E

NEW PENGUIN DICTIONARY OF ELECTRONICS

CAROLYOUNG

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Electronics

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PREFACE

The New Penguin Dictionary of Electronics completely replaces the former *Penguin Dictionary of Electronics*. It is primarily concerned with the words and terms used in electronic research and industry and in solid-state theory; however, it also contains definitions of some of the words and terms in the related fields of computing, communications, and electrical engineering together with some entries of historical interest. It should therefore be of use not only to students and teachers of electronics, physics, and related subjects but also to researchers, technicians, and technologists working in electronics or an associated field or using electronic equipment in their work.

The explosive growth of solid-state electronics during the last few years has revolutionized the entire field; emphasis in this dictionary has therefore been placed on explaining the action of solid-state devices and circuits, and the major technological procedures used in their fabrication.

Throughout the text there are a number of long entries in which a word of major importance is defined and discussed and in which closely associated words, printed in italics, are also defined. In these, as well as in the shorter entries, an asterisk before a word indicates an entry to which the reader should refer for further information. SI units are used throughout, although some non-SI units are used where they are generally accepted as being more convenient.

I would like to acknowledge the invaluable assistance in the preparation of this dictionary given by my husband, John Young, who is a Principal Research Engineer at Standard Telecommunications Laboratory, Harlow. Without his advice and constructive criticism this task would have been much more difficult. I would also like to thank Valerie Pitt, the editor of the book, for her help and encouragement throughout.

CAROL YOUNG, 1979

NOTES

An asterisk indicates an entry to which the reader should cross-refer for further information.

Syn. is an abbreviation for 'synonym'.

Words printed in italics in a definition are closely associated with the entry under which they appear and are defined in this position. Cross-reference has been made to them from elsewhere in the dictionary.

A

ab- A prefix to a unit, indicating its use in the obsolete *CGS electromagnetic system of units.

$$1\ abampere = 10\ \text{amperes}$$
$$1\ abvolt = 10^{-8}\ \text{volt}$$
$$1\ abohm = 10^{-9}\ \text{ohm}$$

Compare stat-.

abampere *See* ab-.

A battery *See* AB pack.

ABC *Abbrev. for* automatic brightness control. *See* television receiver.

aberration A defect in the image produced by an electronic lens system.

abohm *See* ab-.

AB pack *U.S.* A package providing a complete power source for battery-operated valves consisting of both the *A battery* (*Brit.* heater battery) supplying power for the *heater and the *B battery* (*Brit.* H.T. battery) supplying power for the anode circuit.

abrupt junction A *p-n junction in which the impurity concentration changes abruptly from acceptors to donors (*see* semiconductor). In practice such a junction may be approximately realized when one side of the junction is much more highly doped than the other, i.e. a p^+-n or n^+-p junction. This is a *one-sided abrupt junction*.

absolute ampere *See* ampere.

absolute electrometer *See* attracted-disc electrometer.

absolute ohm *See* ohm.

absolute temperature *See* thermodynamic temperature.

absolute unit If a quantity y, such as charge or voltage, is completely defined by a simple function of the quantities x_1, x_2,... (where x could be time, current, etc.) so that

$$y = f(x_1, x_2, \ldots)$$

and the unit of y, u_y, can be obtained from the units of x_1, x_2, etc., by the equation

$$u_y \propto f(u_{x1}, u_{x2}, \ldots)$$

then if the constant of proportionality is unity, the unit is an absolute unit. All *SI units are absolute.

absolute volt *See* volt.

absolute zero The temperature at which the energy of random motion of the particles in a system at thermal equilibrium is zero. It is the lowest temperature theoretically possibly and is the zero of the *thermodynamic temperature scale.

absorption Attenuation of a radiowave due to dissipation of its energy, as by the production of heat.

absorption loss The magnitude of the *absorption of a radiowave, usually expressed in *nepers or *decibels. *See also* unabsorbed field strength.

abvolt *See* ab-.

a.c. *Abbrev. for* alternating current.

