自动化专业本科系列教材

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自动化专业英语

王军　宋舒　主编

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Specialized English for Automation

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内 容 提 要

本书共包括6个部分的内容：即控制理论、电力电子技术、计算机控制技术、电力传动、过程控制、建筑电气及供电技术。

全书共30个单元，每个单元包括2篇文章和1篇专业英语知识介绍，基本覆盖了自动化专业技术基础课所学内容。适合作为高等院校自动化专业或电气工程及其自动化专业、信息工程专业的本科教材。

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前言

本书是根据国家教育部普通高等院校自动化专业本科生专业英语教学大纲的要求，在作者长期从事专业英语课程教学实践的基础上编写的。

《自动化专业英语》可作为高等院校自动化专业或电气工程及其自动化专业、信息工程专业本科教材。教育部颁布的“大学生英语教学大纲”中，把专业英语列为必修课而纳入英语教学计划，强调通过四年不断线教学使学生达到顺利阅读专业书刊和文选的目的。大学生在经过两年基础英语的学习以后，已具备了较扎实的英语基础。进入三年级后，随着专业英语的训练，在保证足够的阅读量基础上，对本专业外文资料的阅读才能达到基本要求。本书是根据上述规定和要求，结合专业特点而编写的一套科技英语教材，其中涉及控制理论、电力电子技术、计算机技术、电力传动和过程控制等多个学科。本教材在编写中力求做到覆盖面较广、内容新颖、文本规范和难度适中。

全书共包括 6 个部分，即控制理论、电力电子技术、计算机控制技术、电力传动、过程控制、建筑电气及供电技术，共 30 个单元。每个单元包括 2 篇文章和 1 篇专业英语知识介绍，基本覆盖了自动化专业技术基础课所学内容。通过本教材的学习，学生能基本掌握本学科中各类专业文献的阅读、翻译和写作能力，掌握在专业英语中英语的运用能力。

本书由四川工业学院王军任主编，长安大学宋舒任副主编，昆明理工大学高雅莉任参编。书中 PART Ⅰ 由宋舒编写，PART Ⅱ，PART Ⅴ 和 PART Ⅵ 由王军编写，PART Ⅲ，PART Ⅳ 由高雅莉编写。郑陆清担任主审。

由于编者水平有限，书中恐有不少疏漏和不当之处，请读者不吝指教，我们将不胜感激。

编者

2002 年 8 月

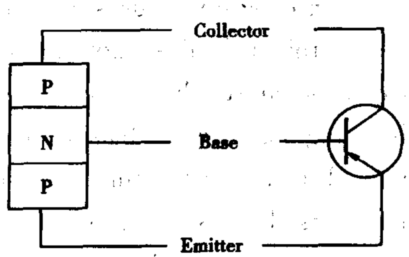
目录

Part Ⅰ
Electronic Technology

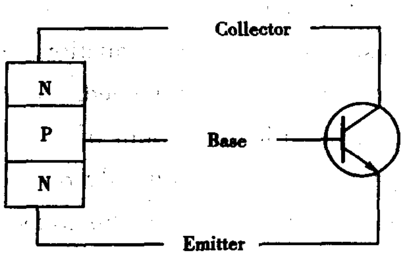
Unit 1

1.1 Bipolar Junction Transistors

Today, industrial electronic systems employ several devices that are described by the term transistor. Each type of transistor has different characteristics and operational conditions that are used to distinguish it from others. In the first part of this discussion, we are concerned with the bipolar junction transistor. Structurally, this transistor is described as bipolar because it has two different current-carrier polarities. Holes are positive current carriers, whereas electrons are negative current carriers. Two distinct kinds of semiconductor crystals are connected together by a common element. The structure of this device is similar to that of two diodes connected back to back; with one crystal being common to both junctions. The center material is usually made thinner than the two outside pieces. Figure 1.1 shows the crystal structure, element names, and schematic symbols of two distinct types of bipolar transistors.



