B+)。
③	已选中通断性。	⑪	电容单位法拉。
④	已启用“显示保持”。	⑫	毫伏或伏特
⑤	已启用最小值或最大值模式（仅限 17B+）。	⑬	直流或交流电压或电流
⑥	已启用 LED 测试（仅限 18B+）。	⑭	微安、毫安或安培
⑦	已选中华氏温标或摄氏温标（仅限 17B+）。	⑮	已启用自动量程或手动量程。
⑧	已选中二极管测试。	⑯	电池电量不足，应立即更换。

选择不同的挡位进行测量

3.1

测量交流电压和直流电压

要测量交流电和直流电电压：

1. 将旋转开关转至 $\tilde{V}$、$\overline{\overline{V}}$ 或 $\overset{\approx}{mV}$ 选择交流电或直流电。
2. 按 [ ] 可以在 mVac 和 mVdc 电压测量之间进行切换。
3. 将红色测试导线连接至 VΩ 端子，黑色测试导线连接至 COM 端子。
4. 用探头接触电路上的正确测试点以测量其电压，如图 1 中所示。
5. 读取显示屏上测出的电压。

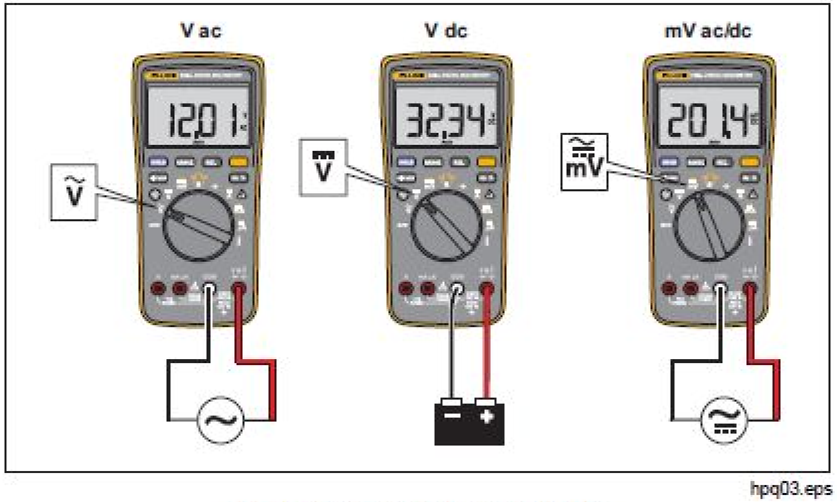


图 1. 测量交流和直流电压

3.2

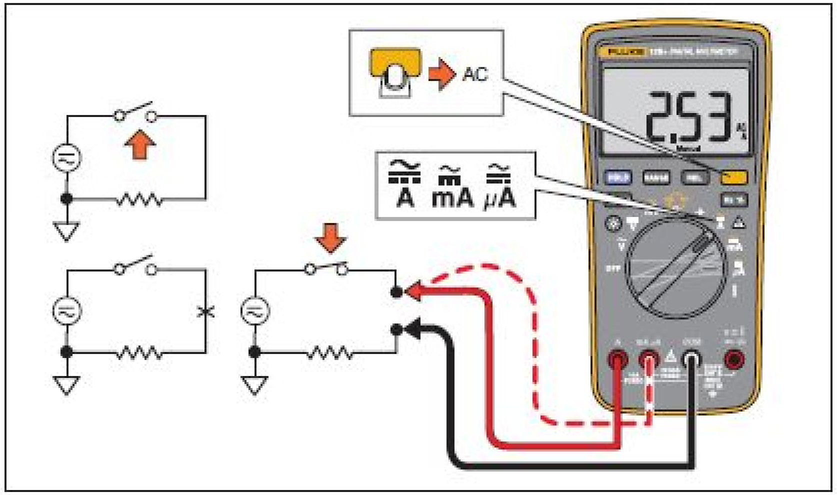
测量交流或直流电流

⚠⚠ 警告

为了防止可能发生的电击、火灾或人身伤害，测量电流时，先断开电路电源，然后再将电表连接到电路中。将产品与电路串联连接。

测量交流或直流电流：

1. 将旋转开关转至 $\widetilde{\overline{\text{A}}}$, μ 或 $\widetilde{\overline{\mu\text{A}}}$。
2. 按 □ 可以在交流和直流电流测量之间进行切换。
3. 根据要测量的电流将红色测试导线连接至 **A 或 mA μA** 端子，并将黑色测试导线连接至 **COM** 端子。参见图 2。
4. 断开待测的电路路径。然后将测试导线衔接断口并施用电源。
5. 阅读显示屏上的测出电流。



hpq04.eps

图 2. 测量交流和直流电流

测量电阻

要测量电阻：

1. 将旋转开关转至 。确保已切断待测电路的电源。

2. 将红色测试导线连接至 端子，并将黑色测试导线连接至 **COM** 端子，如图 3 所示。

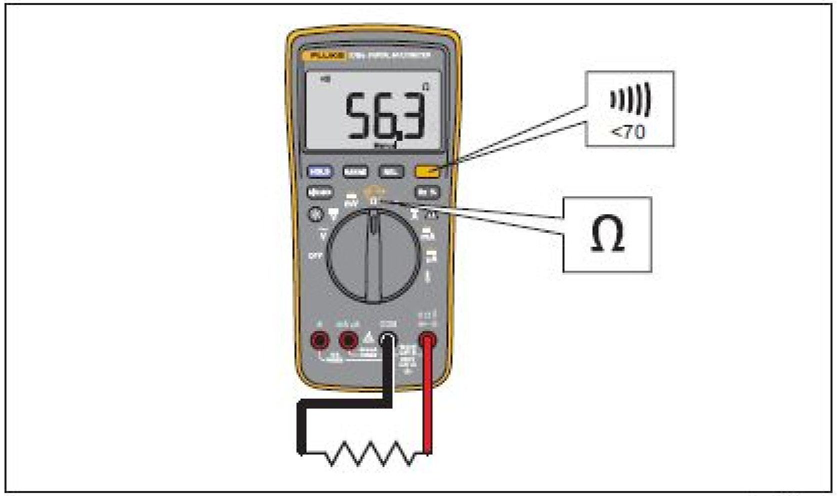
3. 将探针接触想要的电路测试点，测量电阻。

4. 阅读显示屏上的测出电阻。

通断性测试

要测试通断性：

选择电阻模式后，按一次 $\boxed{}$ 以激活通断性蜂鸣器。如果电阻低于 70 Ω，蜂鸣器将持续响起，表明出现短路。参见图 3。



hpq05.eps

图 3. 测量电阻/通断性

3.4

测试二极管

⚠小心

为避免对产品或被测试设备造成可能的损坏，请在测试二极管之前断开电路的电源并将所有的高压电容器放电。

1. 将旋转开关转至 。
2. 按两次 ☐ 以激活二极管测试。
3. 将红色测试导线连接至 端子，黑色测试导线连接至 **COM** 端子。
4. 将红色探针接到待测的二极管的阳极而黑色探针接到阴极。
5. 读取显示屏上的正向偏压。
6. 如果测试导线极性与二极管极性相反，显示读数为 0L。这可以用来区分二极管的阳极和阴极。

3.7

1. 当该产品处于所需功能（交流电压或交流电流）下时，按 Hz %。
2. 读取显示屏上的信号频率。
3. 如要进行占空比测量，则再按一次 Hz %。
4. 阅读显示屏上的占空比百分数。

测量频率和占空比，可选择17B+或者18B+

3.5

测量电容

⚠小心

为避免对产品造成损坏，请在测量电容之前断开电路的电源并将所有的高压电容器放电。

1. 将旋转开关转至 ⊣⊢。
2. 将红色测试导线连接至 端子，黑色测试导线连接至 **COM** 端子。
3. 将探针接触电容器引脚。
4. 读数稳定后（最多 18 秒后），读取显示屏所显示的电容值。

3.6

1. 将旋转开关转至 。
2. 将热电偶插入到该产品的 和 **COM** 端子中。
   确保将热电偶标记有“+”的插头插入到该产品上的 端子中。
3. 读取显示屏上的电压。
4. 按 ☐ 可以在 °C 和 °F 之间切换。

测量温度，可选择17B+

3.8

注意

不要使用 LED TEST 模式来进行 LED 老化测试。

通过 LED 测试插孔测量 LED：

1. 调节旋钮至 LED TEST。
2. 将 LED 引脚放在电表前侧的 LED 测试插孔中，如图 4 所示。

测量发光二极管LED，可选择18B+

如果 LED 状态良好，本产品将会点亮被测的 LED，而且正极指示灯将会亮起，以指示 (+) 管脚。如果 LED 破损，LED 不会点亮，两个正极指示器均不点亮。如果 LED 短路，LED 将不点亮，两个正极指示器将点亮。

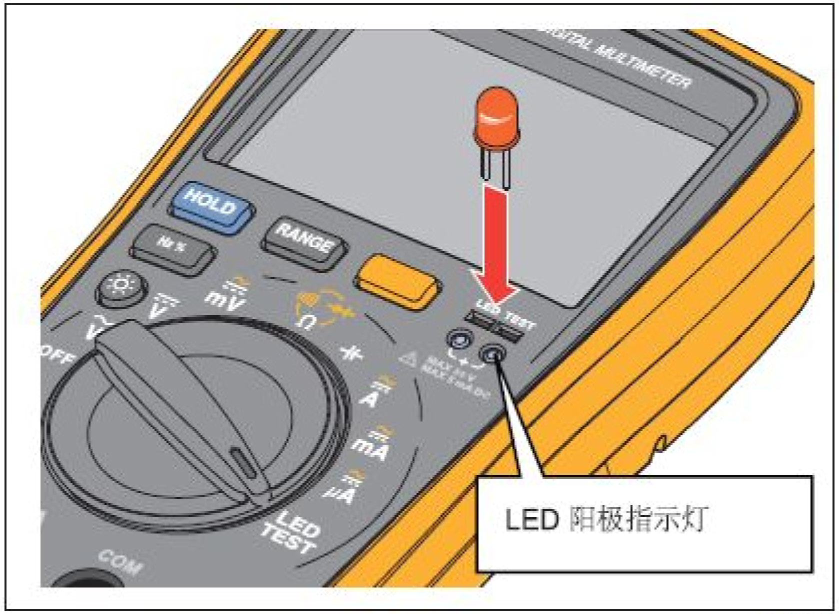


图 4. LED 测试插孔

什么是电阻

导体对电流的阻碍作用就叫该导体的电阻。电阻（Resistance，通常用“R”表示）是一个物理量，在物理学中表示导体对电流阻碍作用的大小。导体的电阻越大，表示导体对电流的阻碍作用越大。不同的导体，电阻一般不同，电阻是导体本身的一种性质。导体的电阻通常用字母R表示，电阻的单位是欧姆，简称欧，符号为Ω。

