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INTRODUCTION

This dictionary of electrical terms has its origin in the revision of the Group 05, General (Fundamental and Derived) Terms, portion of the 1941 edition of the American Standard Definitions of Electrical Terms, ASA C42. Responsibility for the preparation of these definitions was centered in Subcommittee No. 1 of ASA Sectional Committee C42, the personnel of which was:

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Comments and suggestions were received from many sources, including Sectional Committee C61 which furnished many suggestions for definitions in electromagnetic fields.

Special appreciation is due the Basic Terms Subcommittee of the former IRE Standards Committee, consisting of:

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which reviewed all definitions except those pertaining to Electric Power Circuits, and offered many of the modifications included in this edition.

Throughout this document there are many numerical cross-references, such as "See 65.06.529." These are identification numbers for terms in the American Standard Definitions of Electrical Terms (Group 65—Communication), ASA C42.65-1957, available from the IEEE or ASA.

PROPOSED STANDARD DEFINITIONS OF GENERAL (FUNDAMENTAL AND DERIVED) ELECTRICAL AND ELECTRONICS TERMS

Abampere. The unit of current in the cgs electromagnetic system. The abampere is 10 amperes.

Absolute Capacitivity (Absolute Dielectric Constant) (Permittivity). Of a homogeneous, isotropic, insulating material or medium, in any system of units, the product of its relative capacitance and the electric constant appropriate to that system of units. *See also* Electric Constant.

Absolute Dielectric Constant. *See* Absolute Capacitivity.

Absolute Measurement (in a system of units). Measurement in which the comparison is directly with quantities whose units are basic units of the system. *Note 1:* For example, the measurement of speed by measurements of distance and time is an absolute measurement, but the measurement of speed by a speedometer is not an absolute measurement. *Note 2:* The word absolute implies nothing about precision or accuracy.

Absolute Value of a Number. The absolute value of a number u (real or complex) is that positive real number $|u|$ given by

$$|u| = +\sqrt{u_1^2 + u_2^2}$$

where u_1 and u_2 are respectively the real and imaginary parts of u in the equation $u = u_1 + ju_2$. If u is a real number, $u_2 = 0$.

Abstract Quantity. *See* Mathematico-Physical Quantity.

Acceptance Test. A test to demonstrate the degree of compliance of an apparatus with purchasers' requirements.

Acceptor (in a semiconductor). *See* Impurity, Acceptor.

Access Time. A time interval which is characteristic of a storage unit, and is essentially a measure of the time required to communicate with that unit. Many definitions of the beginning and ending of this interval are in common use.

Accessible Terminal. A network node that is available for external connections.

Accumulator. A device, which stores a number and which, on receipt of another number, adds it to the number already stored and stores the sum. *Note:* The term is also applied to devices which function as described but which also have other properties.

Accuracy. The quality of freedom from mistake or error, that is, of conformity to truth or to a rule. Accuracy is distinguished from precision as in the following example: A six-place table is more precise than a four-place table. However, if there are errors in the six-place table it may be either more or less accurate than the four-place table.

Acoustic Filter (Acoustic Wave Filter). *See* 65.06.529.

Acoustic Wave Filter. *See* Acoustic Filter.

Active Power of a Polyphase Circuit (Power)[†]. At the terminals of entry of a polyphase circuit into a delimited region, the algebraic sum of the active powers for the individual terminals of entry when the voltages are all determined with respect to the same arbitrarily selected

common reference point in the boundary surface (which may be the neutral terminal of entry). The active power for each terminal of entry is determined by considering each conductor and the common reference point as a single-phase, two-wire circuit and finding the active power for each in accordance with the definition of Active Power of a Single-Phase, Two-Wire Circuit. If the voltages and currents are sinusoidal and of the same period, the active power P for a three-phase circuit is given by

$$P = E_a I_a \cos(\alpha_a - \beta_a) + E_b I_b \cos(\alpha_b - \beta_b) + E_c I_c \cos(\alpha_c - \beta_c)$$

where the symbols have the same meaning as in Instantaneous Power of a Polyphase Circuit. If there is no neutral conductor and the common point for voltage measurement is selected as one of the phase terminals of entry, the expression will be changed in the same way as that for Instantaneous Power of a Polyphase Circuit. If both the voltages and the currents in the preceding equations constitute symmetrical sets of the same phase sequences

$$P = 3E_a I_a \cos(\alpha_a - \beta_a)$$

In general the active power P at the $(m+1)$ terminals of entry of a polyphase circuit of m phases to a delimited region, when one of the terminals is the neutral terminal of entry, is expressed by the equation

$$P = \sum_{s=1}^m \sum_{r=1}^m E_{sr} I_{sr} \cos(\alpha_{sr} - \beta_{sr})$$

where E_{sr} = rms amplitude of the r th harmonic of the voltage e_s , from phase conductor to neutral. I_{sr} = rms amplitude of the r th harmonic of the current i_s , through terminal s . α_{sr} = phase angle of the r th harmonic of e_s , with respect to a common reference. β_{sr} = phase angle of the r th harmonic of i_s , with respect to the same reference as the voltages. The indexes s and r have the same meaning as in Instantaneous Power of a Polyphase Circuit. The active power can also be stated in terms of the rms amplitudes of the symmetrical components of the voltages and currents as

$$P = m \sum_{k=0}^{m-1} \sum_{r=1}^{\infty} E_{kr} I_{kr} \cos(\alpha_{kr} - \beta_{kr})$$

where m is the number of phase conductors, k denotes the number of the symmetrical component, and r denotes the number of the harmonic component. When the voltages and currents are quasi-periodic and the amplitudes of the voltages and currents are slowly varying, the active power for the circuit of each conductor may be determined for this condition as in Active Power of a Single-Phase, Two-Wire Circuit. The active power for the polyphase circuit is the sum of the active power values for the individual conductors. The active power is also the time average of the instantaneous power for the polyphase circuit. Mathematically the active power at any time t_0 is

$$P = \frac{1}{T} \int_{t_0 - T/2}^{t_0 + T/2} p dt$$

where T is the period, and p is the instantaneous power. This formulation may be used when the voltage and current are periodic or quasi-periodic so that the period is defined. The active power is expressed in watts when the voltages are in volts and the currents in amperes.

† When it is clear that average power and not instantaneous power is meant, "power" is often used for "active power."

Active Power of a Single-Phase, Two-Wire Circuit (Power)†. At the terminals of entry of a single-phase, two-wire circuit into a delimited region, when the voltage and current are periodic or quasi-periodic, is the time average of the values of the instantaneous power when the average is taken over one period. Mathematically, the active power P at a time t_0 is given by the equation

$$P = \frac{1}{T} \int_{t_0 - T/2}^{t_0 + T/2} p dt$$

where T is the period, and p is the instantaneous power. If both the voltage and current are sinusoidal and of the same period the active power P is given by

$$P = EI \cos(\alpha - \beta)$$

in which the symbols have the same meaning as in Instantaneous Power of a Two-Wire Circuit. If both the voltage and current are sinusoidal, the active power P is also equal to the real part of the product of the phasor voltage and the conjugate of the phasor current, or to the real part of the product of the conjugate of the phasor voltage and the phasor current. Thus

$$P = \text{Real part of } E\mathbf{I}^* = \text{Real part of } E^*\mathbf{I} = \frac{1}{2}[E\mathbf{I}^* + E^*\mathbf{I}]$$

in which E and $\mathbf{I}$ are the rms phasor voltage and rms phasor current, respectively, (see Phasor Quantity) and the $*$ denotes the conjugate of the phasor to which it is applied. If the voltage is an alternating voltage and the current is an alternating current, (see Alternating Voltage and Alternating Current) the active power is given by the equations