accelerated life test A form of *life test of a circuit or device so designed that the duration of the test is appreciably less than the normal expected life of the device. This is achieved by subjecting the item to an excessive applied stress level without altering the basic modes or mechanisms of failure or their relative prevalence. Thermal stress is a commonly applied stress. *See* Arrhenius equation.

accelerating anode *See* electron gun.

accelerating electrode Any electrode that accelerates electrons in the electron beam of an *electron tube. *See also* electron gun.

acceleration voltage In general, any voltage that produces acceleration of a beam of charged particles. The term is usually reserved for those devices in which an appreciable acceleration of an electron beam is produced, as in velocity-modulated tubes.

accelerator A machine used to accelerate charged particles or ions in an electric field in order to produce high-energy beams for the study of nuclear structure and reactions. Magnetic fields are used to focus and determine the direction of the beam. The simplest form of accelerator is a *direct-voltage accelerator*, such as the *Van de Graaff accelerator. This form consists of an ion source and a target that are held at a high potential difference. The maximum energy available is severely limited by the maximum potential difference that can be maintained between source and target.

Very high energies are achieved using machines in which the beams of particles are subjected to a series of relatively small accelerating voltages. The particles travel either in a straight line, as in *linear accelerators, or in cyclic paths. In the *cyclotron the energies available are limited by the relativistic mass increase. Higher energies are achieved using the *betatron, *synchrocyclotron, and proton *synchrotron. The maximum energies at present achieved are given in the table.

acceptance angle *See* phototube.

acceptor (1) *Syn. for* series resonant circuit. *See* resonant circuit; resonant frequency.

(2) *Short for* acceptor impurity. *See* semiconductor.

acceptor level *See* semiconductor.

access time *See* memory.

accumulator (1) *Syn. for* secondary cell. *See* cell. (2) *See* register.

a.c./d.c. receiver A *radio receiver that can operate with either an alternating-current supply or a direct-current supply.

Major particle accelerators, giving energy in gigaelectronvolts (GeV)

proton synchrotrons		electron linear accelerator	
Fermilab	400.0	Stanford (SLAC)	22.0
CERN (SPS)	400.0	electron synchrotrons	
Serpukhov	76.0		
Brookhaven (AGS)	33.0	Cornell	12.0
CERN(PS)	28.0	Hamburg (DESY)	7.5
Argonne (ZGS)	12.7	Yerevan (ARUS)	6.1
Tokyo (KEK)	12.0	electron annihilators	
Dubna	10.0		
Rutherford (NIMROD)	8.0	Stanford (SPEAR)	4.5
Moscow	7.0	Novosibirsk (VEPP 3)	3.5
Berkeley (BEVATRON)	6.2	Hamburg (DORIS)	3.0
proton storage rings			
CERN (ISR)	31.0		

acoustic delay line *See* delay line.

acoustic feedback Unwanted *feedback of the sound output of an audiofrequency loudspeaker to a preceding part of a sound-reproduction system. The sound waves can be detected and amplified by the electronic circuits in the system; above a critical level oscillations are produced that are heard as an unpleasant howling noise from the loudspeaker.

acoustic wave *Syn.* sound wave. A wave that is transmitted through a solid, liquid, or gaseous material as a result of the mechanical vibrations of the particles forming the material. The normal mode of propagation is longitudinal, i.e. the direction of motion of the particles is parallel to the direction of propagation of the wave, and the wave therefore consists of compressions and rarefactions of the material. The term 'sound wave' is sometimes confined to those waves with a frequency falling within the audible range of the human ear, i.e. from about 20 hertz to 20 kilohertz. Waves of frequency greater than about 20 kilohertz are ultrasonic waves.