电阻是描述导体导电性能的物理量，用R表示。

电阻由导体两端的电压U与通过导体的电流I的比值来定义，即： $R = U \div I$

所以，当导体两端的电压一定时，电阻愈大，通过的电流就愈小；反之，电阻愈小，通过的电流就愈大。因此，电阻的大小可以用来衡量导体对电流阻碍作用的强弱，即导电性能的好坏。电阻的量值与导体的材料、形状、体积以及周围环境等因素有关。

电阻率描述导体导电性能的参数。对于由某种材料制成的柱形均匀导体，其电阻R与长度L成正比，与横截面积S成反比，即： $R = \rho \times L \div S$

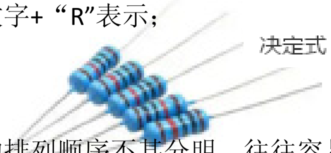
式中ρ为比例系数，由导体的材料和周围温度所决定，称为电阻率。它的国际单位制(SI)是欧姆·米 (Ω·m)。常温下一般金属的电阻率与温度的关系为： $\rho = \rho_0 (1 + \alpha t)$

式中ρ_0为0℃时的电阻率； α为电阻的温度系数； 温度t的单位为摄氏温度。半导体和绝缘体的电阻率与金属不同，它们与温度之间不是按线性规律变化的。当温度升高时，它们的电阻率会急剧地减小。呈现出非线性变化的性质 。

电阻的单位是欧姆，简称欧，用希腊字母“Ω”表示。

常用的电阻单位还有千欧姆(kΩ)，兆欧姆(MΩ)，
它们的关系是：1kΩ=1000Ω，1MΩ=1000kΩ

在电原理图中为了简便，一般将电阻值中的“Ω”省去，
阻值在千欧以下的电阻，直接用数字+“R”表示；
阻值在千欧以上的，用“k”表示；
阻值在兆欧以上的，用“M”表示。
计算公式：



串联：$R = R_1 + R_2 + \cdots + R_n$。

并联：$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots + \frac{1}{R_n}$，特别地，两个电阻并联式也可表示为 $R = (R_1 \times R_2) \div (R_1 + R_2)$。

定义式：$R = U \div I$。

决定式：$R = \rho \times L \div S$（ρ表示电阻的电阻率，是由其本身性质决定，L表示电阻的长度，S表示电阻的横截面积）

但在实践中发现，有些色环电阻的排列顺序不甚分明，往往容易读错，
在识别时，可运用如下技巧加以判断：
技巧1：先找标志误差的色环，从而排定色环顺序。最常用的表示电阻误差的颜色是：金、银、棕，尤其是金环和银环，一般绝少用做电阻色环的第一环，所以在电阻上只要有金环和银环，就可以基本认定这是色环电阻的最末一环。
技巧2：棕色环是否是误差标志的判别。棕色环既常用做误差环，又常作为有效数字环，且常常在第一环和最末一环中同时出现，使人很难识别谁是第一环。
在实践中，可以按照色环之间的间隔加以判别：比如对于一个五道色环的电阻而言，第五环和第四环之间的间隔比第一环和第二环之间的间隔要宽一些，据此可判定色环的排列顺序。
技巧3：在仅靠色环间距还无法判定色环顺序的情况下，还可以利用电阻的生产序列值来加以判别。
比如有一个电阻的色环读序是：棕、黑、黑、黄、棕，其值为：
100×10000=1MΩ误差为1%，属于正常的电阻系列值，
若是反顺序读：棕、黄、黑、黑、棕，其值为140×1Ω=140Ω，误差为1%。

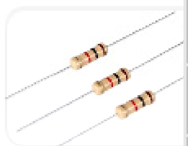
纯电容的交流电路　　电工技术与电子技术

小　结

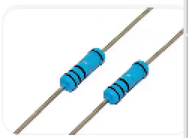
项目＼参数		电阻	电感	电容
阻抗或电抗		R	$X_L = 2\pi f L$	$X_C = \frac{1}{2\pi f C}$
u与i的关系	基本关系	$u = iR$	$u = L\frac{di}{dt}$	$i = C\frac{du}{dt}$
	相位关系	u与i同相位	U超前i 90°	u滞后i 90°
	有效值	$U = IR$	$U = IX_L$	$U = IX_C$
	相量式	$\dot{U} = \dot{I}R$	$\dot{U} = jX_L\dot{I}$	$\dot{U} = -jX_C\dot{I}$
功率	有功功率	$P = UI = \frac{U^2}{R} = I^2R$	0	0
	无功功率	0	$Q = UI = I^2X_L = U^2/X_L$	$Q = -UI = -I^2X_C = -U^2/X_C$

显然按照后一种排序所读出的电阻值，
在电阻的生产系列中是没有的，故后一种色环顺序是不对的。

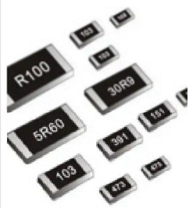
颜色	银	金	黑	棕	红	橙	黄	绿	蓝	紫	灰	白	无
有效数字	—	—	0	1	2	3	4	5	6	7	8	9	—
数量级	10^-2	10^-1	10^0	10 ^1	10^2	10^3	10^4	10^5	10^6	10^7	10^8	10^9	—
允许偏差（%）	±10	±5	—	±1	±2	—	—	±0.5	±0.25	±0.1	±0.05	—	±20
温度关系/（×10 /℃）	—	—	—	100	50	15	25	—	10	5	—	1	—



碳膜电阻



金属膜电阻



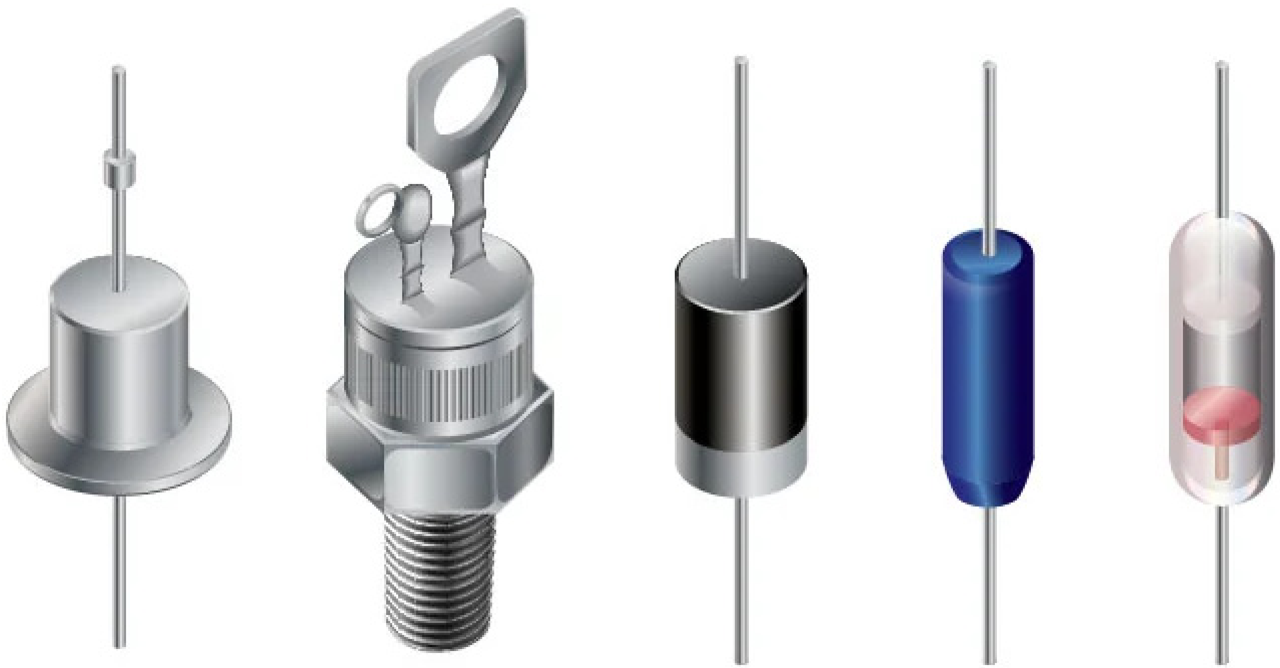
贴片电阻

水泥电阻

另外还有中间只有一道黑色色环的电阻 其阻值为零

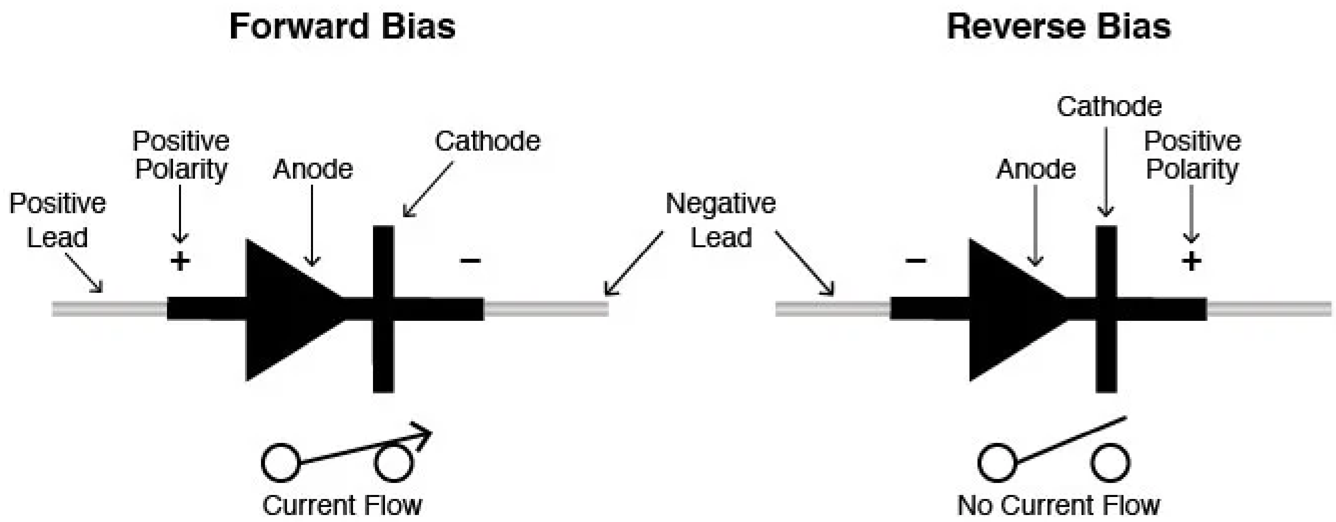
什么是二极管？

A diode is a semiconductor device, typically made of silicon, that essentially acts as a one-way switch for current. It allows current to flow easily in one direction but severely restricts current from flowing in the opposite direction.
Diodes are also known as rectifiers because they change alternating current (AC) into pulsating direct current (DC). Diodes are rated according to their type, voltage, and current capacity.



Diodes are available in various configurations. From left: metal case, stud mount, plastic case with band, plastic case with chamfer, glass case.

What Does a Diode Do?
Diodes have polarity, determined by an anode (positive lead) and cathode (negative lead). Most diodes allow current to flow only when positive voltage is applied to the anode. When a diode allows current flow, it is forward-biased. When a diode is reverse-biased, it acts as an insulator and does not permit current to flow.