$$\begin{aligned} P &= E_1 I_1 \cos(\alpha_1 - \beta_1) + E_2 I_2 \cos(\alpha_2 - \beta_2) + \dots \\ &= \sum_{r=1}^{\infty} E_r I_r \cos(\alpha_r - \beta_r) \\ &= \text{Real part of } \sum_{r=1}^{\infty} E_r I_r = \frac{1}{2} \sum_{r=1}^{\infty} [E_r I_r + E_r^* I_r^*] \\ &= \text{Real part of } \sum_{r=1}^{\infty} E_r I_r \end{aligned}$$

in which r is the order of the harmonic component of the voltage (see "Harmonic Components (Harmonics)") and $r = q$ is the order of the harmonic component of the current. E_r and $\mathbf{I}_r$ are the phasors corresponding to the r th harmonic of the voltage and current, respectively. If the voltage and current are quasi-periodic functions of the form given in Instantaneous Power of a Two-Wire Circuit, the integral over the period T will not result in the simple expressions which are obtained when E_r and $\mathbf{I}_r$ are constant. However, if the relative rates of change of the quantities are so small that each may be considered to be constant during any one period, but to have slightly different values in successive periods, the active power at any time t is very closely approximated by

$$P = \sum_{r=1}^{\infty} E_r(t) I_r(t) \cos(\alpha_r - \beta_r)$$

which is analogous to the preceding expression. When the amplitudes of voltage and current are slowly changing, the active power may be represented by this expression. Active power is expressed in watts when the voltage is in volts and the current in amperes.

† When it is clear that average power and not instantaneous power is meant, "power" is often used for "active power."

Active Transducer. A transducer whose output waves are dependent upon sources of power, apart from that supplied by any of the actuating waves, which power is controlled by one or more of these waves. *Note:* The definition of active transducer is a restriction of the more general "active network"; i.e., one in which there is an impressed driving force. See also 65.06.458.

Adder. A device, which can form the sum of two or more numbers or quantities.

Address. An expression, usually numerical, which designates a particular location in a memory or storage device or other source or destination of information. See also Instruction Code.

Address Part. In an instruction, any part that is usually an address. See also Instruction Code.

Adjustable Capacitor. A capacitor, the capacitance of which can be readily changed.

Adjustable Inductor. An inductor in which the self or mutual inductance can be readily changed.

Adjustable Resistor. A resistor so constructed that its resistance can be changed by moving and setting one or more movable contacting elements.

Admittance. 1. Of a linear constant-parameter system, the corresponding admittance function with p replaced by $j\omega$ in which ω is real. 2. Of a linear constant-parameter system, the ratio of the phasor equivalent of the steady-state sine wave current or current-like quantity (response) to the phasor equivalent of the corresponding voltage or voltage-like quantity (driving force). *Note:* Definitions 1 and 2 are equivalent.

Admittance Function (Defined for linear constant-parameter systems or parts of such systems): The ratio of the phasor equivalent of a steady-state sine-wave current or current-like quantity (response) to the phasor equivalent of a steady-state sine-wave voltage or voltage-like quantity (driving force). *Note:* An admittance function is the reciprocal of a corresponding impedance function, but in some cases care must be used in applying this. For example, the impedance and admittance functions per unit length of a transmission line are not reciprocals of one another; the input impedance function determined on a mesh basis may differ substantially in form from the reciprocal of the input admittance function determined on a node basis and in some cases these may not be interchanged.

All-Pass Network (All-Pass Transducer). A network which introduces phase shift or delay without introducing appreciable attenuation at any frequency.

All-Pass Transducer. See All-Pass Network.

Alternating Current. A current which has positive and negative values during a finite time interval. See also Alternating Function.

Alternating-Current Circuit. A circuit which includes two or more interrelated conductors intended to be energized by alternating current.

Alternating-Current Component. That current remaining when the average value has been subtracted from an

alternating current.

Alternating Function. A periodic function whose average value over a period is zero. For instance, $f(t) = B \sin \omega t$ is an alternating function (ω, B assumed constants).

Alternating Voltage. See Alternating Current.

Ampere. The unit of current in SI units. The ampere is a unit of current of such magnitude that if one ampere is maintained constant in each of two straight parallel conductors of infinite length and of negligible circular sections, placed 1 meter apart in a vacuum, the force on each conductor will be 2×10^{-7} newtons per meter of length.

Ampere's Law. See Magnetic Field Strength Produced by an Electric Current.

Ampere-Turn Per Meter. The unit of magnetic field strength in the rationalized mksa system. The ampere-turn per meter is the magnetic field strength in the interior of an elongated uniformly wound solenoid which is excited with a linear current density in its winding of one ampere per meter of axial distance.

Amplitude. Of a simple sine wave, the positive real A in $A \sin(\omega t + \theta)$, where A, ω, θ are constants. In this case, amplitude is synonymous with maximum or peak value. Of a sine wave, A in $A \sin(\omega t + \theta)$ where A, ω, θ are not necessarily constants, but are specified functions of t . In amplitude modulation, for example, the amplitude A is a function of time. In electrical engineering, the term "amplitude" is often used for the modulus of a complex quantity. Amplitude with a modifier, such as peak or maximum, minimum, rms, average, etc., denotes values of the quantity under discussion which are either specified by the meanings of the modifiers or otherwise understood.

Amplitude Characteristic (Amplitude-Frequency Characteristic). The variation with frequency of the amplitude (i.e., modulus or absolute magnitude) of a phasor quantity. *Note:* The magnitudes of transfer admittances, transfer ratios, amplification, etc. plotted against frequency are a few examples; measures in decibels or other units of these same quantities plotted against frequency are included.

Amplitude Distortion (Amplitude-Frequency Distortion). Distortion due to an undesired amplitude-frequency characteristic. *Note 1:* The usual desired characteristic is flat over the frequency range of interest. *Note 2:* Also sometimes called Frequency Distortion.

Amplitude-Frequency Characteristic. See Amplitude Characteristic.

Amplitude-Frequency Distortion. See Amplitude Distortion.

Amplitude Resonance. Resonance in which amplitude is stationary with respect to frequency.

Analog (in electronic computers). A physical system on which the performance of measurements yields information concerning a class of mathematical problems.

Analog Computer. A physical system together with means of control for the performance of measurements (upon the system) which yield information concerning a class of mathematical problems.

And-Circuit. See And-Gate.

And-Gate (And-Circuit). A gate whose output is energized when and only when every input is in its prescribed state. An and-gate performs the function of the logical "and."

Angle of Lag. The angle of lag of one simple sine wave with respect to a second having the same period is the angle by which the second must be assumed to be shifted backward to make it coincide in position with the first.

Angle of Lead. The angle of lead of one simple sine wave with respect to a second having the same period is the angle by which the second function must be assumed to be shifted forward to make it coincide in position with the first.

Angular Frequency. The angular frequency of a periodic function is 2π times the frequency.

Anode Terminal (of a semiconductor diode). The terminal which is positive with respect to the other terminal when the diode is biased in the forward direction.

Anti-Node of a Standing Wave. See Loop of a Standing Wave.

Aperiodic Damping*. See Overdamping.

* Depreciated.

Aperiodic Function. Any function which is not periodic.

Apparatus. An article of equipment, machine, appliance, or collection of implements to accomplish one or more specific actions or operations.

Apparent Power of a Polyphase Circuit. At the terminals of entry of a polyphase circuit, a scalar quantity equal to the magnitude of the vector power. In determining the apparent power, the reference terminal for voltage measurement shall be taken as the neutral terminal of entry, if one exists, otherwise as the true neutral point. If the ratios of the components of the vector power, for each of the terminals of entry, to the corresponding apparent power are the same for every terminal of entry, the total apparent power is equal to the arithmetic apparent power for the polyphase circuit; otherwise the apparent power is less than the arithmetic apparent power. If the voltages have the same wave form as the corresponding currents, the apparent power is equal to the amplitude of the phasor power. Apparent power is expressed in volt-amperes when the voltages are in volts and the currents in amperes.