In a crystalline solid an acoustic wave is transmitted as a result of the displacement of the lattice points about their mean position, and the modes of propagation are constrained by the interatomic forces active between the lattice points. The wave is transmitted as an elastic wave through the crystal lattice. The angular frequency, ω, of the wave is related to the wave vector $\boldsymbol{K}$ by the relation

$$m\omega^2 = 2\Sigma_{p>0}C_p(1 - \cos pKa)$$

where m is the mass of an atom, C_p the force constant between planes of atoms separated by p, where p is an integer, and a is the

spacing between atomic planes. The range of physically realizable waves that may be transmitted is

$$\pi > Ka > -\pi$$

The limits of this range define the first Brillouin zone for the crystal lattice, and at these limits travelling waves cannot be propagated; standing waves are formed. The energy of the lattice vibrations is quantized. The quantum of energy is the *phonon, which is analogous to the photon of energy of an electromagnetic wave. The phonon energy is given by $h\nu$, where ν is the frequency and is equal to $\omega/2\pi$.

A travelling acoustic wave in a solid can be produced by applying mechanical stress to the crystal or as a result of *magnetostriction or of the *piezoelectric effect. The resulting phonons can interact with mobile charge carriers present in the material. The interaction can be considered as an electric vector, analogous to the electric vector associated with an electromagnetic wave, that extends for about a quarter wavelength distance orthogonal to the direction of propagation of the wave.

acoustic wave device A device used in a signal-processing system in which acoustic waves are transmitted on a miniature substrate in order to perform a wide range of functions. Active and passive signal-processing devices formed on a single semiconductor chip have been produced including delay lines, attenuators, phase shifters, filters, amplifiers, oscillators, mixers, and limiters.

Bulk acoustic waves are acoustic waves propagated through the bulk substrate material. The substrate material consists of a piezoelectric semiconductor, such as cadmium sulphide. The acoustic waves are generated from electrical signals as a result of the *piezoelectric effect. The electric field vector of the acoustic wave interacts with the conduction electrons of the semiconductor, which have a drift velocity due to an external applied d.c. electric field. At a sufficient value of the drift velocity the kinetic energy of the drift electrons is converted to radiofrequency energy as a result of the interaction with the acoustic field, and amplification of the original signals can result.

Surface acoustic waves are propagated along the surface of a substrate. The associated electric field extends for a short distance out of the surface and can interact with the conduction electrons of a separate semiconductor placed just above the surface. The physical separation of the acoustic substrate and the semiconductor allows the materials to be chosen so that the energy dissipation in the system is minimized. The acoustic material is a piezoelectric material that has a high electromechanical coupling coefficient and low acoustic loss. The semiconductor material is one that has high

mobility electrons, optimum resistivity, and low d.c. power requirement so that the optimum efficiency is obtained.

action current (or **potential**) A very small current wave (or potential wave) associated with nerve impulses.

activated cathode *Syn. for* coated cathode. *See* thermionic cathode.

active Denoting any device, component, or circuit that introduces *gain or has a directional function. In practice any item except pure resistance, capacitance, inductance, or a combination of these three is active. *Compare* passive.

active aerial *Syns.* primary radiator; driven aerial. *See* directive aerial.

active area *See* metal rectifier.

active component (1) *See* active. (2) *See* active current. (3) *See* active volt-amperes. (4) *See* active voltage.

active current *Syns.* active component, energy component, power component, in-phase component of the current. The component of the current that is in *phase with the voltage, alternating current and voltage being regarded as vector quantities. *Compare* reactive current.

active filter *See* filter.

active interval *Syn.* trace interval. *See* sawtooth waveform.

active load A *load that is formed from an active device, particularly an MOS transistor. The active device is not used for its inherent gain, but the resistance of the device is utilized to form the load. MOS transistors are particularly useful as active load devices since no extra processing stops are required to form resistors, during the manufacture of MOS integrated circuits.

active network *See* network; active.

active satellite *See* communications satellite.

active transducer *See* transducer.

active voltage *Syns.* active component, energy component, power component, in-phase component of the voltage. The component of the voltage that is in *phase with the current, alternating current and voltage being regarded as vector quantities. *Compare* reactive voltage.

active volt-amperes *Syns.* active component, energy component, power component, in-phase component of the volt-amperes. The product of the voltage and the *active current or of the current and the *active voltage. It is equal to the power in watts. *Compare* reactive volt-amperes.