Strange but true: The diode symbol's arrow points against the direction of electron flow. The reason is that engineers conceived the symbol, and their schematics show current flowing from the positive (+) side of the voltage source to the negative (-). It's the same convention used for semiconductor symbols that include arrows — the arrow points in the permitted direction of "conventional" flow, and against the permitted direction of electron flow.

Types of Diodes

Different diode types all perform key functions in an electrical system. Here are some of the most important types of diodes.

Rectifier Diodes: A rectifier diode converts AC into DC. Direct current flows in one consistent direction, making it easier to control.

Zener Diodes: Zener diodes are designed to protect electrical systems from overvoltage. They conduct current in reverse whenever the cathode reaches a predetermined threshold voltage.

Light Emitting Diodes: A light-emitting diode (LED) emits light when forward-biased current flows through it. LEDs are widely used in displays and indicators.

Schottky Diodes: Schottky diodes, also known as barrier diodes or hot-carrier diodes, are often used in high-speed applications because of their fast-switching capabilities and their low forward voltage drop.

Photodiodes: Photodiodes produce electrical currents when they absorb photons. They are widely used in sensors and in solar cells.

Diode Ratings and Testing

Every diode has a current and voltage rating, determined by factors like materials and design. Those ratings represent the maximum levels of voltage and currency the diode can tolerate.

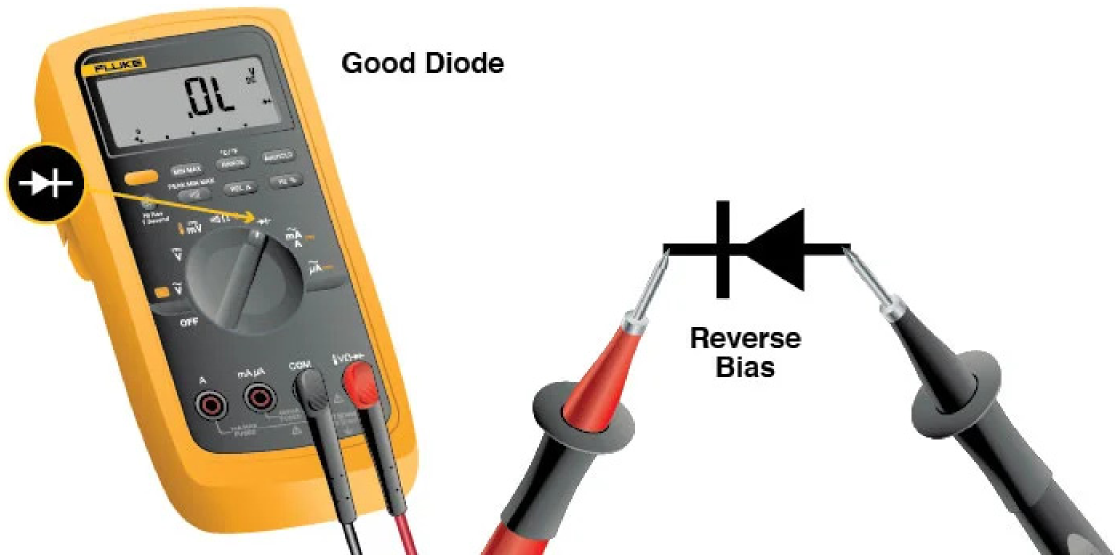
Exceeding currency and voltage levels can cause permanent damage to the diode or to the whole circuit. High voltage levels may also cause the diode to short circuit and either allow current to flow in both directions or halt current from flowing in either direction.

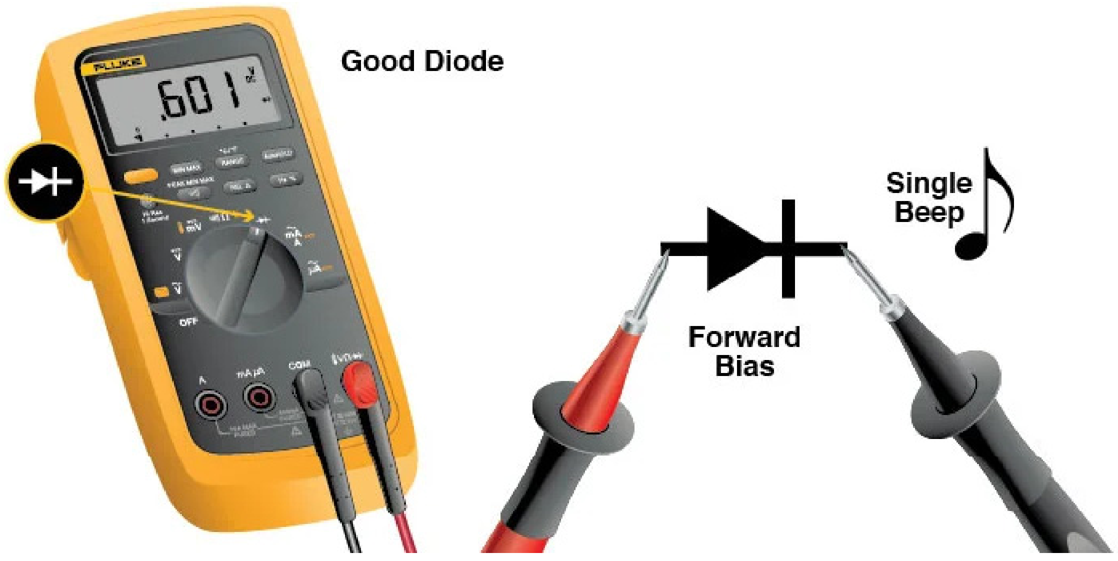
Proper diode function can be tested with a digital multimeter (DMM).

Testing Diodes with a Digital Multimeter

There are two methods of testing diodes using a digital multimeter: diode test mode and resistance mode. Diode test mode is by far the more effective means of testing. Resistance testing is less reliable and should only be used if the multimeter does not have a diode test mode.

A digital multimeter's diode test produces a small voltage between the test leads, enough to forward-bias a diode junction. A good forward-bias diode displays a voltage drop from 0.5 to 0.8 volts (for most silicon diodes). The meter will display ‘OL’ when a good diode is reverse-biased. OL will indicate the diode is functioning as an open switch.





The forward-biased resistance of a good diode should range from 1000 ohms to 10 Mohms. Thereverse-biased resistance on a good diode, will read OL The diode is bad if readings are the same in both directions.

Applications of Diodes

Power Conversion: Rectifiers convert AC signal into pulsing DC signal, making it easier to control the flow of power.

Signal Demodulation: Demodulation diodes are a critical part of radio receivers. The diodes retrieve the original message sent through the airwaves for transmission.

Overvoltage Protection: Zener diodes are used to protect circuits from unsafe voltage levels. They are also used to protect supply lines and power supply control lines.

Logic Gates: Diodes play a crucial role in modern computing and digital technology. They make it possible to reinforce binary systems through gates that perform simple logic functions, like and/or/not.

Case Study: Using Diodes with the Fluke 87V Digital Multimeter

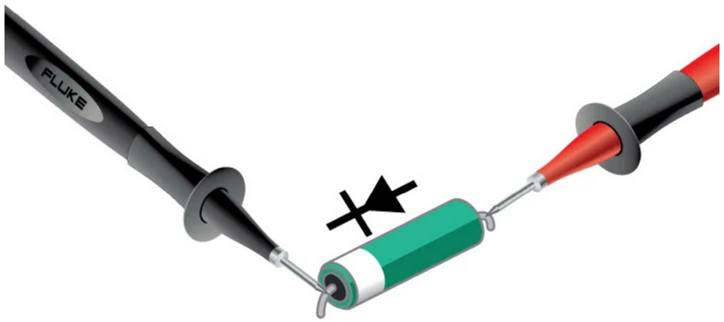
Scoreboards often use LEDs in connected series. When one diode fails, all or part of a segment often fails to light.

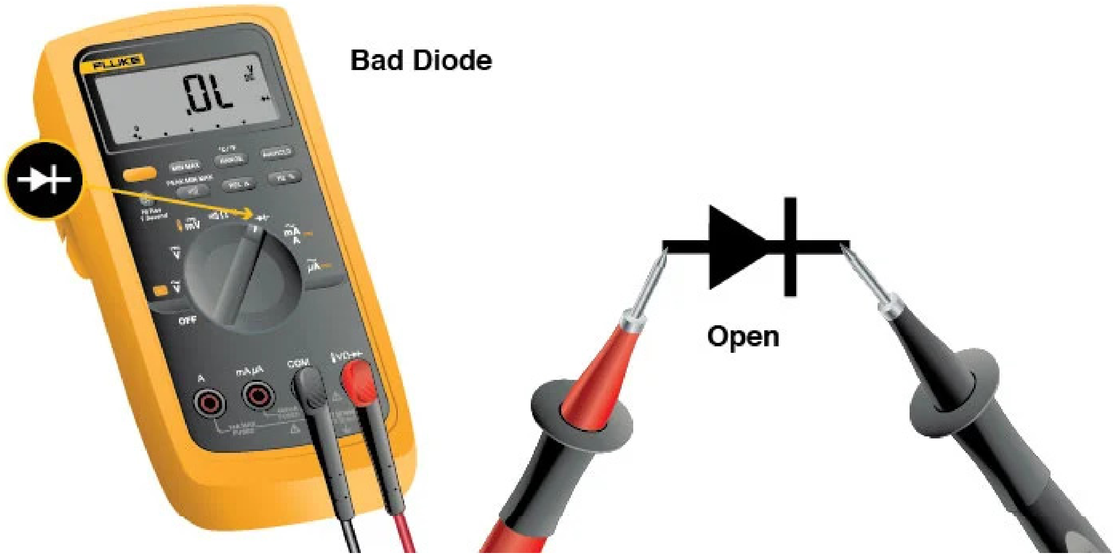
Solving this problem using legacy tools can be time-consuming: it means setting up a DC power source and resistor to test each LED individually.