(A) PNP transistor



(B) NPN transistor

Fig. 1.1 PNP and NPN transistors

A bipolar transistor is primarily used as an amplifying device that regulates the amount of current that passes through it. Current from the energy source enters the emitter, flows through the base region, and exits through the collector. Variations in collector current are usually identified as the output of a transistor. Collector current is controlled by a small change in base current. This relationship is described as current gain or beta. Expressed mathematically,

$$\text{Current gain} = \frac{\text{collector-current}}{\text{base-current}}$$

$$(\text{Beta}) = \frac{I_C}{\Delta I_B}$$

The Greek letter delta of this formula indicates a change value. This is used to denote the response of a transistor when ac values are applied. Conditions of this type are called dynamic characteristics. Omission of the delta sign in a formula denotes dc or static operating conditions.

All the current entering a transistor at the emitter is identified as emitter current, or I_E. The collector current, or I_C, is always somewhat less than I_E. The difference between I_E and I_C is due to base current. Mathematically, this is base current (I_B) = emitter current—collector current

$$I_B = I_E - I_C$$

Example 1-1: Determine the base current of a bipolar transistor with an I_E of 11 mA and an I_C of 10.95 mA.

Solution:

$$I_B = I_E - I_C = 11\ \text{mA} - 10.95\ \text{mA} = 0.05\ \text{mA or } 0.05 \times 10^{-3}\ \text{A}$$

Fig. 1.2 shows the circuit connections of a simple NPN silicon transistor. Operation of this circuit is based on a forward-biased emitter-base junction and a reverse-biased collector. Forward biasing of the emitter-base junction is accomplished by connecting the negative side of the dc source to the emitter and the positive side through R_B to the base. Reverse biasing of the collector occurs when it is connected to the positive side of the source through resistor R_L. Collector current through R_L is controlled by the forward-bias voltage of the emitter-base junction.

In the operation of a single PN diode junction, forward biasing causes conduction and reverse biasing causes nonconduction. In a transistor, this rule does not apply directly because two junctions are involved. For example, when the emitter-base junction is forward biased, it causes a large amount of I_E to enter the base region. Reverse biasing of the base-collector junction would ordinarily restrict this current. But due to the thin base structure, I_E will immediately enter into the collector when it reaches the base area. Ultimately, this current passes through the collector and appears as collector current I_C or output current. Forward biasing of the emitter-base junction therefore alters or reduces the reverse biasing effect of the base-collector junction in normal transistor operation.

A transistor is primarily classified as a current-operating device. This means that the output or collector I_C will occur only when the emitter-base junction is forward biased and producing base current. When the base current ceases, collector current stops and the transistor become nonconductive. This condition is called *cut off* on the other hand, if an excessive amount of base current occurs, the transistor is driven into *saturation*. When this condition occurs, a further increase in I_B will not cause a corresponding change in I_C. When amplitude control is being achieved, a transistor is rarely operated in the saturation region. When a transistor is used as a switch, it usually operates in the saturation region.