Apparent Power of a Single-Phase, Two-Wire Circuit. At the two terminals of entry of a single-phase, two-wire circuit into a delimited region, a scalar equal to the product of the rms voltage between one terminal of entry and the second terminal of entry, considered as the reference terminal, and the rms value of the current through the first terminal. Mathematically the apparent power U is given by the equation

$$U = EI = (\pm) \sqrt{(E_1^2 + E_2^2 + \dots + E_r^2 + \dots) (I_1^2 + I_r^2 + \dots + I_q^2 + \dots)}$$

in which E and I are the rms amplitudes of the voltage and current, respectively. E_r and I_q are the rms amplitudes of the r th harmonic of voltage and the q th harmonic of current, respectively. If both the voltage and current are sinusoidal, and of the same period, the apparent power becomes

$$U = EI = E_1 I_1$$

in which E_1 and I_1 are the rms amplitudes of voltage and current of the primitive period. The apparent power is equal to the magnitude of the phasor power. If the voltage and current are sinusoidal and of the same period, so that the distortion power is zero, the apparent power is equal to the amplitude of the phasor power. If the voltage and current are quasi-periodic and the amplitude of the

voltage and current components are slowly varying, the apparent power at any instant may be taken as the value derived from the amplitudes of the components at that instant. Apparent power is expressed in volt-amperes when the voltage is in volts and the current in amperes. Because apparent power has the property of magnitude only and its sign is ambiguous, it does not have a definite direction of flow. For convenience it is usually treated as positive.

Appliance. Utilization equipment, generally other than industrial, normally built in standardized sizes or types, which is installed or connected as a unit to perform one or more functions, such as clothes washing, air-conditioning, food mixing, deep frying, etc.

Appliance—Fixed. An appliance which is fastened or otherwise secured at a specific location.

Appliance—Portable. An appliance which is actually moved or can easily be moved from one place to another in normal use.

Appliance—Stationary. An appliance which is not easily moved from one place to another in normal use.

Arc. A continuous luminous discharge of electricity across an insulating medium, usually accompanied by the partial volatilization of the electrodes.

Arithmetic Apparent Power of a Polyphase Circuit. At the terminals of entry of a polyphase circuit, a scalar quantity equal to the arithmetic sum of the apparent powers for the individual terminals of entry. The apparent power for each terminal of entry is determined by considering each phase conductor and the common reference terminal as a single-phase circuit, as described for distortion power. The common reference terminal shall be taken at the neutral terminal of entry, if one exists, otherwise as the true neutral point. If the ratios of the components of the vector powers, for each of the terminals of entry, to the corresponding apparent power are the same for every terminal of entry, the arithmetic apparent power is equal to the apparent power for the polyphase circuit; otherwise the arithmetic apparent power is greater than the apparent power. If the voltages have the same wave form as the corresponding currents, the arithmetic apparent power is equal to the amplitude of the phasor power. Arithmetic apparent power is expressed in volt-amperes when the voltages are in volts and the currents in amperes.

Arithmetic Element. See Arithmetic Unit.

Arithmetic Power Factor. The ratio of the active power to the arithmetic apparent power. The arithmetic power factor is expressed by the equation

$$F_{pa} = \frac{P}{U_a}$$

where F_{pa} = arithmetic power factor, P = active power and U_a = arithmetic apparent power. *Note:* Normally power factor, rather than arithmetic power factor, will be specified, but in particular cases, especially when the determination of the apparent power for a polyphase circuit is impractical with the available instruments, arithmetic power factor may be used. When arithmetic power factor and power factor differ, arithmetic power factor is the smaller.

Arithmetic Reactive Factor. The ratio of the reactive power to the arithmetic apparent power.

Arithmetic Unit (Arithmetic Element). That part of a computer which performs arithmetic operations.

Arm. See Branch.

Armature of a Magnet. A piece or an assembly of pieces of ferromagnetic material associated with the pole pieces of a magnet in such a manner that it and the pole pieces can move in relation to each other.

Artificial Line. An electric network which simulates the electrical characteristics of a line over a desired frequency range. *Note:* Although the term basically is applied to the case of simulation of an actual line, by extension it is used to refer to all periodic lines which may be used for laboratory purposes in place of actual lines, but which may represent no physically realizable line. For example, an artificial line may be composed of pure resistances.

Artificial Load. A dissipative but essentially nonradiating device having the impedance characteristics of an antenna, transmission line or other practical utilization circuit.

Attenuation Constant. The real part of the propagation constant.

Attenuation Equalizer. See 65.06.546.

Attenuation Loss. The reduction in radiant power surface density, excluding the reduction due to spreading.

Attenuation Network. A network providing relatively little phase shift and substantially constant attenuation over a range of frequency.

Attenuation of a Traveling Wave. The reduction in amplitude with increasing distance from its source, excluding the reduction due to spreading.

Automatic Check. See Check, Automatic.

Available Conversion Power Gain (of a conversion transducer). The ratio of the available output-frequency power from the output terminals of the transducer to the available input-frequency power from the driving generator with terminating conditions specified for all frequencies which may affect the result. *Notes:* 1. This applies to outputs of such magnitude that the conversion transducer is operating in a substantially linear condition. 2. The maximum available conversion power gain of a conversion transducer is obtained when the input termination admittance, at input frequency, is the conjugate of the input-frequency driving-point admittance of the conversion transducer.

Available Power. Of a linear source of electric energy, the mean square of the open-circuit terminal voltage of the source divided by four times the resistive component of the impedance of the source.

Available Power Gain (of a linear transducer). The ratio of the available power from the output terminals of the transducer, under specific input termination conditions, to the available power from the driving generator. *Note:* The maximum available power gain of an electric transducer is obtained when the input termination admittance is the conjugate of the driving-point admittance at the input terminals of the transducer. It is sometimes called "completely matched power gain."

Avalanche Breakdown (of a semiconductor device). A breakdown that is caused by the cumulative multiplication of charge carriers through field-induced impact ionization.

Avalanche Impedance*. See Breakdown Impedance.

* Deprecated.

Average Absolute Pulse Amplitude. The average of the absolute value of the instantaneous amplitude taken over the pulse duration.

Average Absolute Value of a Periodic Quantity. The

average of the instantaneous absolute value $|x|$ of the quantity over one period:

$$\frac{1}{T} \int_t^{t+T} |x| dt$$

where the lower limit of the integral may be any value of t , and the upper limit T greater. *Note:* Average Value of a Periodic Quantity and Average Absolute Value of a Periodic Quantity are not equivalent, and care must be taken to specify the definition being used.

Average Active Power (of a single-phase, two-wire, or polyphase circuit) (Average Power)[†]. The time average of the values of active power when the active power varies slowly over a specified period of time (long in comparison with the period of a single cycle). This situation is normally encountered because electric system voltages or currents or both are regularly quasi-periodic (*see* Instantaneous Power of a Two-Wire Circuit). The average active power is readily obtained by dividing the energy flow during the specified period of time, by the time.

[†] See footnotes to Active Power of a Single-Phase, Two-Wire Circuit and Active Power of a Polyphase Circuit.

Average Magner. *See* Average Reactive Power (of a single-phase, two-wire, or polyphase circuit).

Average Phasor Power (of a single-phase, two-wire, or polyphase circuit). A phasor of which the real component is the average active power and the imaginary component is the average reactive power. The amplitude of the phasor power is

$$S_{av} = \sqrt{(P_{av})^2 + (Q_{av})^2}$$

in which P_{av} and Q_{av} are the active power and the reactive power respectively.

Average Power. *See* Average Active Power (of a single-phase, two-wire or polyphase circuit).

Average Power Factor (for a single-phase, two-wire, or a polyphase circuit, when the voltages and currents are sinusoidal). The ratio of the average active power to the amplitude of the average phasor power, for a specified period of time.

Average Pulse Amplitude. The average of the instantaneous amplitude taken over the pulse duration.

Average Reactive Factor (for a single-phase, two-wire, or a polyphase circuit, when the voltages and currents are sinusoidal). The ratio of the average reactive power to the amplitude of the average phasor power, for a specified period of time.