Fortunately, the Fluke 87V Industrial Multimeter has a built-in diode test mode, so that technicians can identify the defective LED and fix the problem quickly. The process consists of just four steps:

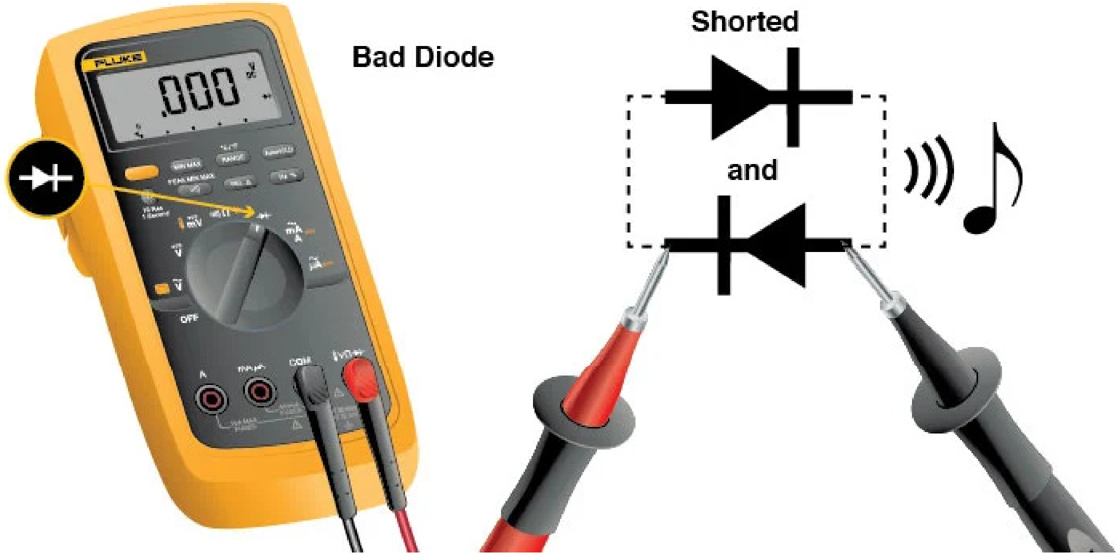
1. Verify that all power to the circuit is off and that all capacitors are discharged.
2. Set the multimeter to measure either AC or DC voltage, as needed. Turn the dial to diode test mode.
3. Connect the test leads to the diode and record the measurement displayed.
4. Reverse the test leads and record the measurement displayed.

This test pinpoints exactly which diodes are causing the trouble.





A shorted diode will have the same voltage reading in both directions (usually in the range of 0.4 volts).



Once the faulty diodes are identified, a technician can simply replace them, and the scoreboard should work like normal again.

Bad diodes, like the ones that brought down the scoreboard, stop current from flowing in both directions. The multimeter display will read OL for both steps three and four when measuring a bad diode.

Final Thoughts

Though small and simple, the diode is an essential part of modern electrical systems. By controlling the flow and direction of current, diodes enable countless applications of modern electronics. Fortunately, tools like digital multimeters make it easy to measure diode health and determine when it's time to replace diodes. This allows technicians to keep circuits in good running order, powering the electrical systems we all rely on.

什么是三极管？

内容主要概括为以下几个方面：

①认识三极管　　　②三极管的分类

③三极管的工作原理　　④三极管的3种状态

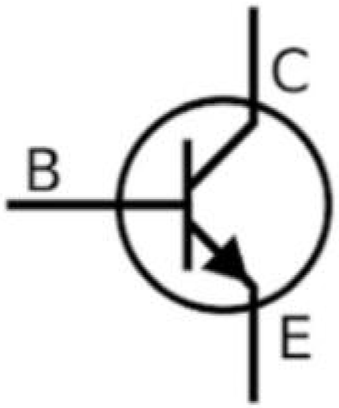
⑤三极管的功能及应用

一、什么是三极管？

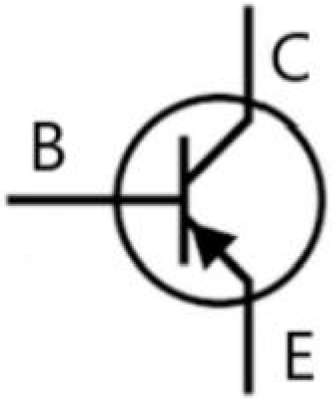
三极管，全称应为半导体三极管，也被称为双极型晶体管或晶体三极管，是一种控制电流的半导体器件。它的主要功能是将微弱的电信号放大成幅度值较大的电信号，同时也被用作无触点开关。

三极管的分类

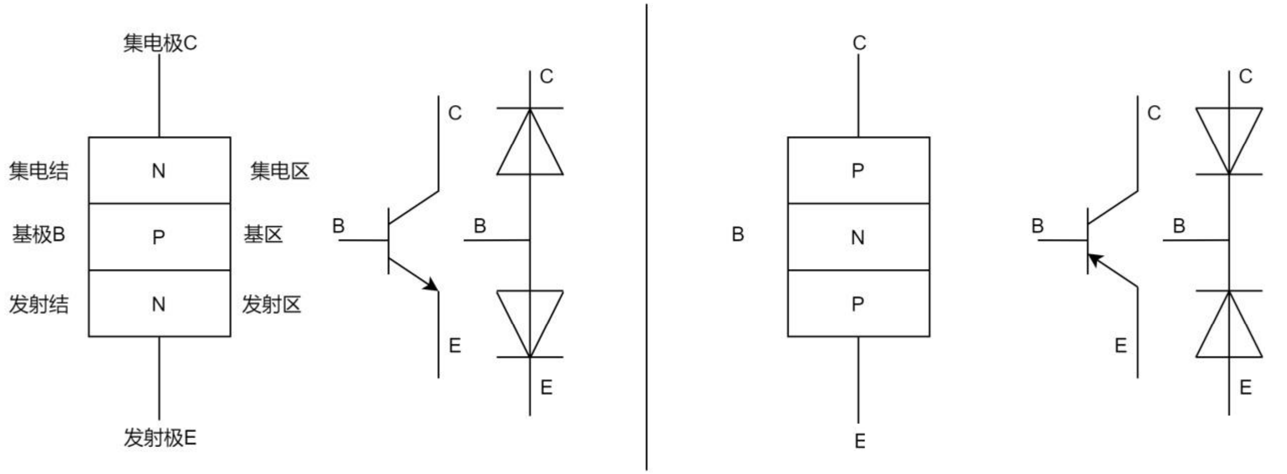
根据结构和工作原理的不同，三极管可以分为**NPN**型和**PNP**型两种类型。NPN型三极管的集电极和发射极都是N型半导体，而基极是P型半导体；相反，PNP型三极管的集电极和发射极都是P型半导体，而基极是N型半导体。



NPN



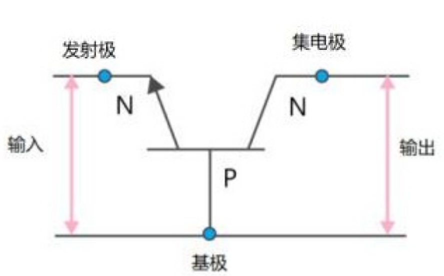
PNP



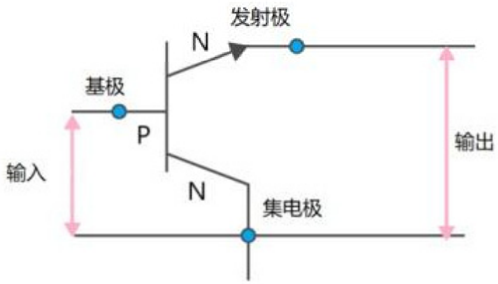
*三极管的两个PN结，类似于两个共阴或共阳的二极管。
与晶闸管和MOS管相比，三极管的特点是具有放大功能，而晶闸管和MOS管则没有这种功能。

二、三极管的工作原理

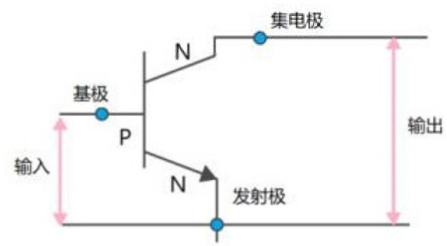
三极管的工作原理基于小电流控制大电流的原则，其工作机制像一个可控制的阀门。根据不同的工作状态和连接方式，三极管主要可以分为三种类型：共基极（CB）、共集电极（CC）和共发射极（CE）。



共基极



共集电极



共发射集

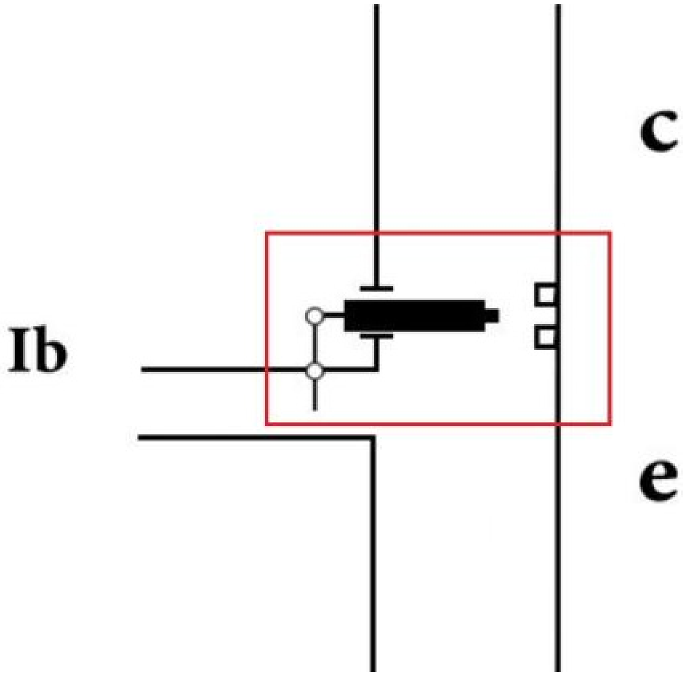
共基极（CB）：基极端子在输入和输出端子之间是公共的。
共集电极（CC）：集电极端子在输入和输出端子之间是公共的。
共发射极（CE）：发射极端子在输入和输出端子之间是公共的。

三极管的3种状态

三极管有三种状态：截止状态、放大状态和饱和状态。我们可以把三极管想象成一个水龙头。

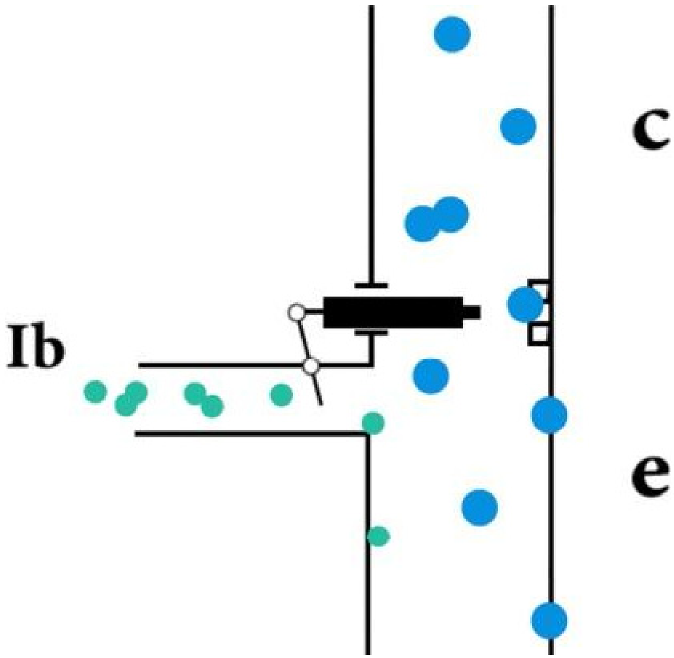
①截止状态

首先，当我们没有对水龙头施加任何外力时，水龙头是关闭的，水流无法通过，这时的状态相当于三极管的截止状态。

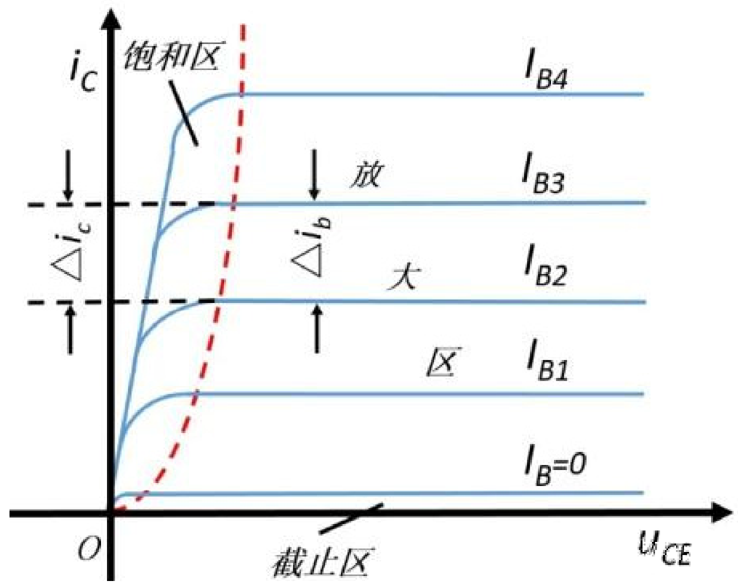


具体来说，就是加在三极管发射结的电压小于PN结的导通电压，基极电流为零，集电极电流和发射极电流都为零，三极管这时失去了电流放大作用，集电极和发射极之间相当于开关的断开状态。