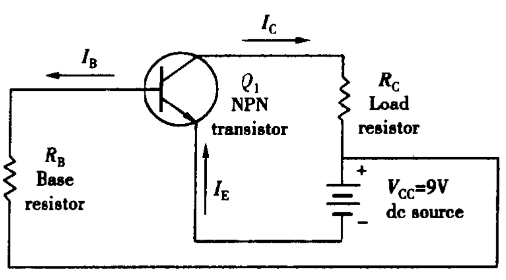


Fig. 1. 2 NPN transistor circuits

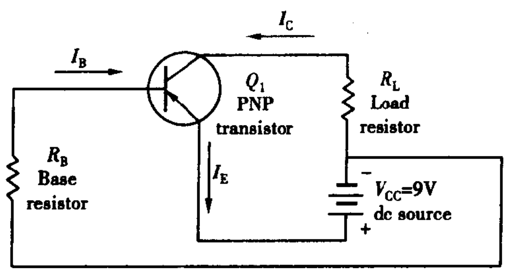


Fig. 1. 3 PNP transistor circuits

The transistor amplifier circuit of Figure 1. 3 is a PNP counterpart of the previous NPN circuit. The battery of this circuit is connected in a reverse direction in order to achieve proper biasing. Performance is basically the same as that of the NPN circuit. Currents I_C, I_B, and I_E are represented in this diagram by arrows. The emitter current of this circuit still provides the largest current value. The composite of I_C plus I_B also equals I_E in this circuit.

WORDS AND TERMS

bipolar *a.* 双极的,双向的
carrier *n.* 载流子
polarity *n.* 极性
positive *a.* 正的,(电)阳性的
negative *a.* 负的,(电)阴性的
semiconductor *n.* 半导体
crystal *n.* 结晶,晶体,晶粒
symbol *n.* 符号,记号,象征
emitter *n.* 发射极
collector *n.* 集电极
current gain *n.* 电流增益
base *n.* 基极
beta *n.* 希腊字母"β"
Greek *a.* 希腊的,希腊语的
delta *n.* 希腊字母"Δ,δ"
denote *v.* 表示,意味着
formula(*pl.* -s 或 formulae)*n.* 公式
forward-biased 正偏置的,正偏压的
reverse-biased 反偏置的,反偏压的

1.2 UJT Thyristors and SCRs

The term thyristor refers to a rather general classification of solid-state devices that are used as electronic switches. Thyristors can be two-, three-, or four-terminal devices. In this section we are concerned with the conductivity capabilities of these devices. Devices placed in this classification operate through a type of regenerative feedback. When conduction is initiated, the device will latch or hold in its *on state*. Momentarily removing or reducing the energy level of the source will cause nonconduction or switching to the *off state*. In general, a unidirectional thyristor is classified as a voltage-controlled switch.

Thyristors should not be confused with bipolar junction transistors or field-effect transistors. BJTs and FETs are both capable of performing switching operations. As a rule, these devices are not as efficient as a thyristor and do not have the power-handling capability. Thyristors are used as power control devices, whereas transistors are primarily used in amplifying applications.

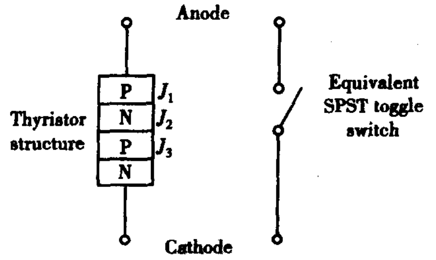
A variety of unidirectional thyristors is now being used in industrial electronic applications. One of the first to be developed was the silicon-controlled rectifier (SCR). The SCR was designed as a solid-state counterpart of the thyratron gaseous tube. The term thyristor was derived from the words thyratron-transistor. An SCR is classified as a reverse blocking triode thyristor. This means that the device has conductivity in only one direction. When its anode and cathode are reverse biased, the device will not conduct. The silicon-controlled switch (SCS) and the programmable unijunction transistor (PUT) are two other thyristors of this classification. A Shockley diode is classified as a reverse blocking diode thyristor.

The crystal structure of a thyristor is unique when compared with other solid-state devices. Most thyristors are classified as PNPN devices. This type of structure consists of four alternately doped semiconductor layers and three PN junctions. The number of terminals attached to the structure is based on the function of the device. The two outer terminals are usually called the anode and cathode. Conduction between these two terminals is the same in nearly all thyristors.

The basic structure of a four-layer thyristor is shown in Figure 1. 4. Notice that the anode terminal is connected to the P region on one end of the structure. The cathode is connected to the N region on the other end. Three junctions are formed between the top and bottom terminals. Conduction between the anode-cathode is similar to that of a mechanical toggle switch. This means that the device must have two operational states. In its on state the three junctions are low resistant. The off state has an infinite resistance between the anode-cathode.