Average Reactive Power (of a single-phase, two-wire, or polyphase circuit) (Average Magner). The time average of the values of reactive power when the reactive power varies slowly over a specified period of time (long in comparison with the period of a single cycle). This situation is normally encountered because electric power system voltages or currents, or both, are regularly quasi-periodic. (*See* Instantaneous Power of a Two-Wire Circuit.) The average reactive power is readily obtained by dividing the quadergy flow during the specified period, by the time.

Average Value of a Function. The average value of a function, over an interval $a \leq x \leq b$, is:

$$\frac{1}{b-a} \int_a^b f(x) dx$$

Average Value of a Periodic Quantity. The average of

instantaneous value x of the quantity over one period:

$$\frac{1}{T} \int_t^{t+T} x dt$$

where the lower limit of the integral may be any value of t , and the upper limit T greater. *See also* Average Absolute Value of a Periodic Quantity.

Balanced Capacitance Between Two Conductors (Mutual Capacitance Between Two Conductors)*. The capacitance between two conductors when the changes in the charges on the two are equal in magnitude but opposite in sign and the potentials of the other $n-2$ conductors are held constant. (*See* Direct Capacitances of a System of Conductors.)

* Deprecated.

Ballast. An impedor connected in series with a circuit or device, such as an arc, which normally is unstable when connected across a constant-voltage supply, for the purpose of stabilizing the current.

Band (in electronic computers). A group of tracks on a magnetic drum.

Band-Elimination Filter. *See* 65.06.535.

Band-Pass Filter. *See* 65.06.534.

Bandwidth. 1. The difference between the limiting frequencies of a continuous frequency band. 2. Of a device, the difference between the limiting frequencies within which performance with respect to some characteristic falls within specified limits.

Base (of a transistor). A region which lies between an emitter and a collector of a transistor and into which minority carriers are injected.

Base (Radix). *See* Positional Notation.

Basic Units. The basic units of a system of units are those particular units arbitrarily selected to serve as a basis, in terms of which the other units of the system may be conveniently derived. *Note:* A basic unit is usually determined by a specified relationship to a single prototype standard.

Beat. A periodic variation in the amplitude of an oscillation resulting from the combination of two oscillations of different frequencies.

Biased Induction. At a point in a magnetic material which is subjected simultaneously to a periodically varying magnetizing force and a biasing magnetizing force, the mean value of the magnetic induction at the point.

Biasing Magnetizing Force. At a point in a magnetic material which is subjected simultaneously to a periodically varying magnetizing force and a constant magnetizing force, the mean value of the combined magnetizing forces.

Bidirectional Pulse. A pulse in which pertinent departures from the normally constant value occur in both directions.

Bidirectional Pulse Train. A pulse train, some pulses of which rise in one direction and the remainder in the other direction. (*See also* 65.02.069).

Bidirectional Transducer. *See* Bilateral Transducer.

Bilateral Network. A network which is not a unilateral network.

Bilateral Transducer (Bidirectional Transducer). *See* 65.06.465.

Binary. *See* Positional Notation.

Binary Cell. An elementary unit of storage which can be placed in either of two stable states.

Binary-Coded-Decimal System. A system of number representation in which each decimal digit is represented by a group of binary digits (e.g., Excess-Three Code).

Binary Number System. See Positional Notation.

Binary Point. See Point.

Biot-Savart Law. See Magnetic Field Strength Produced by an Electric Current.

Bit (in electronic computers). (1) An abbreviation of "binary digit." (2) A single character of a language employing exactly two distinct kinds of characters. (3) A unit of storage capacity. The capacity, in bits, of a storage device is the logarithm to the base two of the number of possible states of the device. See also Storage Capacity.

Block. A group of words considered as a unit.

Borrow. See Carry.

Boundary. Of a region, comprises all the boundary points of that region.

Boundary, p-n. A surface in the transition region between p type and n type material at which the donor and acceptor concentrations are equal.

Boundary Point. Of a region, a point any neighborhood of which contains points which belong and points which do not belong to the region.

Bounded Function. One whose absolute value never exceeds some finite number M .

Bracket Function $[x]$. Equal to x if x is an integer and is the lesser of the two integers between which x falls if x is not an integer. Thus if $x = 2$ then $[x] = 2$, if $x = 1.5$ then $[x] = 1$, if $x = -3.7$ then $[x] = -4$ (note that lesser means less positive).

Branch (Arm). A portion of a network consisting of one or more two-terminal elements in series. See Conditional Jump.

Branch Current. The current in a branch of a network.

Branch Impedance. The impedance of a passive branch when no other branch is electrically connected to the branch under consideration.

Branch Point. See Node.

Branch Voltage. The voltage between the two nodes terminating the branch, the path of integration coinciding with the branch.

Break Point. A place in a routine at which a special instruction is inserted which, if desired, will cause a digital computer to stop for a visual check of progress.

Breakdown (of a semiconductor diode). A phenomenon occurring in a reverse biased semiconductor diode, the initiation of which is observed as a transition from a region of high dynamic resistance to a region of substantially lower dynamic resistance for increasing magnitude of reverse current.

Breakdown Impedance (of a semiconductor diode). The small-signal impedance at a specified direct current in the breakdown region.

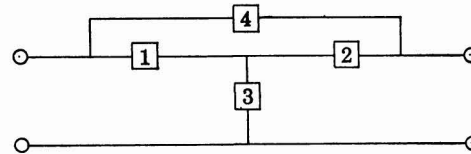
Breakdown Region (of a semiconductor-diode characteristic). That entire region of the volt-ampere characteristic beyond the initiation of breakdown for increasing magnitude of reverse current.

Breakdown Strength. See Dielectric Strength.

Breakdown Voltage (of a semiconductor diode). The voltage measured at a specified current in the breakdown region.

Bridge Network. Any network (of relatively few branches), containing only two-terminal elements, which is not a series-parallel network. Note: Elementary "bridges" such as the Wheatstone bridge are special cases of a bridge network.

Bridged-T Network. A T network with a fourth branch connected across the two series arms of the T, between an input terminal and an output terminal.



Bridged-T network branches 1, 2 and 3 comprise the T network and branch 4 is the fourth branch. (See also 65.06.494).

Brush Discharge. An intermittent discharge of electricity having the form of a mobile brush, which starts from a conductor when its potential exceeds a certain value, but remains too low for the formation of an actual spark. It is generally accompanied by a whistling, or crackling noise.

Buffer. (1) An isolating circuit used to avoid reaction of a driven circuit upon the corresponding driving circuit. (2) A storage device used to compensate for a difference in rate of flow of information or time of occurrence of events when transmitting information from one device to another.

Bus (in electronic computers). One or more conductors which are used as a path for transmitting information from any of several sources to any of several destinations.

Capacitance (Capacity)*. That property of a system of conductors and dielectrics which permits the storage of electrically separated charges when potential differences exist between the conductors. Its value is expressed as the ratio of a quantity of electricity to a potential difference. Note: As defined elsewhere, "self," "direct," "balanced," and "plenary," are used to indicate the capacitances corresponding to different groupings of the n conductors of a multiple-conductor system, and the names are used even if, in addition to the n conductors constituting the working system, additional conductors are present which, either intentionally or because they are inaccessible, are not explicitly considered either experimentally or theoretically. Two or more conductors when connected conductively together are regarded as one conductor. Ground is regarded as one of the n conductors of the system.

* Deprecated.

Capacitance (of a semiconductor diode). The small-signal capacitance measured between the terminals of the diode under specified conditions of bias and frequency.

Capacitance Between Two Conductors. The capacitance between two conductors, although it is a function only of the total geometry and the absolute capacitivity of the medium, is defined most conveniently as the ratio of the change in charge on one conductor to the corresponding change in potential difference between it and the second conductor with the charges or the potentials of the other conductors of the system specified. In the ideal case where one, and only one, conductor is completely surrounded by

another, the capacitance between them is not affected by the presence of the other $n-2$ conductors. The capacitance between two conductors may be made independent of all except a third if the third conductor completely surrounds the two under discussion.