②放大状态
当三极管发射结正偏，集电结反偏时，三极管就会进入放大状态。即当我们逐渐打开水龙头时，水会开始流出，这就相当于三极管进入了放大状态。

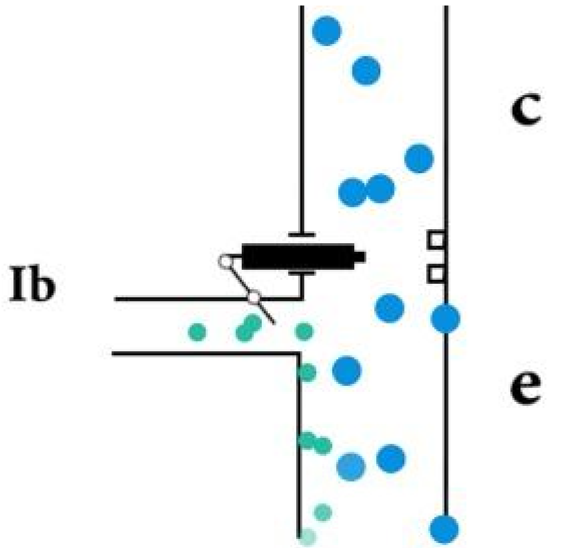


这里需要注意的是，这个“放大”并不是无中生有地创造能量，而是通过控制电流的大小来实现信号的放大。



③饱和状态

当三极管发射结正偏，集电结正偏时，三极管工作在饱和状态。饱和状态下的三极管基极电流即使变大，集电极电流也不会增大，相当于水龙头完全打开时，水流已经最大。



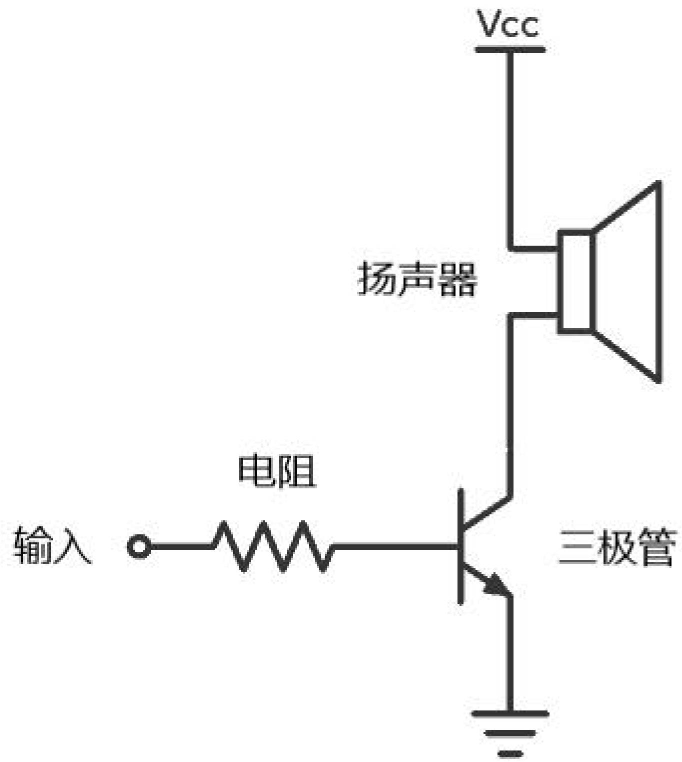
三、三极管的应用

①放大作用

三极管最主要的功能就是放大功能。通过控制输入信号的大小，三极管可以对电流进行放大，从而实现对信号的增强。其基于小电流控制大电流的原则，通过较小的基极电流IB来控制较大的集电极电流IC。当基极电流IB有微小的变化时，会引发集电极电流IC和发射极电流IE的大幅度变化。这种“放大”并非将基极电流IB放大，而是通过控制输入信号的大小，使输出信号得到增强。

三极管的放大功能实现还要求基极和发射极之间加正向电压（**发射结正偏**），基极与集电极之间加反向电压（**集电结反偏**）。

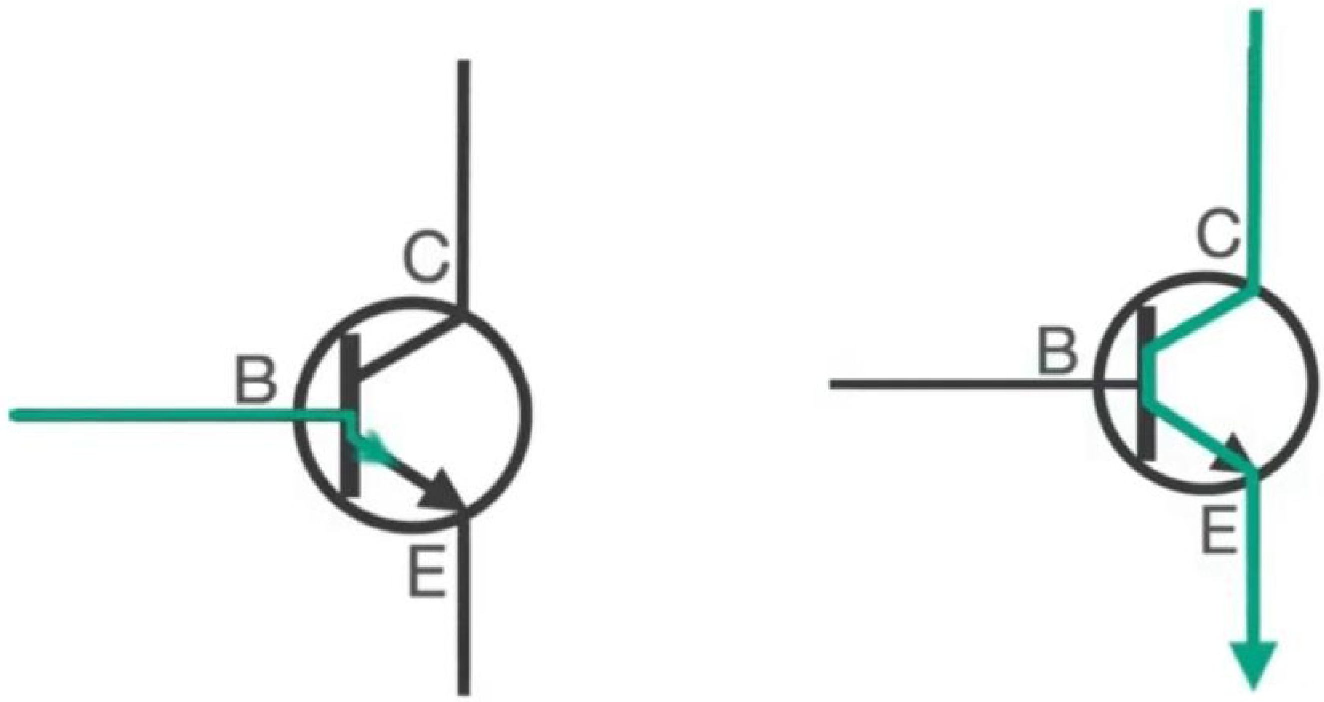
这种放大功能被广泛应用于放大器、功率放大器等电路中。例如，在音频放大器中，三极管可以将微弱的声音信号放大为足够大的声音输出。



示例：简单的放大器来驱动扬声器

②开关控制

三极管可以通过控制输入信号的高低电平，以实现对电路的开关控制。开关作用基于三极管在电路中导通或截止的特性。这种开关功能被广泛应用于逻辑门电路、计数器、计时器等电路中。

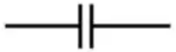
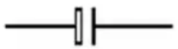
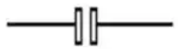
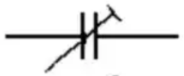
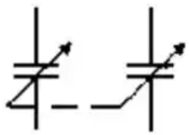


③稳压功能

三极管还具有稳压功能，可以用于稳定电压。通过调整三极管的工作状态，可以使电路的输出电压保持稳定。在稳压电源、电池充电器中应用较多。

什么是电容？

电容（Capacitor）是一种能够储存电荷的元件，它有两个电极板，当两个电极板之间有电压差时，就会产生电荷的积累。电容在电路中用字母C表示，单位是F（法拉）。当电容器的两个极板之间加上电压时，极板上的电荷会发生变化，产生一个电场，这个电场会使得电容器中的电荷保持在两个极板之间，从而实现电荷的储存。当电压消失时，电容器中的电荷仍然会保持在两个极板之间，这就是电容的储能特性。

图形符号	名称
	一般无极性电容器
	有极性电解电容器
	无极性电解电容器
	微调电容器
	可变电容器
	双联可变电容器

型号				
符号	瓷介	云母	有机	电解
1	圆形	非密封	非密封	箔式
2	管形	非密封	非密封	箔式
3	叠片	密封	密封	烧结粉液体
4	独石	密封	密封	烧结粉液体
5	穿心	/	穿心	/
6	支柱形	/	/	/
7	/	/	/	无极性
8	高压	高压	高压	/
9	/	/	特殊	特殊

常见电容

固定电容：固定电容是一种无极性的电容器，其电容值在一定范围内是固定的。固定电容通常用于低频电路中。

可变电容：顾名思义，是可以改变电容值的电容，可变电容的电容值可以通过旋转或滑动调节。可变电容在调谐电路和滤波电路中比较常见。

陶瓷电容：以陶瓷材料为介质的电容器叫陶瓷电容，陶瓷材料可以有很多种。陶瓷电容具有体积小、容量大、稳定性好等特点，多用于高频电路。另外，陶瓷电容容易碎裂。

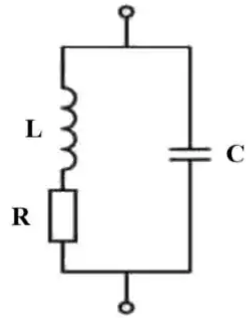
电解电容：以电解质为介质的电容器。电解电容具有电容值大、损耗低等特点。电解电容多用于电源滤波和耦合电路。电解电容一般都会有储能的作用。