activity The ratio of the peak value of the oscillations in a *piezoelectric crystal to the peak value of the exciting voltage.

actuating transfer function *See* feedback control loop.

actuator A device that is used to calibrate electronic equipment, to bring such equipment into operation, or, in a control system, to convert an electrical signal into the appropriate mechanical energy. The last application is a special case of a transducer. When a device,

such as a microphone, is calibrated by applying a known electrostatic force to it the actuator is described as an *electrostatic actuator.*

Adcock direction finder *Syn.* Adcock antenna. A radio direction finder consisting of a number of spaced vertical *aerials. The errors due to the horizontally polarized components of the received waves are effectively eliminated as such components have only a minimal effect on the observed bearings.

adder A circuit in a digital *computer that performs mathematical addition. It normally contains several identical sections each of which add the corresponding *bits of the two numbers to be added together with a carry digit from the preceding section and produce an output corresponding to the sum of the bits and a carry digit for the next section.

A *half-adder* is a circuit that adds two bits only and produces two outputs; the outputs must be suitably combined in another half-adder in order to produce the correct outputs for all possible combinations of inputs.

If two numbers each consisting of x bits are to be added a full adder circuit requires $2x$ inputs to x identical sections and $(x + 1)$ outputs in order to perform the addition.

address (1) A number that identifies a unique *memory location in computer *memory. Memories may be *word-addressable* or *byte-addressable* depending on the nature of the smallest addressable unit of store.

(2) A number that identifies a particular input/output channel through which the *central processing unit of a computer communicates with its peripheral devices.

adiabatic demagnetization *See* magnetocaloric effect.

admittance Symbol: Y; unit: siemens. The reciprocal of *impedance. It is a complex quantity given by

$$Y = G + iB$$

where G is the *conductance and B the *susceptance. Since impedance, Z, is given by

$$Z = R + iX,$$

where R and X are the resistance and reactance, respectively, then

$$Y = 1/Z = 1/(R + iX)$$
$$= (R - iX)/(R^2 + X^2)$$

admittance gap A gap in the wall of a *cavity resonator that allows it to be excited by a source of radiofrequency energy, such as a velocity-modulated electron beam, or that allows it to affect such a source.

ADP *Abbrev. for* automatic *data processing.

aeolight *U.S.* A cold-cathode glow-discharge lamp (*see* gas-discharge tube) that is filled with a mixture of permanent gases. The intensity

of illumination produced varies with the applied signal and it is used as a modulating light for sound recording.

aerial *Syn.* antenna (mainly U.S.). The part of a radio system that radiates energy into space (*transmitting aerial*) or receives energy from space (*receiving aerial*). An aerial together with its *feeders and all its supports is known as an *aerial system.* There is a great variety of specially designed aerials, most of which are described by their shape, e.g. umbrella, clover leaf, H, L, T, cigar, and corner aerials. The most important types of aerial are *dipole and *directive aerials. *See also* Yagi aerial.

aerial array *Syn.* beam aerial. An arrangement of radiating or receiving elements so spaced and connected to produce directional effects. Very great directivity and consequently large *aerial gain can be produced by suitable design. An array of elements along a horizontal line is referred to either as a *broadside array* or *end-fire array* depending on whether the directivity is in the horizontal plane at right angles to or along the line of the array, respectively. Arrays are commonly designed to have both horizontal and vertical directivity. The horizontal directivity is determined by the horizontal arrangement of aerial elements while the vertical directivity is dependent on the number of elements arranged in tiers (or stacks) one above the other.

The performance of a *directive aerial or an aerial array is indicated by the *radiation pattern of the system. The direction of maximum transmission or reception is given by the major lobe of the radiation pattern (*see also* steerable aerial).

aerial current The root-mean-square value of the current measured at a specified point in an aerial, usually either at the feed point or at the current maximum.

aerial efficiency *Syn.* radiation efficiency. The ratio of the power radiated by an aerial, at a specified frequency, to the total power supplied to it.

aerial feed-point impedance The *impedance of an aerial at the point at which it is fed. The real part of this impedance is the aerial feed-point resistance and the imaginary part is the aerial feed-point reactance.

aerial gain (1) (in transmission) The ratio of the power that must be supplied to a reference aerial compared to the power supplied to the aerial under consideration in order that they produce exactly similar field strengths at the same distance and in the same specified direction (usually the direction of maximum radiation).