A unique feature of the thyristor structure is its latching characteristic. Latching refers to a condition that holds the device in its on state after conduction has been initiated. Removal of the original actuating signal does not necessarily cause conduction to stop. This action permits the thyristor to be used as an electronic switching device. When the device has been triggered, it usually takes a different procedure for it to be turned off. Switching techniques vary a great deal in thyristors. Diode thyristors change states due to a change in anode-cathode voltage. State changes in a three-element device are initiated by an independent triggering signal.

Description of the operation of a basic PNPN thyristor is often simplified by the two-transistor anology. This method divides the PNPN structure into two imaginary transistors. Junctions J_1 and J_2 form a PNP transistor, while J_2 and J_3 form an NPN device. The J_2



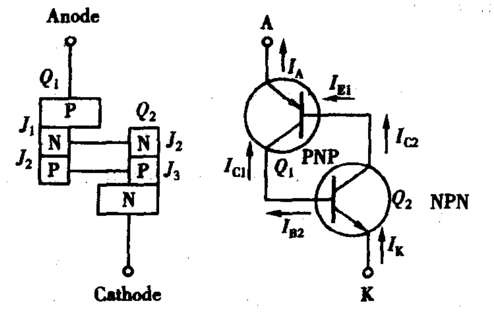


Fig. 1. 4 Four-layer thyristor structure

Fig. 1. 5 Two-transistor equivalent of a PNPN structure

junction is common to both transistor structures. See the two-transistor equivalent of the PNPN structure in Figure 1. 5. Note also the schematic symbol representation of the same structure.

Assume now that a thyristor is connected to an energy source and a load resistor. Figure 1. 6 (A) shows the positive side of the source connected through R_L to the anode and the negative side to the cathode. Connected in this manner, junctions J_1 and J_3 are forward biased and J_2 is reverse biased. This means that J_2 will have an infinite resistance, while J_1 and J_3 are low resistant. J_2 will therefore have practically all of V_S appearing across it, while J_1 and J_3 will have zero voltage. Very little current will flow through the structure. This means that $I_A = I_K$ with a current value of approximately zero. This condition will exist as long as V_{AK} is below the breakdown voltage of J_2 junction.

Refer now to the two-transistor analogy of the thyristor structure in Figure 1. 6 (B). Connected in this manner, the emitter-base (E-B) junctions of Q_1 and Q_2 are both slightly forward biased by the source. The E-B junction of Q_1 is the equivalent of J_1, and E-B of Q_2 is representative of J_3. The J_2 junction is equivalent to the collection-base (C-B) junctions of both Q_1 and Q_2. These two junctions are both reverse biased. Connected in this manner, the two transistors are properly biased for conduction. However, the two E-B junctions have practically no forward bias voltage. This will permit very little or practically no current to flow through the structure. A thyristor connected in this manner is considered to be in its off or nonconductive state.

Note the element current designations for the two-transistor equivalent circuit of Figure 1. 6 (B). The emitter current of Q_1 is representative of the anode current (I_A). I_{B1} is indicative of the base current of Q_1. I_{B1} is determined by the expression

$$I_{B1} = (1-\alpha_1)\, I_A - I_{CBO1}$$

where α_1 = current gain of Q_1

$I_A = I_{E1}$

I_{CBO1} = collector-emitter leakage current of Q_1

For transistor Q_2, the emitter current I_{E2} is equal to the cathode current (I_K). The base current of Q_2 is designated as I_{B2}. The collector current of Q_1 is equal in value to the base current of Q_2. I_{C1} therefore equals I_{B2}. The collector current (I_{C2}) can be determined by the formula