Capacitivity of Free Space. See Electric Constant.

Capacitor (Condenser)*. A device, the primary purpose of which is to introduce capacitance into an electric circuit. See Capacitance.

* Deprecated.

Capacitor Unit. A single assembly of dielectric and electrodes in a container with terminals brought out.

Capacity. (a) The capacity of a machine, apparatus or appliance is the rated load. (Rated Capacity.) (b) The capacity of a machine, apparatus or appliance is the maximum load of which it is capable under existing service conditions. (Maximum Capacity.)

* Deprecated.

Carrier Wave. See 65.16.012.

Carry. (1) A signal, or expression, produced as a result of an arithmetic operation on one digit place of two or more numbers expressed in positional notation and transferred to the next higher place for processing there. (2) Usually, a signal or expression as defined in (1) above which arises in adding, when the sum of two digits in the same digit place equals or exceeds the base of the the number system in use. If a carry into a digit place will result in a carry out of the same digit place, and if the normal adding circuit is bypassed when generating this new carry, it is called a high-speed carry, or standing-on-nines carry. If the normal adding circuit is used in such a case, the carry is called a cascaded carry. If a carry resulting from the addition of carries is not allowed to propagate (e.g., when forming the partial product in one step of a multiplication process), the process is called a partial carry. If it is allowed to propagate, the process is called a complete carry. If a carry generated in the most significant digit place is sent directly to the least significant place (e.g., when adding two negative numbers using nines complements) that carry is called an end-around carry. (3) A carry, in subtraction, is a signal or expression as defined in (1) above which arises when the difference between the digits is less than zero. Such a carry is frequently called a borrow. (4) To carry is the action of forwarding a carry. (5) A carry is the command directing a carry to be forwarded.

Cascade. See Tandem.

Cascaded Carry. See Carry.

Cathode Terminal (of a semiconductor diode). The terminal which is negative with respect to the other terminal when the diode is biased in the forward direction.

Cell. An elementary unit of storage (e.g., binary cell, decimal cell).

CGS Electromagnetic System of Units. A system in which the basic units are the centimeter, gram, second, and abampere. *Note 1:* The abampere is a derived unit defined by assigning the magnitude 1 to the unrationalized magnetic constant (sometimes called the permeability of space). *Note 2:* Most electrical units of this system are designated by prefixing the syllable "ab-" to the name of the corresponding unit in the mksa system. Exceptions are the maxwell, gauss, oersted, and gilbert.

CGS Electrostatic System of Units. The system in

which the basic units are the centimeter, gram, second, and statcoulomb. *Note 1:* The statcoulomb is a derived unit defined by assigning the magnitude 1 to the unrationalized electric constant (sometimes called the permittivity of space). *Note 2:* Each electrical unit of this system is commonly designated by prefixing the syllable "stat-" to the name of the corresponding unit in the SI system.

CGS System of Units. A system in which the basic units are the centimeter, gram, and second.

Channel (in electronic computers). That portion of a storage medium which is accessible to a given reading station. See also Track.

Character (in electronic computers). One of a set of elementary marks or events which may be combined to express information. *Note:* A group of characters, in one context, may be considered as a single character in another, as in the binary-coded-decimal system.

Characteristic Angular Phase Difference. The characteristic angular phase difference of a set of polyphase voltages or currents of m -phases is the minimum phase angle difference by which each member of a polyphase symmetrical set of polyphase voltages or currents may lag the preceding member of the set, when the members are arranged in the normal sequence. The characteristic angular phase difference is $2\pi/m$ radians, where m is the number of phases.

Characteristic Impedance (Surge Impedance). Of a transmission line, the driving-point impedance which the line would have if it were of infinite length. *Note:* It is recommended that this term be applied only to lines having approximate electrical uniformity. For other lines or structures the corresponding term is "iterative impedance."

Charge. See Electric Charge.

Charge Carrier (of a semiconductor). A mobile conduction electron or mobile hole.

Check. A process of partial or complete testing of (1) the correctness of machine operations, (2) the existence of certain prescribed conditions within the computer, (3) the correctness of the results produced by a routine. A check of any of these conditions may be made automatically by the equipment or may be programmed. See also Marginal Checking; Verification.

Check, Automatic. A check performed by equipment built into the computer specifically for that purpose, and automatically accomplished each time the pertinent operation is performed. Sometimes referred to as a built-in check. Machine check can refer to an automatic check, or to a programmed check of machine functions.

Check Digits. See Check, Forbidden-Combination.

Check, Forbidden-Combination. A check (usually an automatic check) which tests for the occurrence of a nonpermissible code expression. A self-checking code (or error-detecting code) uses a code expression such that one (or more) error(s) in a code expression produces a forbidden combination. A parity check makes use of a self-checking code employing binary digits in which the total number of 1's (or 0's) in each permissible code expression is always even or always odd. A check may be made for either even parity or odd parity. A redundancy check employs a self-checking code which makes use of redundant digits called check digits.

Check Problem. See Check, Programmed.

Check, Programmed. A check consisting of tests inserted into the program of the problem and accomplished by appropriate use of the machine's instructions. A mathematical check (or control) is a programmed check of a sequence of operations which makes use of the mathematical properties of that sequence. A check routine or check problem is a routine or problem which is designed primarily to indicate whether a fault exists in the computer without giving detailed information on the location of the fault. *See also* Diagnostic Routine; Test Routine.

Check Routine. *See* Check, Programmed.

Check, Selection. A check (usually an automatic check) to verify that the correct register, or other device, is selected in the performance of an instruction.

Check, Transfer. A check (usually an automatic check) on the accuracy of the transfer of a word.

Circuit. A network providing one or more closed paths.

Circuit Parameters. The values of physical quantities associated with circuit elements, as for example, the resistance (parameter) of a resistor (element), the amplification factor and plate resistance (parameters) of a tube (element), the inductance per unit length (parameter) of a transmission line (element), etc.

Circuitation. *See* Circulation.

Circularly Polarized Wave. An elliptically polarized wave in which the displacement vector at any point describes a circle.

Circulating Memory. *See* Circulating Register.

Circulating Register. A register consisting of a means for delaying information and a means of regenerating and reinserting the information into the delaying means.

Circulation (Circuitation). The circulation of a vector field is its line integral over a closed curve C .

Clear. To restore a storage or memory device to a prescribed state, usually that denoting zero. *See also* Reset.

Clock. A primary source of synchronizing signals.

Closed Region. An open region and its boundary.

Coaxial (Coaxial Line) (Concentric Line) (Coaxial Pair)*. A transmission line formed by two coaxial conductors.

* Deprecated.

Coaxial Line. *See* Coaxial.

Coaxial Pair*. *See* Coaxial.

* Deprecated.

Code (in electronic computers). (1) A system of characters and rules for representing information. (2) A code, loosely, is the set of characters resulting from the use of a code. (3) To code is to prepare a routine in machine language for a specific computer. (4) To encode is to express given information by means of a code. *See also* Language.

Coefficient of Coupling. (Used only in the case of resistive, capacitive, self-inductive, and inductive coupling), the ratio of impedance of the coupling to the square root of the product of the total impedances of similar elements in the two meshes. *Note:* Unless otherwise specified coefficient of coupling refers to *inductive* coupling, in which case it is $M/\sqrt{L_1 L_2}$ where M is the mutual inductance, L_1 the total inductance of one mesh, L_2 the total inductance of the other. (*See also* 65.08.246)

Coefficients of Capacitance and Induction—Maxwell. *See* Coefficients of Capacitance of a System of Conductors.