电容的特性

①隔直流通交流、耦合：电容可以起到隔直流，通交流的作用，实现不同电路之间的信号耦合，将一个电路的信号传递到另一个电路中。
②滤波、整流：可以使用电容来滤除电源中不同频率的交流干扰信号，只保留需要的频率分量，以便输出稳定干净的直流信号。
③储能作用：电容可以将电能转化为其他形式的能量，如热能、光能等。因此，在一些特殊应用中，电容可以代替电池，起到储能作用。在交流电路中应用较多的是电容器作功率储存器件。
④谐振：电容和电感进行组合可以设计出不同形式的谐振电路。

串联谐振回路

并联谐振回路



给谐振电路注入和谐振频率相同的信号，谐振电路就会产生谐振。谐振计算公式：
$F = 1/(2\pi\sqrt{LC})$。谐振频率仅由电感L和电容C决定，电阻R决定谐振电路的品质因数。
⑤计时：无论是充电还是放电，电容两端的电压是不能突变的。利用电容这一特性，同时在电路中并联一个电阻，起到控制放电时间的作用。
⑥自愈：当电路发生故障时，电容可以吸收电流而使故障自动消除。当两个电路计划连接起来时，必须用电容将两个电路连接起来。

什么是电感

电感（**Inductor**）是一种能够储存磁场能量的元件，可以把电能转换成磁能储能起来。常用字母“L”表示电感。电感由一个线圈组成，当电流通过线圈时，线圈周围会产生磁场。当电流通过电感线圈时，线圈周围会产生磁场。当电流发生变化时，磁场也会随之变化，产生一个电动势。这个电动势会阻碍电流的变化，从而实现电流的平滑和稳定；当电流消失时，线圈周围的磁场仍然存在。

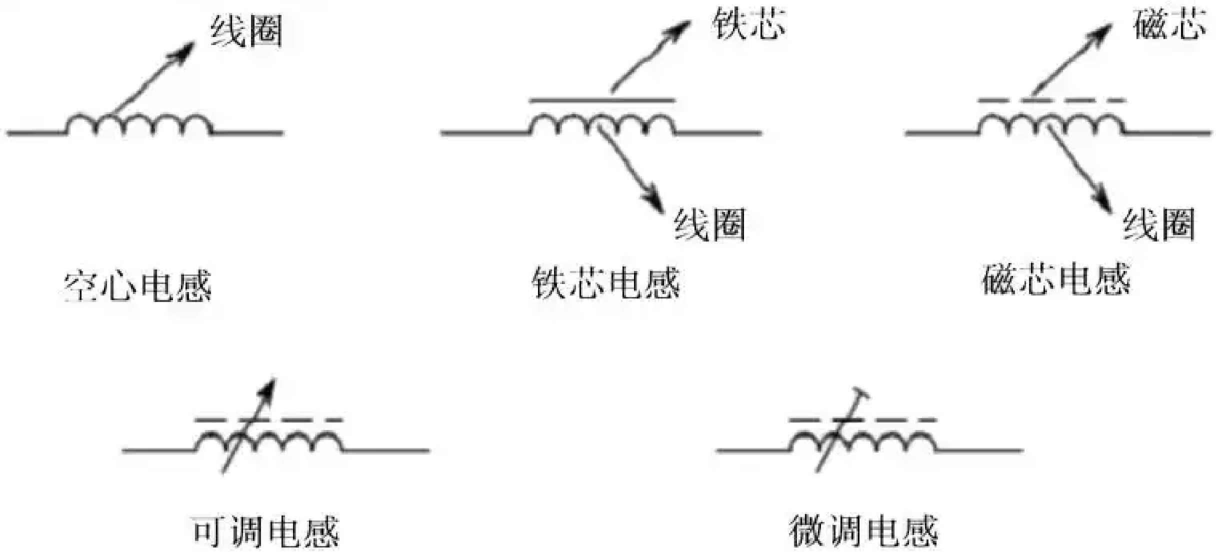
常见电感

固定电感：固定电感的电感值在一定范围内是固定的。固定电感通常用于低频电路中。

可调电感：可调电感可以改变电感值，通常通过调节线圈的匝数或气隙来实现。可调电感通常用于调谐电路和滤波电路中。

空心电感：空心电感没有磁芯，电感值非常小、损耗低，一般使用在高频电路中，比如收音机的谐振选频电路中。

铁芯电感：体积大、重量大，具有高磁导率和低损耗等特点。铁芯电感通常用于功率变压器和电源滤波器中。



电感的特性

阻交流通直流：电感对直流呈现很小的电阻，相当于短路；而对交流呈现的阻抗与信号频率成正比，交流信号频率越高，电感的阻抗越大。（与电容相反）

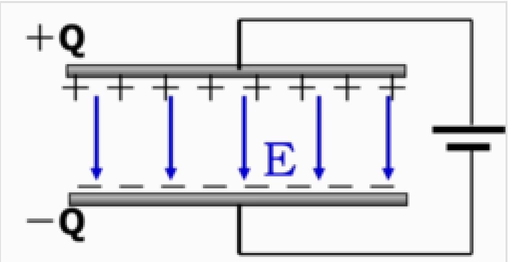
流过电感的电流不会发生突变，电感在电路最常见的作用就是与电容一起，组成LC滤波电路。

电容和电感的主要区别

功能作用：电容是通过电荷的累积来存储能量的，而电感是通过磁场能量的累积来存储能量的。电容“阻直流通交流”，电容两端的电压是不能突变；电感“阻交流通直流”，流过电感的电流不会发生突变。

容抗和感抗：容抗是电阻对交流信号的阻碍作用，与频率成正比；而感抗是电感对交流信号的阻碍作用，与频率成反比。因此，在相同频率下，容抗大于感抗；而在相同阻抗下，容抗小于感抗。

响应速度：由于电容的充电和放电过程较快，因此电容对交流信号的响应速度较快；而电感的储能和释能过程较慢，对交流信号的响应速度较慢。



电容充电过程

电感图样

CSD 大电流数字功放电感

- 2合1结构，节省空间
- 高音质，低失真

CPD 大电流数字功放电感

- 防辐射干扰的磁屏蔽结构
- 低损耗材质，大功率输出，高音质

CPE 大电流数字功放电感

- 立式2合1结构，节省空间
- 大电流，低磁损，低阻抗

TCS 磁环电感

- 环形磁芯结构紧凑
- 电磁干扰小，可定制

SPF 贴片功率电感

- 开磁路结构
- 耐震动性能强

SPBL 贴片功率电感

- 耐震动性能强
- 磁屏蔽结构

SPRH 贴片功率电感

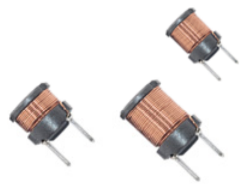
- 磁屏蔽结构
- 适合高密度贴装

RKR 磁棒电感

- 高饱和电流
- 低直流电阻

PK 插件工字电感

- 非屏蔽、通孔插装
- 可根据客户需求提供定制产品



PKS 插件工字电感

- 非屏蔽、通孔插装
- 可根据客户需求提供定制产品

PRD 插件工字电感

- 电磁屏蔽，减少电磁干扰
- 低成本，高效率

CPQX 超级大电流电感

- 使用扁平线，低电阻
- 具有高饱和电流负载能力

什么是真有效值？

A **true-RMS** device (RMS = root mean square) is one of three tools that can measure alternating current (ac) or ac voltage:

True-RMS digital multimeters (or clamp meter)

Average-responding digital multimeter (or clamp meter)

Oscilloscope

Only the first two tools are commonly used, and both can accurately measure standard (pure ac) sinusoidal waveforms.

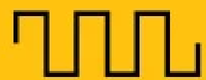
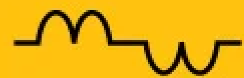
Yet a true-RMS meter is widely preferred because it is the only one that can accurately measure both sinusoidal and non-sinusoidal ac waveforms.

Sinusoidal (sine) waves: Pure, without distortion, with symmetrical transitions between peaks and valleys.

Nonsinusoidal waves: Waves with distorted, irregular patterns—spikes, pulse trains, squares, triangles, sawtooth and any other ragged or angular waves.

How to calculate RMS

As mentioned previously, **RMS = root mean square.** Though its formula can be challenging to grasp, RMS essentially **calculates the equivalent direct current (dc) value of an ac waveform**. More technically, it determines the "effective," or dc heating value, of any ac wave shape.
An **average-responding meter** uses averaging mathematical formulas to accurately measure pure sinusoidal waves. It can measure non-sinusoidal waves, but with uncertain accuracy.
A more sophisticated **true-RMS meter** can accurately measure both pure waves and the more complex non-sinusoidal waves. Waveforms can be distorted by nonlinear loads such as variable speed drives or computers. An averaging meter attempting to measure distorted waves can be up to 40% low or 10% high in its calculations.

Multimeter type	**Response to sine wave** 	**Response to square wave** 	**Response to single phase diode rectifier** 	**Response to 3 $\varnothing$ diode rectifier** 
Average responding	Correct	10 % high	40 % low	5 % to 30 % low
True-rms	Correct	Correct	Correct	Correct

Where to measure true-RMS

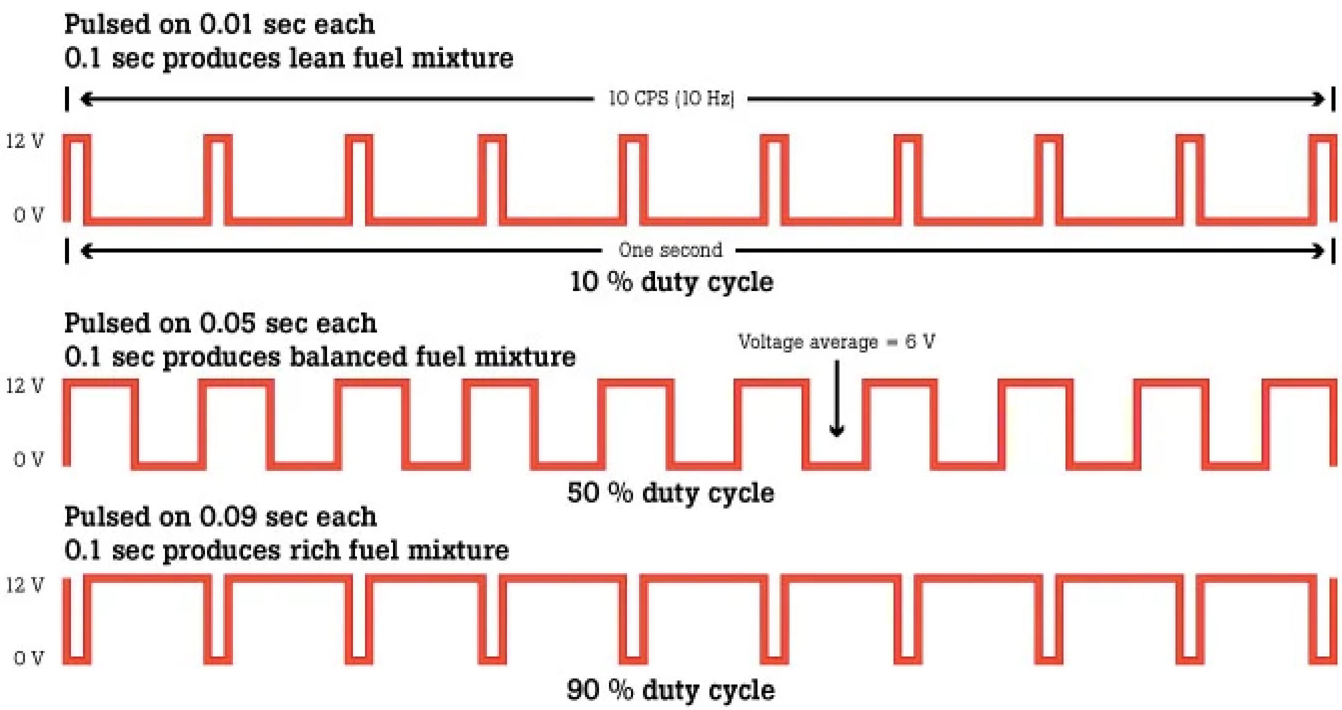
The need for true-RMS meters has grown as the possibility of non-sinusoidal waves in circuits has greatly increased in recent years. Some examples:
Variable-speed motor drives / Electronic ballasts / Computers / HVAC / Solid-state environments