$$I_{C2} = (\alpha_2) + I_{CBO2}$$

where α_2 = current gain of Q_2

$$I_K = I_{E2}$$

I_{CBO2} = collector-emitter leakage current of Q_2

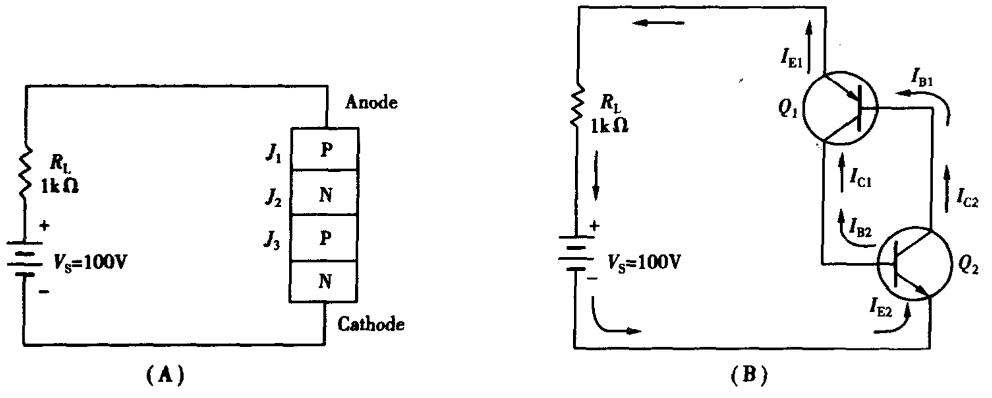


Fig. 1. 6 Thyristor connected to an energy source

Note that I_{C2} of Q_2 and I_{B1} of Q_1 are of the same value. This permits the two previous expressions to be equated. The combined expression then becomes

$$I_{B1} = I_{C2}$$

or

$$(1-\alpha_1) I_A - I_{CBO2} = (\alpha_2) I_K + I_{CBO2}$$

Combining the two expressions permits us to solve for either I_A or I_K. This is given by the formula

$$I_A \text{ or } I_K = \frac{I_{CBO1} + I_{CBO2}}{1-(\alpha_1 Q_1 + \alpha_2 Q_2)}$$

The combined $I_A = I_K$ expression is an extremely important concept in the operation of all thyristors. We will use this expression to show how a thyristor responds in its nonconductive state. A small modification of the alpha values will cause a thyristor to change into its conductive state.

WORDS AND TERMS

UJT [unijunction transistor] 单结晶体管

thyristor *n.* 半导体开关元件,晶闸管(闸流晶体管),可控硅整流器

SCR [selicon controlled rectifier] 可控硅(半导体可控硅整流器)

gaseous *a.* 气体的,气态的

blocking *n.* 封锁,阻断,中断

triode *n.* [无]三极管

FET (field effect transistor) 场效应晶体管

counterpart *n.* 对应物,配对物,副本

thyratron *n.* [无]闸流管

term *n.* 术语,学期,期间,项

terminal *n.* 端子,接头,引线

conductivity *n.* 导电性,电导率

anode *n.* 阳极，正极
cathode *n.* 阴极，负极
doped *a.* 掺杂质的
removal *n.* 移动，排除，除去
trigger *n.* 触发器，触发脉冲，启动装置
classification *n.* 分类，分级，等级，类别
regenerative *a.* 再生的，新生的，反馈的
feedback *n.* [无] 反馈
initiate *v.* 启动，开始
latch *v.* 封锁

1.3 专业英语概述

随着科学技术的飞速发展，科技用语、专业词汇、专用语汇和词汇、日常用语和词汇在科技语言环境中的特殊含义等等，必然大量出现在各个专业的英语话语和书刊中，形成一种与基础英语、日常生活英语有很大差别的英语语言，这就是科技英语。科技英语又因为各个不同的专业而形成很多小的门类，如医学专业英语、建筑专业英语、电子专业英语等等。本书要讲述的是自动化专业英语的一些特点和要点。