Coefficients of Capacitance of a System of Conductors (Coefficients of Capacitance and Induction—Maxwell). The coefficients in the array of linear equations which express the charges on the conductors in terms of their potentials. For a set of n conductors, $n - 1$ of which are insulated from each other and mounted on insulating supports within a closed conducting shell or on one side of a conducting plane of infinite extent, the shell or plane as a common conductor (or ground) is taken to be at zero potential and the charge on each insulated conductor is regarded as having been transferred from the common conductor. Hence the algebraic sum of the charges on the $n - 1$ insulated conductors is equal and opposite in sign to the charge on the common conductor. The charges on the insulated conductors are given by the equations:

$$\begin{aligned} Q_1 &= c_{11}V_1 + c_{12}V_2 + c_{13}V_3 \dots + c_{1(n-1)}V_{n-1} \\ Q_2 &= c_{21}V_1 + c_{22}V_2 + c_{23}V_3 \dots + c_{2(n-1)}V_{n-1} \\ &\dots \\ Q_{n-1} &= c_{(n-1)1}V_1 + c_{(n-1)2}V_2 + c_{(n-1)3}V_3 + \dots + c_{(n-1)(n-1)}V_{n-1} \end{aligned}$$

The coefficients c_{rr} are the self-capacitances and the coefficients c_{rp} are the negatives of the direct (or mutual) capacitances of the system. *Note:* Under the conventions stated both self and direct capacitances have positive signs; also $c_{rp} = c_{pr}$. If the m -th conductor completely surrounds the k -th conductor and no other, then $c_{kp} = 0$ for $p \neq k$ or m ; and $c_{km} = -c_{km}$.

Coefficients of Elastance of a System of Conductors (Coefficients of Potential—Maxwell). The coefficients in the array of linear equations which express the potentials of the conductors in terms of their charges. For the system of n conductors (including ground) described in Coefficients of Capacitance of a System of Conductors the equations for the potentials of the insulated conductors are:

$$\begin{aligned} V_1 &= s_{11}Q_1 + s_{12}Q_2 + s_{13}Q_3 \dots + s_{1(n-1)}Q_{n-1} \\ V_2 &= s_{21}Q_1 + s_{22}Q_2 + s_{23}Q_3 \dots + s_{2(n-1)}Q_{n-1} \\ &\dots \\ V_{n-1} &= s_{(n-1)1}Q_1 + s_{(n-1)2}Q_2 + s_{(n-1)3}Q_3 \dots + s_{(n-1)(n-1)}Q_{n-1} \end{aligned}$$

The coefficients s_{rr} are the self-elastances and the coefficients s_{re} are the negatives of the mutual elastances of the system. *Note:* The matrix of the coefficients of elastance is the reciprocal of the matrix of the coefficients of capacitance.

Coefficients of Potential—Maxwell. *See* Coefficients of Elastance of a System of Conductors. *See* Elastances of a System of Conductors.

Coercive Force. For a magnetic material, the magnetizing force at which the magnetic induction is zero when the material is in a symmetrically cyclically magnetized condition. *See also* Coercivity.

Coercivity. The maximum value of coercive force.

Coil. An assemblage of successive convolutions of a conductor.

Collector (of a transistor). A region through which a primary flow of charge carriers leaves the base.

Column. *See* Place.

Command. (1) One of a set of several signals (or groups of signals) which occurs as a result of an instruction; the commands initiate the individual steps which form the process of executing the instruction. (2) Synonym for instruction.

Complement. (1) A number whose representation is derived from the finite positional notation of another by one of the following rules: (a) True complement—Subtract each digit from one less than the base; then add one to the least significant digit, executing all carries required. (b) Base minus one's complement—Subtract each digit from one less than the base (e.g., "9's complement" in the base 10, "1's complement" in the base 2, etc.). (2) To complement is to form the complement of a number. *Note:* In many machines, a negative number is represented as a complement of the corresponding positive number.

Complete Carry. See Carry.

Completely Mesh-Connected Circuit. A mesh-connected circuit in which a current path extends directly from the terminal of entry of each phase conductor to the terminal of entry of every other phase conductor.

Complex Apparent Permeability. The complex (phasor) ratio of induction to applied magnetizing force. *Note 1:* In ordinary ferromagnetic materials, there is a phase shift between the applied magnetizing force and the resulting total magnetizing force, caused by eddy currents. *Note 2:* In anisotropic media, complex apparent permeability becomes a matrix.

Complex Capacitivity. See Relative Complex Dielectric Constant.

Complex Dielectric Constant, Relative. See Relative Complex Dielectric Constant.

Complex Permeability. The complex (phasor) ratio of induction to magnetizing force. *Note 1:* This is related to a phenomenon wherein the induction is not in phase with the total magnetizing force. *Note 2:* In anisotropic media, complex permeability becomes a matrix.

Complex Permittivity. See Relative Complex Dielectric Constant.

Components of a Vector. The components of a vector are any vectors the sum of which gives the original vector. The components of a vector $\mathbf{V}$ in a specified coordinate system are the directed projections of $\mathbf{V}$ on that system. Thus if V_x , V_y and V_z are the scalar values of the projections of $\mathbf{V}$ on the x , y , and z axes respectively and $\mathbf{i}$, $\mathbf{j}$, $\mathbf{k}$ are unit vectors along these axes, then $\mathbf{i}V_x$, $\mathbf{j}V_y$ and $\mathbf{k}V_z$ are the components of $\mathbf{V}$. Moreover: $\mathbf{V} = \mathbf{i}V_x + \mathbf{j}V_y + \mathbf{k}V_z$. Again if V is the magnitude of the vector $\mathbf{V}$, and θ its polar angle with the x axis and ϕ its azimuth with the x - y plane, then:

$$\begin{aligned}V_x &= V \cos \theta \\V_y &= V \sin \theta \cos \phi \\V_z &= V \sin \theta \sin \phi\end{aligned}$$

and $\mathbf{V} = \mathbf{i}V_x + \mathbf{j}V_y + \mathbf{k}V_z$. *Note:* A right-handed system of coordinates for a rectangular system is such that if $\mathbf{i}$, $\mathbf{j}$, $\mathbf{k}$ are unit vectors measured along the x , y and z axes respectively then the 90° rotation from $\mathbf{i}$ to $\mathbf{j}$ of a right-handed screw causes that screw to progress along the direction of $\mathbf{k}$.

Computer. (1) A machine for carrying out calculations. (2) By extensions, a computer is a machine for carrying out specified transformations on information.

Concentric Line. See Coaxial.

Concrete Quantity. See Physical Quantity.

Condenser*. See Capacitor.

* Deprecated.

Condenser Box*. See Subdivided Capacitor.

* Deprecated.

Conditional Jump (Conditional Transfer of Control) (Branch). An instruction which will cause the proper one of two (or more) addresses to be used in obtaining the next instruction, depending upon some property of one or more numerical expressions or other conditions.

Conditional Transfer of Control. See Conditional Jump.

Conductance. 1. That physical property of an element, device, branch, network or system, which is the factor by which the mean square voltage must be multiplied to give the corresponding power lost by dissipation as heat or as other permanent radiation or loss of electromagnetic energy from the circuit. 2. The real part of admittance. *Note:* Definitions 1 and 2 are not equivalent but are supplementary. In any case where confusion may arise specify definition being used.

Conducting Material. A conducting medium in which the conduction is by electrons, and whose temperature coefficient of resistivity is, except for certain alloys, non-negative at all temperatures below the melting point.

Conduction Band. A range of states in the energy spectrum of a solid in which electrons can move freely.

Conduction Current. Through any surface, the integral of the normal component of the conduction current density over that surface. *Notes:* (a) Conduction current is a scalar and hence has no direction. (b) Current does not flow. In speaking of conduction current through a given surface it is appropriate to refer to the charge flowing or moving through that surface, but not to the current "flow." (c) For the use on circuit diagrams of arrows or other graphical symbols in connection with currents, see Reference Direction (for a current).

Conductivity. Of a material, a factor such that the conduction current density is equal to the electric field in the material multiplied by the conductivity.

Conductivity Modulation (of a semiconductor). The variation of the conductivity of a semiconductor by variation of the charge-carrier concentration.

Conductivity, n Type. The conductivity associated with conduction electrons in a semiconductor.

Conductivity, p Type. The conductivity associated with holes in a semiconductor.