(2) (in reception) The ratio of the signal power produced at the receiver input by the given aerial to that produced by a reference aerial under similar receiving conditions and transmitted power.

In both cases the reference aerial must be specified.

aerial radiation resistance The power radiated by an aerial divided by the mean square value of the current at a given specified reference point on the aerial, usually the feed point or a current antinode. This resistance takes into account the energy consumed by the aerial system as a result of radiation.

aerial resistance The total power supplied to an aerial divided by the mean square value of the current at a given specified reference point on the aerial, usually the feed point or a current antinode. This resistance takes into account the energy consumed by the aerial system as a result of radiation and other losses.

aerial system *See* aerial.

a.f. *Abbrev. for* audiofrequency.

a.f.c. *Abbrev. for* automatic frequency control.

afterglow *See* persistence.

a.g.c. *Abbrev. for* automatic gain control.

ageing *Syn. for* burn-in. *See* failure rate.

agglomerate cell *See* Leclanché cell.

air-break (of a switch, *circuit-breaker, etc.) Having contacts that separate in air. *Compare* oil-break.

air capacitor A *capacitor that uses air as the main dielectric.

air gap *See* gap.

airport surveillance radar (ASR) *See* precision approach radar.

Alcomax *Tradename* A material used for permanent magnets because of its exceptionally high coercivity. It consists of an alloy of iron, nickel, aluminium, cobalt, and copper.

ALGOL-60 *See* programming language.

aliasing An effect that occurs when an analog signal $f(t)$ is sampled digitally at a sampling frequency less than twice the signal frequency: a signal $f(t')$ is retrieved from the sampled information that differs from the original input signal. The retrieved signal—the *alias signal*—has a frequency that corresponds to the harmonics of the high-frequency components of $f(t)$.

aligned-grid valve *Syn.* beam-power valve. A type of *thermionic valve in which the power-handling capacity of the valve is increased by arranging for only a very small fraction of the total space current to be intercepted by the screen grid. This may be achieved by placing the grids so that the conductors forming the screen grid are in the shadow of those forming the control grid. Alternatively, special plates can be used to split the beam into thin pencils that are directed to fall mainly in the spaces between the grid conductors.

alive *Syn. for* live. *See* dead.

allowed band *See* energy bands.

alloy device *See* alloyed device. *See also* alloyed junction.

alloyed device *Syn.* alloy device. A semiconductor device, such as a *transistor or *diode, that contains one or more *alloyed junctions.

alloyed junction A semiconductor junction formed by bonding metal contacts on to a wafer of semiconductor material and then heating to produce an alloy: it is a method commonly used for germanium diodes and transistors and in early silicon devices, the devices being termed *alloyed* (or *alloy*) *transistors* or *diodes*. It has been generally superceded by the *planar process for all but special-purpose items, although it is a useful technique for gallium arsenide devices.

all-pass network *See* network.

Alnico *Tradename* A material used for high-energy permanent magnets. It is an alloy of nickel, iron, aluminium, cobalt, and copper.

alpha current factor *Syn. for* common-base forward-current transfer ratio. *See* transistor.

alpha cut-off frequency The frequency at which the common-base forward-current transfer ratio, α, of a bipolar junction *transistor has fallen to $1/\sqrt{2}$ (i.e. 0.707) of the low-frequency value.

alphanumeric Ordering or ordered by both letters and numbers.

alpha particle (α-particle) The nucleus of a helium (^{4}He) atom. The positively charged particle is very stable, having two protons and two neutrons.

alpha rays A stream of *alpha particles that have energies characteristic of the emitting radioactive substance.