根据现行的教学大纲，大学生进入三年级后便开始开设专业英语课程。学习专业英语需要具备两个基础条件，一是较为扎实的英语基础，基本掌握英语常用语法和 4 000 以上的词汇量；二是一定程度的本学科专业知识技能。掌握专业英语技能是大学基础英语学习的主要目的之一，专业英文资料的阅读与翻译能力直接关系到学生的求职和毕业后的工作能力。随着国际间科学技术交流的日益扩大，互联网的进一步应用和发展，专业英语必然拥有更为重要的意义并受到更多的重视。

与基础英语相比，专业英语有着许多受本专业影响的词语特征以及与日常用语迥然不同的独特的含义，如：

The boot is a small routine. Generally, the boot is stored on the first sector (or two) of a disk.

（错误译法）靴子是一个小的日常工作。一般来说，靴子储藏在唱片的第一（或第一，二）个地段上。

（正确译法）引导程序是一小段程序。一般来说，引导程序存放在磁盘的第一（或第一，二）个扇区上。

所以，不能因为基础英语水平较高就忽视专业英语的学习，仅靠日常用语进行望文生义的理解不仅会闹笑话，甚至有可能造成事故。

同时，专业英语在结构上有三多，长句多、被动语态多、名词化结构多，这些会给理解和翻译带来很多困难；由于涉及许多科技内容和专业知识，专业英语往往极其复杂深奥，艰涩难懂。所以，只有在努力学好专业知识的前提下，再经过刻苦的专业英语训练，才能完成从基础英语到专业英语的过渡，达到英语学以致用的目的。

在听说读写译方面，专业英语侧重于“读”和“译”，要求通过大量的阅读达到对原文的正确理解和翻译，在读和译的基础上，对听、说、写进行必要的训练；由于专业英语的翻译经常直接应用于科研工作或工程技术，因而对“译”的质量具有更高的要求，如果翻译上失之毫厘，科研或工程中就可能谬以千里，造成极大的损失。

专业英语是十分重要、不可或缺的课程之一，学好专业英语将会获益终生。

Unit 2

2.1 Operational Amplifiers

The internal construction of an op-amp is quite complex and usually contains a large number of discrete components. A person working with an op-amp does not ordinarily need to be concerned with its internal construction. It is helpful, however, to have some general understanding of what the internal circuitry accomplishes. This permits the user to see how the device performs and indicates some of its limitations as a functioning unit.

The internal circuitry of an op-amp can be divided into three functional units. Figure 1.7 shows a simplified diagram of the internal functions or an op-amp. Notice that each function is enclosed in a triangle. Electronic schematics use the triangle to denote the amplification function. This diagram shows that the op-amp has three basic amplification functions. These functions are generally called stages of amplification. A stage of amplification contains one or more active devices and all the associated components needed to achieve amplification.

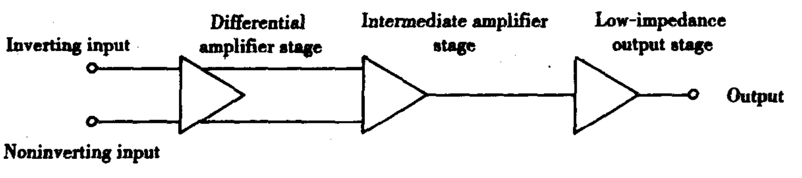


Fig. 1.7 Op-amp diagram

The first stage or input of an op-amp is usually a differential amplifier. This amplifier has two inputs, which are labeled V_1 and V_2. It provides high gain of the signal difference supplied to the two inputs and low gain for common signals applied to both inputs simultaneously. The input impedance is high to any applied signal. The output of the amplifier is generally two signals of equal amplitude and 180° out of phase. This could be described as a push-pull input and output.