Conductor. A substance or body which allows a current of electricity to pass continuously along it. See Conducting Material.

Conjugate Branches. Any two branches of a network such that a driving force impressed in either branch produces no response in the other.

Conjugate Impedance. An impedance the value of which is the complex conjugate of a given impedance. *Note:* For an impedance associated with an electric network, the complex conjugate is an impedance with the same resistance component and a reactance component the negative of the original.

Connected. A network is connected if there exists at least one path, composed of branches of the network, between every pair of nodes of the network.

Connection Diagram. A diagram that shows the connection of an installation or its component devices or parts. It may cover internal or external connections, or both, and shall contain such detail as is needed to make or trace connections that are involved. The connection diagram usually shows the general physical arrangement of the component devices or parts.

Constant-K Network. A ladder network for which the product of series and shunt impedances is independent of frequency within the range of interest.

Construction Diagram. A diagram that shows the physical arrangement of parts, such as wiring, buses, resistor units, etc. Example—A diagram showing the arrangement of grids and terminals in a grid type resistor.

Contact, High Recombination Rate. A semiconductor-semiconductor or metal-semiconductor contact at which thermal equilibrium charge-carrier concentrations are maintained substantially independent of current density.

Contact Potential (Volta Effect). When two dissimilar uncharged metals are placed in contact with each other, one becomes positively charged and the other negatively charged, and a difference of potential, depending on the nature of the metals, is set up between them.

Continuous Duty. A duty that demands operation at a substantially constant load for an indefinitely long time.

Continuous Rating. The rating that defines the load which can be carried for an indefinitely long time.

Continuously Adjustable Resistor. A continuously adjustable resistor in which the resistance can have every possible value within its range.

Continuously Variable Capacitor. A variable capacitor in which the capacitance can have every possible value within its range.

Continuously Variable Inductor (Variable Inductor). An adjustable inductor in which the inductance can have every possible value within its range.

Control. (1) Usually, those parts of a digital computer which effect the carrying out of instructions in proper sequence, the interpretation of each instruction, and the application of the proper signals to the arithmetic unit and other parts in accordance with this interpretation. (2) Frequently, one or more of the components in any mechanism responsible for interpreting and carrying out manually-initiated directions. Sometimes called manual control. (3) In some business applications of mathematics, a mathematical check.

Control Sequence Table. A tabulation of the connections which are made for each successive position of the controller.

Controller Diagram. A diagram that shows the electric connections between the parts comprising the controller and which shows the external connections.

Conversion Transconductance (of a heterodyne conversion transducer). The quotient of the magnitude of the desired output-frequency component of current by the magnitude of the input-frequency component of voltage when the impedance of the output external termination is negligible for all of the frequencies which may affect the result. *Note:* Unless otherwise stated, the term refers to the cases in which the input-frequency voltage is of infinitesimal magnitude. All direct electrode voltages and the magnitude of the local-oscillator voltage must be specified, fixed values.

Conversion Transducer (Frequency Conversion Transducer). *See* 65.06.466.

Copy. *See* Transfer.

Converter. *See* 65.06.076. *See* Heterodyne Conversion Transducer.

Core-Loss Current. The in-phase component (with respect to the induced voltage) of the exciting current sup-

plied to a coil.

Core of an Electromagnet. That part of the magnetic structure around which the magnetizing winding is placed.

Corona Effect. The particular form of the glow discharge that occurs in the neighborhood of electric conductors where the insulation is subject to high electric stress.

Correction. *See* Error.

Corrective Network. *See* 65.06.544.

Cosine Function. A periodic function of the form $A \cos x$ or $A \cos \omega t$. The amplitude of the cosine function is A and its argument is x or ωt .

Coulomb. The unit of electric charge in SI units. The coulomb is the quantity of electric charge which passes any cross section of a conductor in one second when the current is maintained constant at one ampere.

Coulomb's Law of Electrostatic Attraction. The force of repulsion between two like charges of electricity concentrated at two points in an isotropic medium is proportional to the product of their magnitudes and inversely proportional to the square of the distance between them and to the dielectric constant of the medium. The force between unlike charges is an attraction.

Counter. (1) A device, capable of changing from one to the next of a sequence of distinguishable states upon each receipt of an input signal. (2) Less frequently, a counter is an accumulator.

Counter, Ring. A loop of interconnected bistable elements such that one and only one is in a specified state at any given time and such that, as input signals are counted, the position of the one specified state moves in an ordered sequence around the loop.

Coupled Circuit. A network containing at least one element common to two meshes.

Coupling. 1. The circuit element or elements, or the network, which may be considered common to the input mesh and the output mesh, and through which energy may be transferred from one to the other. 2. The association of two or more circuits or systems in such a way that power may be transferred from one to another.

Crest Factor of a Periodic Function. The ratio of its crest (peak, maximum) value to its root-mean-square (rms) value.

Crest Factor of a Pulse. The ratio of the peak pulse amplitude to the root-mean-square pulse amplitude.

Crest Value (Peak Value). The maximum absolute value of a function when such a maximum exists.

Critical Damping. The name given to that special case of damping which is the boundary between underdamping and overdamping. A damped harmonic system is critically damped if $F^2 = 4MS$.

Cross Product. *See* Vector Product.

Curie Point. A temperature marking a transition between ferromagnetic (ferroelectric, antiferromagnetic) properties and nonferromagnetic (nonferroelectric, non-antiferromagnetic) properties of a material. *Note 1:* Ferromagnetic materials have a single Curie point, above which they are paramagnetic. *Note 2:* The susceptibility of an antiferromagnetic material increases with temperature, up to the Curie point, decreasing thereafter. *Note 3:* Some ferroelectric materials have both upper and lower Curie points, and some have different Curie points associated with different crystal axes. *Note 4:* Experimentally, the transition may cover an appreciable temperature range.

Curl of a Vector Field. A vector which has a magnitude equal to the limit of the quotient of the circulation around a surface element on which the point is located by the area of the surface, as the area approaches zero, provided the surface is oriented to give a maximum value of the circulation; the positive direction of this vector is that traveled by a right-hand screw turning about an axis normal to the surface element when an integration around the element in the direction of the turning of the screw gives a positive value to the circulation. If the vector, $\mathbf{A}$, of a vector field is expressed in terms of its three rectangular components A_x , A_y , and A_z , so that the values of A_x , A_y , and A_z are each given as a function of x , y , and z , the curl of the vector field (abbreviated curl $\mathbf{A}$ or $\nabla \times \mathbf{A}$) is the vector sum of the partial derivatives of each component with respect to the axes that are perpendicular to it, or

$$\text{curl } \mathbf{A} = \nabla \times \mathbf{A} = \begin{vmatrix} \mathbf{i} & \mathbf{j} & \mathbf{k} \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ A_x & A_y & A_z \end{vmatrix} =$$

$$\mathbf{i} \left(\frac{\partial A_z}{\partial y} - \frac{\partial A_y}{\partial z} \right) + \mathbf{j} \left(\frac{\partial A_x}{\partial z} - \frac{\partial A_z}{\partial x} \right) + \mathbf{k} \left(\frac{\partial A_y}{\partial x} - \frac{\partial A_x}{\partial y} \right) =$$

$$\mathbf{i}(D_y A_z - D_z A_y) + \mathbf{j}(D_z A_x - D_x A_z) + \mathbf{k}(D_x A_y - D_y A_x)$$

where $\mathbf{i}$, $\mathbf{j}$, and $\mathbf{k}$ are unit vectors along the x , y , and z axes respectively. Example: The curl of the linear velocity of points in a rotating body is equal to twice the angular velocity. The curl of the magnetic field strength at a point within an electric conductor is equal to $\mathbf{k}$ times the current density at the point where $\mathbf{k}$ is a constant depending on the system of units.

Current. A generic term used when there is no danger of ambiguity to refer to any one or more of the currents specifically described. (For example, in the expression "the current in a simple series circuit," the word current refers to the conduction current in the wire of the inductor and the displacement current between the plates of the capacitor.) A direct current is a unidirectional current in which the changes in value are either zero or so small that they may be neglected. A given current would be considered a direct current in some applications, but would not necessarily be so considered in other application.