In these environments, current occurs in short pulses rather than the smooth sine wave drawn by a standard induction motor. The current wave shape can have a dramatic effect on a current clamp reading. In addition, a true-RMS meter is the better choice for taking measurements on power lines where ac characteristics are unknown.

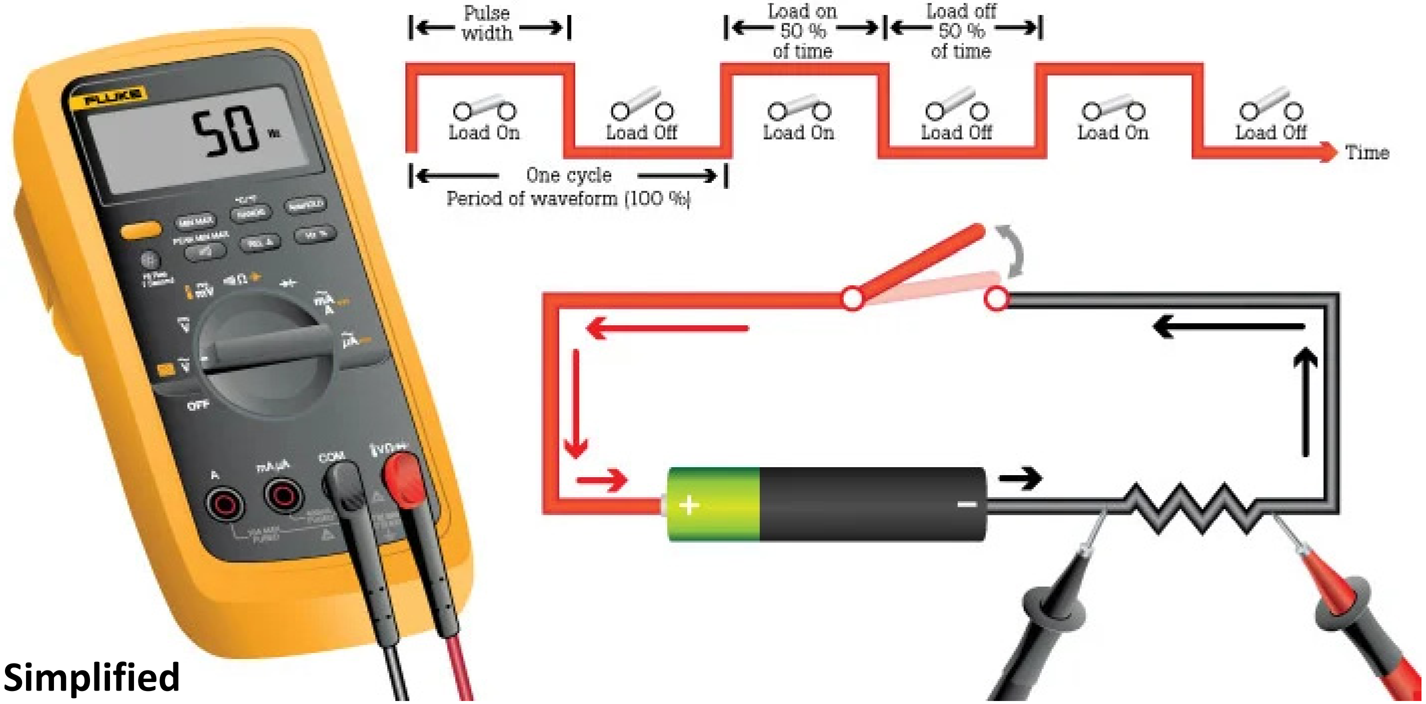
Reference: Digital Multimeter Principles by Glen A. Mazur, American Technical Publishers.

什么是占空比？

Duty cycle is the ratio of time a load or circuit is ON compared to the time the load or circuit is OFF.
Duty cycle, sometimes called "duty factor," is expressed as a percentage of ON time. A 60% duty cycle is a signal that is ON 60% of the time and OFF the other 40%.



Graphical representation of duty cycle, or duty factor, at 10%, 50%, and 90%.Many loads are rapidly cycled on and off by a fast-acting electronic switch which accurately controls the output power of the load. Load operation—such as lamp brightness, heating element outputs and the magnetic strength of a coil—can be duty cycle-controlled by ON and OFF time periods or cycles per second.



Duty Cycle, Simplified

If the valve is pulsed ON at variable durations (called pulse-width modulation), the duty cycle varies. If it is pulsed ON for 0.05 seconds in a 0.1-second cycle, the fuel injector duty cycle equals 50%. If it pulsed ON for 0.09 seconds of that same 0.1-second cycle, the fuel injector duty cycle equals 90%.

Example of Duty Cycle in Automotive

In an automotive electronic fuel injection system, voltage pulses supplied to the fuel injector valve solenoid control the fuel injector valve at a fixed rate of 10 cycles per second, or 10 Hz.

Pulse width modulation allows fuel supplied to the engine to be precisely controlled electronically. The voltage average for each duty cycle is determined by the amount of pulse ON time.

Duty cycled solenoids use a variable duty cycle signal to vary flow or adjust pressure. The longer a solenoid remains open, the more flow and less pressure develops. These solenoids are either feed-controlled or ground-controlled.

What is a Pulse Width?

Pulse width is a measure of the actual ON time, measured in milliseconds. The OFF time does not affect signal pulse width. The only value being measured is how long the signal is ON (ground-controlled).

什么是欧姆定律？

Ohm’s Law is a fundamental principle in electronics and electrical engineering. It defines the relationship between three essential electrical quantities: voltage, current, and resistance. Whether you're a technician, or engineer, understanding Ohm’s Law is crucial for calibration, analyzing, and troubleshooting electrical circuits.

The Ohm's Law formula

To students of electronics, the Ohm's Law formula (E = IR) is as fundamentally important as Einstein's Relativity equation ($E = mc^2$) is to physicists.

E = I x R

When spelled out, it means **voltage = current x resistance**, or **volts = amps x ohms**, or **V = A x Ω**.

Who Was Georg Ohm?

Ohm’s Law is named after Georg Simon Ohm, a German physicist who published his findings in 1827. His experiments demonstrated that the electric current through a conductor is directly proportional to the voltage and inversely proportional to the resistance. Ohm's Law addresses the key quantities at work in circuits:

Key Electrical Elements Explained

Here’s a quick breakdown of the three core elements in Ohm’s Law:

Quantity	Ohm's Law symbol	Unit of measure (abbreviation)	Role in circuits	In case you're wondering:
Voltage	E	Volt (V)	Pressure that triggers electron flow	E = electromotive force (old-school term)
Current	I	Ampere, amp (A)	Rate of electron flow	I = intensity
Resistance	R	Ohm (Ω)	Flow inhibitor	Ω = Greek letter omega

How to Use Ohm’s Law

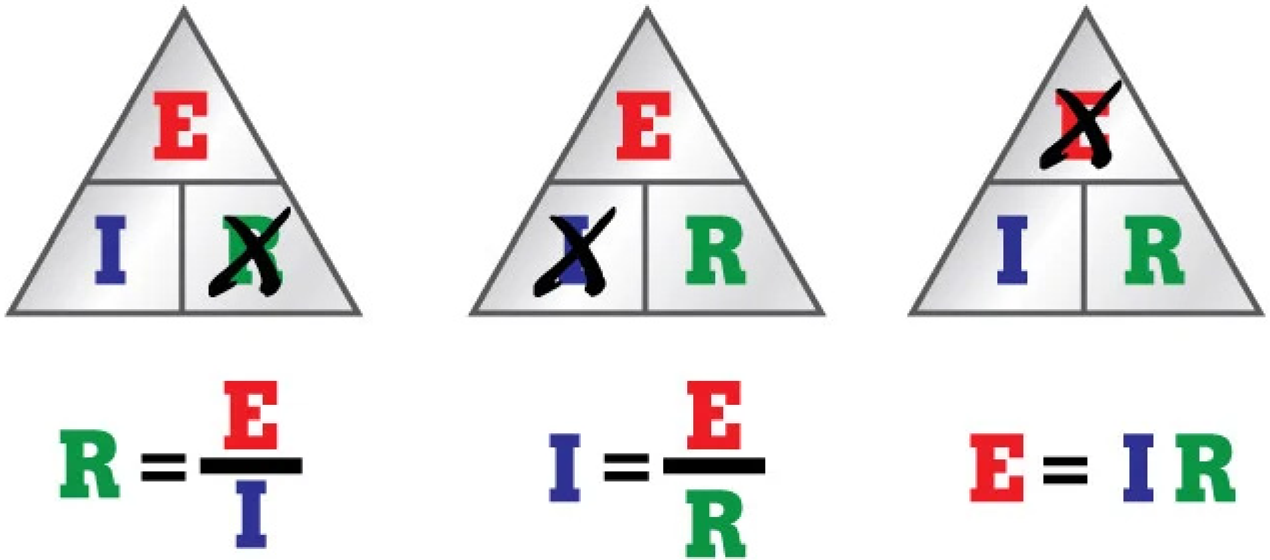
Ohm’s Law can be rearranged depending on which values you know:

To find current (I): $I = V / R$

To find resistance (R): $R = V / I$

To find voltage (V): $V = I \times R$

These formulas are especially useful when direct measurement isn’t possible, such as calculating resistance in a live circuit where disconnecting components isn’t practical. As long as two of these values are known, technicians can reconfigure Ohm's Law to calculate the third. Just modify the pyramid as follows:



If you know voltage (E) and current (I) and want to know resistance (R), X-out the R in the pyramid and calculate the remaining equation (see the first, or far left, pyramid above).