One or more intermediate stages of amplification follow the differential amplifier. Figure 1.7 shows an op-amp with only one intermediate stage. Functionally, this amplifier is designed to shift the operating point to a zero level at the output and has high current and voltage gain capabilities. Increased gain is needed to drive the output stage without loading down the input. The intermediate stage generally has two inputs and a single-ended output.

The output stage of an op-amp has a rather low output impedance and is responsible for developing the current needed to drive an external load. Its input impedance must be great enough that it does not load down the output of the intermediate amplifier. The output stage can be an emitter-follower amplifier or two transistors connected in a complementary-symmetry configuration. Voltage gain is rather low in this stage with a sizable amount of current gain.

A differential amplifier is the key or operational basis of most op-amps. This amplifier is best described as having two identical or balanced transistors sharing a single emitter resistor. Each transistor has an input and an output. A schematic diagram of a simplified differential amplifier is shown in Figure 1. 8. Notice that the circuit is energized by a dual-polarity or split-power supply. The source leads are labeled $+V_{CC}$ and $-V_{CC}$ and measured with respect to a common ground lead.

Operation of a differential amplifier is based on its response to input signals applied to the base. Grounding one base and applying an input signal to the other base produces two output signals. These signals have the same amplitude but are inverted 180°. This type of input causes the amplifier to respond in its differential mode of operation.

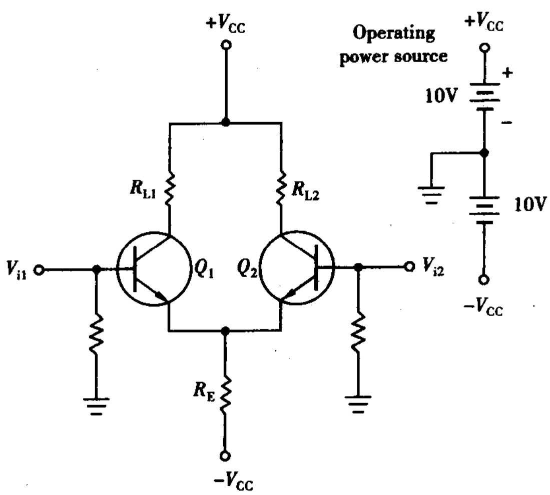


Fig. 1. 8 Simplified differential amplifier

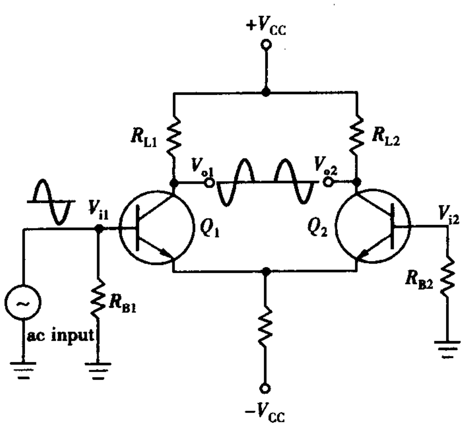


Fig. 1. 9 AC differential amplifier

When two signals of equal amplitude and polarity are applied to each base at the same time, the resulting output is zero. This type of input causes a difference or canceling voltage to appear across the commonly connected emitter resistor. In a sense, the differential amplifier responds as a balanced bridge to identical input signals. There is no output when the circuit is balanced and output when it is unbalanced. This is called the common-mode condition of operation. A differential amplifier is designed to reject signals common to both inputs. The term common-mode rejection ratio (CMRR) is used to describe this action of the amplifier. CMRR is a unique characteristic of the differential amplifier. Undesirable noise, interference, or ac hum can be rejected by this operating condition.

Figure 1. 9 shows a simplified schematic of a differential amplifier connected for differential mode operation. In this circuit an input signal is applied to the base of Q_1, and the base of Q_2 is left open or in a floating state. This condition causes signals to be developed at both outputs and across the emitter resistor. The emitter signal, as indicated, is in phase with the input. The two output signals are out of phase with each other and have a