alternating current (a.c.) An electric current whose direction in the circuit is periodically reversed with a *frequency, f, independent of the circuit constants. In the simplest form the instantaneous current varies with time:

$$I = I_0 \sin 2\pi ft,$$

where I_0 is the *peak value of the current. A.c. is measured either by its peak value, its *root-mean-square value, or more rarely by the *current average*—the algebraic average of the current during one positive half cycle.

alternating-current bias *Syn. for* magnetic bias. *See* magnetic recording.

alternating-current generator A *generator for producing alternating currents or voltages. *See* induction generator; synchronous alternating-current generator.

alternating-current Josephson effect *See* Josephson effect.

alternating-current motor A *motor that requires alternating current for its operation.

alternating-current resistance *See* effective resistance.

alternating-current transmission A method of transmission used in television in which the direct-current component of the luminance signal (*see* colour television) is not transmitted. *A direct-current restorer must be used in this form of transmission. *Compare* direct-current transmission.

alternator *See* synchronous alternating-current generator.

alumina Aluminium oxide, symbol: Al_2O_3. In solid-state electronics it is used as a dielectric, as in thin-film capacitors, or as the gate dielectric in *MIS transistors. In valve electronics it was used as an insulator due to its excellent electrical and thermal resistance.

aluminium Symbol: Al. A metal, atomic number 13, that is extensively used in electronic equipment and devices. It is a good conductor and is ductile, malleable, resistant to corrosion, lightweight, easily evaporated on to surfaces, and abundant, making it the element of choice in both micro- and macroelectronic applications.

aluminium antimonide Symbol: AlSb. A semiconductor with useful properties up to operating temperatures of 500°C.

aluminium gate circuit *See* MOS integrated circuit.

aluminized screen *See* cathode-ray tube.

a.m. (or **AM**) *Abbrev. for* amplitude modulation.

American wire gauge *Syn.* Brown and Sharpe wire gauge. *See* wire gauge.

AM/FM receiver A *radio receiver that detects both amplitude-modulated and frequency-modulated signals.

ammeter An indicating instrument for measuring current. The most common types are *moving-coil and *moving-iron instruments and the *thermoammeter. Most ammeters are shunted *galvanometers.

amp *Short for* ampere.

ampere Symbol: A. The *SI unit of electric *current defined as the constant current that, if maintained in two straight parallel conductors of infinite length and negligible cross section and placed one metre apart in a vacuum, would produce between these conductors a force equal to 2×10^{-7} newton per metre of length.

This unit was once termed the *absolute ampere* and replaced the *international ampere as the standard of electric current in 1948.

ampere balance *See* Kelvin balance.

Ampere-Laplace law *See* Ampere's law.

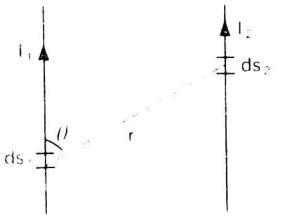
ampere per metre Symbol: A/m. The *SI unit of *magnetic field strength. It is the magnetic field strength in the interior of an elongated uniformly wound solenoid that is excited with a linear current density in its winding of one ampere per metre of axial distance.

Ampere's circuital theorem *See* Ampere's law.

Ampere's law (1) *Syn.* Ampere-Laplace law. The force between two parallel current-carrying conductors in free space is given by

$$dF = \mu_0 I_1 ds_1 I_2 ds_2 \sin\theta / 4\pi r^2$$

where I_1 and I_2 are the currents, ds_1 and ds_2 the incremental lengths, r the distance between the incremental lengths and θ the angle (*see* diagram); μ_0 is the *permeability of free space. Ampere's law thus relates electrical and mechanical phenomena. *See also* Coulomb's law.



Ampere's law

(2) *Syn.* Ampere's circuital theorem. The work done in traversing a closed circuit that encloses a current I is given by

$$\oint \boldsymbol{B}.\mathrm{d}\boldsymbol{s} = \mu_0 I$$

where μ_0 is the *permeability of free space, $\boldsymbol{B}$ is the magnetic flux density, and ds an incremental length.