Note: Resistance cannot be measured in an operating circuit, so Ohm's Law is especially useful when it needs to be calculated. Rather than shutting off the circuit to measure resistance, a technician can determine R using the above variation of Ohm's Law.

Current Formula

If you know voltage (E) and resistance (R) and want to know **current** (I), X-out the I and calculate the remaining two symbols.

I = E/R

Voltage Formula

If you know current (I) and resistance (R) and want to know **voltage** (E), multiply the bottom halves of the pyramid.

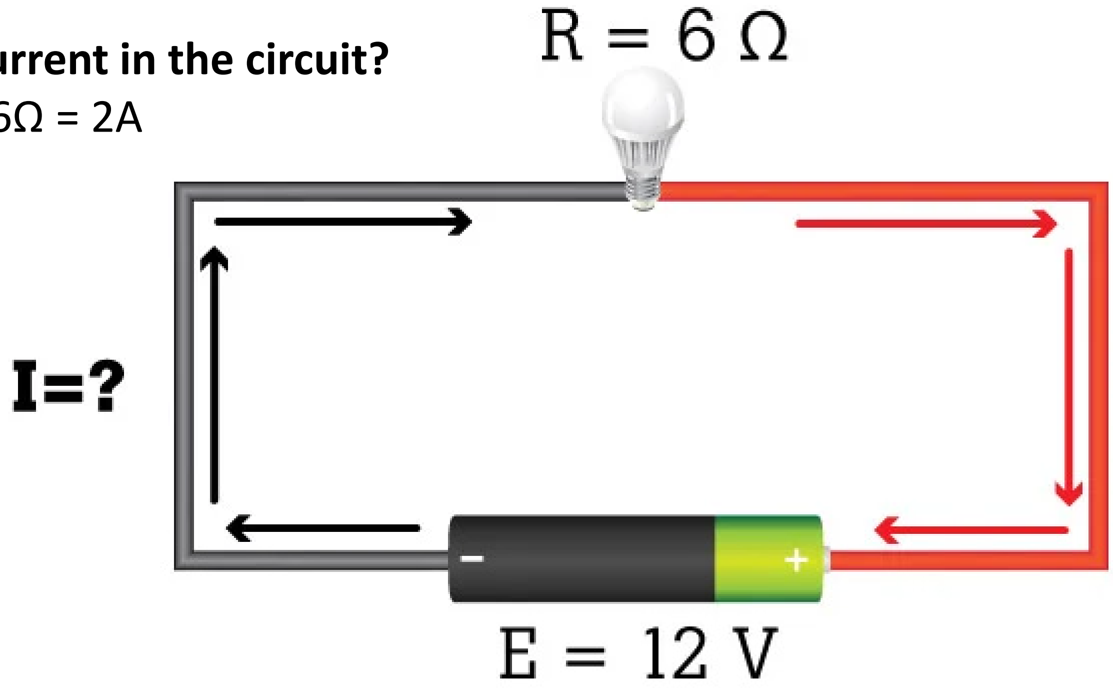
E = I*R

Try a few sample calculations based on a simple series circuit, which includes just one source of voltage (battery) and resistance (light). Two values are known in each example. Use Ohm's Law to calculate the third.

Example 1: Voltage (E) and resistance (R) are known.

What is the current in the circuit?

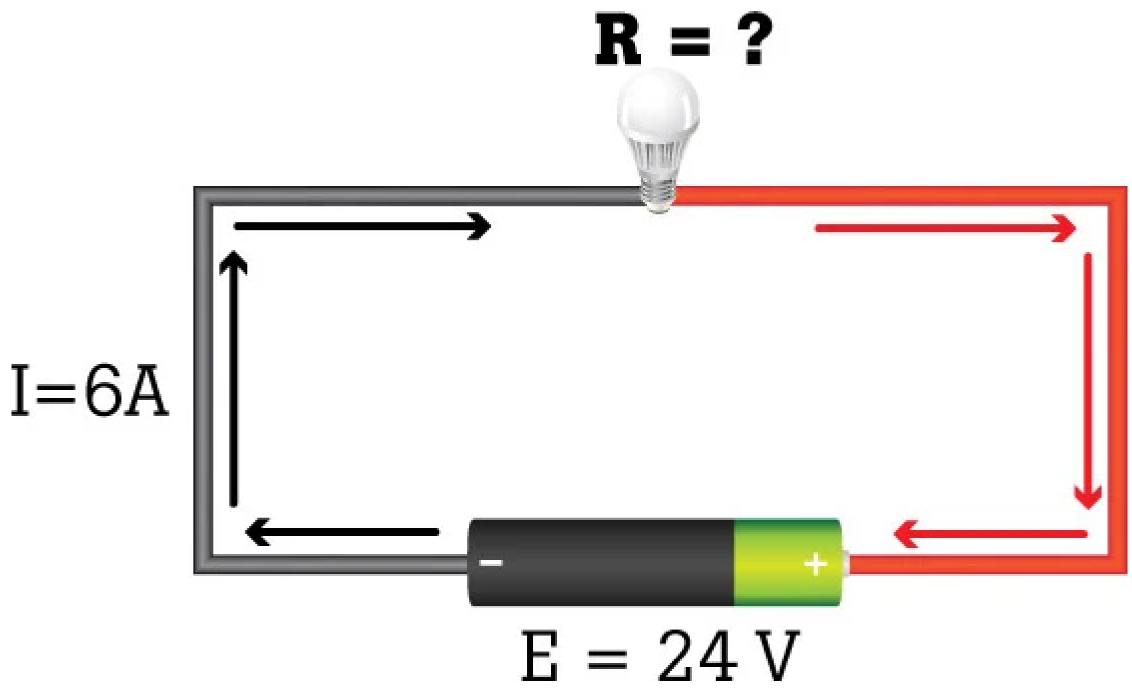
$I = E/R = 12V/6\Omega = 2A$



Example 2: Voltage (E) and current (I) are known.

What is the resistance created by the lamp?

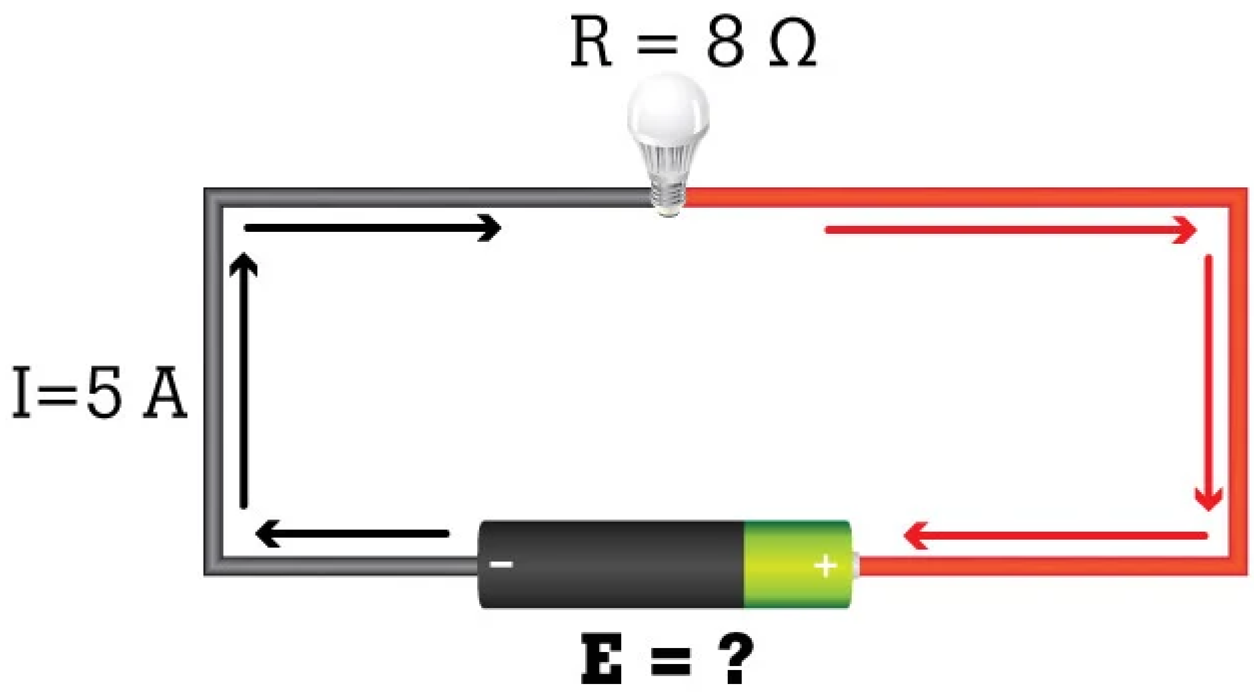
R = E/I = 24V/6A = 4Ω



Example 3: Current (I) and resistance (R) are known. What is the voltage?

What is the voltage in the circuit?

$E = I \times R = (5A)(8\Omega) = 40\ V$



When Ohm published his formula in 1827, his key finding was that the amount of electric current flowing through a conductor is **directly proportional** to the voltage imposed on it. In other words, one volt of pressure is required to push one amp of current through one ohm of resistance.

Why Ohm’s Law Matters in the Field
Technicians use Ohm’s Law to validate circuit behavior and diagnose issues. For example:
Unexpected current levels may indicate a change in resistance or voltage.
Low current in a DC circuit could point to increased resistance from corrosion or loose connections.
High current might suggest a short circuit or a failed component.
By comparing measured values to expected ones (often found on equipment nameplates), technicians can pinpoint faults without dismantling the circuit.
What Ohm’s Law Can Validate
Ohm’s Law can be used to validate the static values of circuit components, current levels, voltage supplies, and voltage drops. If, for example, a test instrument detects a higher than normal current measurement, it could mean that resistance has decreased or that voltage has increased, causing a high-voltage situation. This could indicate a supply or circuit issue.
In direct current (dc) circuits, a lower than normal current measurement could mean that the voltage has decreased, or circuit resistance has increased. Possible causes for increased resistance are poor or loose connections, corrosion and/or damaged components.
Loads within a circuit draw on electrical current. Loads can be any sort of component: small electrical devices, computers, household appliances or a large motor. Most of these components (loads) have a nameplate or informational sticker attached. These nameplates provide safety certification and multiple reference numbers.
Technicians refer to nameplates on components to learn standard voltage and current values. During testing, if technicians find that customary values do not register on their digital multimeters or clamp meters, they can use Ohm's Law to detect what part of a circuit is faltering and from that determine where a problem may lie.
The basic science of circuits
Circuits, like all matter, are made of atoms. Atoms consist of subatomic particles:
Protons (with a positive electrical charge)
Neutrons (no charge)
Electrons (negatively charged)
Atoms remain bound together by forces of attraction between an atom's nucleus and electrons in its outer shell. When influenced by voltage, atoms in a circuit begin to reform and their components exert a potential of attraction known as a potential difference. Mutually attracted loose electrons move toward protons, creating a flow of electrons (current). Any material in the circuit that restricts this flow is considered resistance.