The total current flowing is given by the integral of the current density flowing in the area bounded by the loop. In a medium of *magnetization $\boldsymbol{M}$, the total current density, j_T, is given by the sum of the real current density, j, and the equivalent magnetization current density, j_M, where

$$j_M = \mathrm{curl}\ \boldsymbol{M}$$

Since

$$\oint \boldsymbol{B}.\mathrm{d}\boldsymbol{s} = \int \mathrm{curl}\ \boldsymbol{B}.\mathrm{d}\boldsymbol{A}$$

where $\mathrm{d}\boldsymbol{A}$ is an increment of area, then

$$\int \mathrm{curl}\ \boldsymbol{B}.\mathrm{d}\boldsymbol{A} = \mu_0 \int \boldsymbol{j}_T.\mathrm{d}\boldsymbol{A}$$

and thus

$$\mathrm{curl}(\boldsymbol{B} - \mu_0\boldsymbol{M}) = \mu_0 \boldsymbol{j}$$

Since $\boldsymbol{H}$, the magnetic field strength, is defined as

$$\mu_0\boldsymbol{H} = \boldsymbol{B} - \mu_0\boldsymbol{M}$$

Ampere's law, in differential form, may be written as

$$\mathrm{curl}\ \boldsymbol{H} = \boldsymbol{j}$$

ampere-turn Symbol: At. A unit of *magnetomotive force equal to the product, NI, of the total number of turns, N, in a coil through which a current, I, is flowing.

amplification The reproduction of an electrical signal, usually at an increased intensity, by an electronic device.

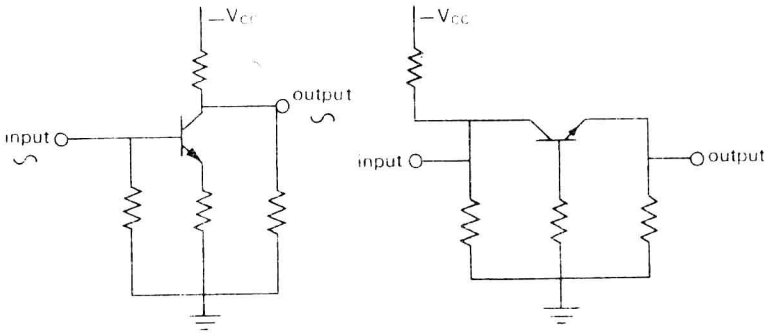
amplification factor Symbol: μ. In an active electronic device used to deliver a constant current to a load, the ratio of the incremental

change in output voltage required to maintain the constancy of the current to a corresponding incremental change in the input voltage. μ is equal to $-A_v$, where A_v is the voltage *gain of the device.

amplifier A device that produces an electrical output that is a function of the corresponding electrical input parameter and increases the magnitude of the input by means of energy drawn from an external source, i.e. it introduces *gain. A *linear amplifier* is one in which the instantaneous output signal is a linear function of the corresponding input signal; otherwise the amplifier is described as *nonlinear*.

Most practical amplifiers are alternating-current amplifiers and consist of several small-gain *amplifier stages coupled together to produce a substantial overall gain. Negative *feedback is commonly used to provide stability and to prevent the amplifier behaving as an *oscillator.

The nomenclature of amplifiers depends on their application, construction, and method of operation according to context. The simple amplifier shown in Fig. *a* can be described as a common-emitter, or linear, or *class A, or audiofrequency amplifier. An



a Common-emitter n-p-n transistor amplifier

b Common-base n-p-n transistor

amplifier that produces an increased e.m.f. operating into a high impedance is a *voltage amplifier*. A *transistor in *common-base connection (Fig. *b*) acts as a simple voltage amplifier operating with low input impedance and high output impedance. One that produces an appreciable current flow into a relatively low impedance or a large increase in output power is a *power amplifier*.

Alternating-current amplifiers are described either by the range of frequencies amplified, i.e. they are either *wideband or *tuned amplifiers, or by the region of the electromagnetic spectrum in which they operate, as with audiofrequency or radiofrequency amplifiers.

Direct-current may be amplified directly using a *direct-coupled