Current Density. A generic term used when there is no danger of ambiguity to refer either to conduction current density or to displacement current density or to both.

Current Modified by an Adjective. The use of certain adjectives before "current" is often convenient, as in convection current, anode current, electrode current, emission current, etc. The definition of conducting current usually applies in such cases and the meaning of adjectives should be defined in connection with the specific applications.

Cutoff. See Cutoff Frequency.

Cutoff Frequency (Cutoff). A frequency that may be either a theoretical cutoff frequency or an effective cutoff frequency.

Cut-Set. A set of branches of a network such that the cutting of all the branches of the set increases the number of separate parts of the network, but the cutting of all the branches except one does not.

Cycle. The complete sequence of values of a periodic function which occurs during a period.

Cyclic Function. One which repetitively assumes a given sequence of values at an arbitrarily varying rate. That is, if y is a periodic function of x and x in turn is a monotonic nondecreasing function of t , then y is said to be a cyclic function of t .

Cyclic Shift. An operation which produces a word whose characters are obtained by a cyclic permutation of the characters of a given word.

Cyclically Magnetized Condition. A magnetic material is in a cyclically magnetized condition when, under the influence of a magnetizing force which is a cyclic (but not necessarily periodic) function of time having one maximum and one minimum per cycle, it follows identical hysteresis loops on successive cycles.

Damped Harmonic System (Linear System with One Degree of Freedom). A physical system in which the internal forces, when the system is in motion, can be represented by the terms of a linear differential equation with constant coefficients, the order of the equation being higher than the first. Example: The differential equation of a damped system is often of the form

$$M \frac{d^2 x}{dt^2} + F \frac{dx}{dt} + Sx = f(t)$$

where M , F and S are positive constants of the system; x is the dependent variable of the system (displacement in mechanics, quantity of electricity, etc.); and $f(t)$ is the applied force. Examples: A tuning fork is a damped harmonic system in which M represents a mass; F a coefficient of damping; S a coefficient of restitution; and x a displacement. Also an electric circuit containing constant inductance, resistance and capacitance is a damped harmonic system, in which case M represents the self inductance of the circuit; F the resistance of the circuit; S the reciprocal of the capacitance; and x the charge which has passed through a cross-section of the circuit.

Damped Oscillation (Damped Vibration). An oscillation in which the amplitude of the oscillating quantity decreases with time. If the rate of decrease can be expressed by means of a mathematical function, the name of the function may be used to describe the damping. Thus if the rate of decrease is exponential, the system is said to be an exponentially damped system.

Damped Sinusoidal Function. A function having the form $f_1(t) \sin(\omega t + \theta)$ where $f_1(t)$ is a monotonic decreasing function, and ω and θ are constants.

Damped Vibration. See Damped Oscillation.

Damped Wave. A wave in which, at every point, the amplitude of each sinusoidal component is a decreasing function of the time.

Damping. The temporal decay of the amplitude of a free oscillation of a system, associated with energy loss from the system.

Damping Factor. Of an underdamped harmonic system, the quotient of the logarithmic decrement by the natural period. The damping factor of an underdamped harmonic system is $F/2M$.

Decade. In electric circuit theory, the frequency interval between two frequencies having a ratio of 10 to 1. *Note:* This definition does not conform with the usual dictionary definition, and does not agree with other uses of "decade" in electrical engineering: e.g., as in "decade resistance box."

Decibel (dB). A dimensionless unit for expressing the ratio of two values of power, the number of decibels

being 10 times the logarithm to the base 10 of the power ratio. *Note:* With P_1 and P_2 designating two values of power and n the number of decibels denoting their ratio:

$$n = 10 \log_{10}(P_1/P_2)$$

Decimal Number System. See Positional Notation.

Decimal Point. See Point.

Decoder. A network or system in which a combination of inputs is excited at one time to produce a single output. Sometimes called matrix.

Degrees of Freedom on a Mesh Basis. See Nullity.

Degrees of Freedom on a Node Basis. See Rank.

Delay Distortion. See 65.08.333.

Delay Equalizer. A corrective network which is designed to make the phase delay or envelope delay of a circuit or system substantially constant over a desired frequency range.

Delay Line. A real or artificial transmission line or equivalent device designed to introduce delay.

Delay Line (in electronic computers). (1) Originally, a device utilizing wave propagation for producing a time delay of a signal. (2) Commonly, any device for producing a time delay of a signal.

Delay-Line Memory. See Delay-Line Storage.

Delay-Line Storage (Delay-Line Memory). A storage or memory device consisting of a delay line and means for regenerating and reinserting information into the delay line.

Delimited Region. For electric-circuit purposes, a space from which, or into which, energy is transmitted by an electric circuit, so chosen that the boundary surface satisfies certain conditions. In order that conventional measurements of electric voltage, current, and power may be correctly interpreted, it is necessary: (1) that the surface bounding the region cut each current-carrying conductor which enters the region in a cross-section that is perpendicular to the electric field intensity within the conductor; (2) that the component of the magnetizing force normal to the boundary surface at every point be constant or negligibly small; (3) that the component of the displacement current normal to the boundary surface at every point (not included within a conductor) be negligibly small; (4) that the paths along which voltages are determined must lie in the boundary surface or be chosen so that equal voltages are obtained. Examples of regions that may be delimited for practical purposes include: a generator, a generating station, a transformer, a substation, a manufacturing establishment, a motor, a lamp, a geographical area, etc.

Delta-Connected Circuit (Δ -Connected). A three-phase circuit which is (simply or completely) mesh connected.

Delta Network. A set of three branches connected in series to form a mesh.

Depletion Layer (in a semiconductor). A region in which the charge-carrier charge density is insufficient to neutralize the net fixed charge density of donors and acceptors.

Derived Units. The derived units of a system of units are those which are not selected as basic, but are derived from the basic units. *Note:* A derived unit is defined by specifying an operational procedure for its realization.

Design Test. A test made by the manufacturer to obtain data for design or application, or to obtain information

on the performance of each type of an apparatus. *Note:* Design tests may be made on selected specimens during production at the request of the purchaser, when specified and agreed upon.

Determinant of a Network. 1. Branch basis—the determinant formed by the coefficients of the branch currents after the application of Kirchhoff's two laws. This determinant is not necessarily symmetrical in the case of a passive network. 2. Mesh or loop basis—the determinant formed by the (impedance) coefficients of the mesh or loop currents in a complete set of mesh or loop equations. 3. Node basis—the determinant formed by the (admittance) coefficients of the node voltages in a complete set of node equations. *Note:* See also Network Function.

Device. 1. A unit of an electric system which is intended to carry but not utilize electric energy. (NEC 1965). 2. A mechanical or an electric contrivance to serve a useful purpose.

Diagnostic Routine. A routine designed to locate either a malfunction in the computer or a mistake in coding. See also Check, Programmed.

Diamagnetic Material. A material whose relative permeability is less than unity.

Dielectric. A medium in which it is possible to maintain an electric field with little or no supply of energy from outside sources.

Dielectric Absorption. A phenomenon which occurs in imperfect dielectrics whereby positive and negative charges are separated and then accumulated at certain regions within the volume of the dielectric. This phenomenon manifests itself usually as a gradually decreasing current with time after the application of a fixed direct voltage.

Dielectric Attenuation Constant. Per unit of length, the reciprocal of the distance that a plane electromagnetic wave travels through a dielectric before its amplitude is reduced to $1/e$ of the original amplitude, where e is the base of the napierian system of logarithms. The dielectric attenuation constant is related to the dielectric dissipation factor by the equation:

$$\alpha = \frac{2\pi}{\lambda} \left[\frac{\epsilon' \mu}{2} \left(\sqrt{1 + \tan^2 \delta} - 1 \right) \right]^{1/2} \text{ (nepers/meter)}$$

where ϵ' is the relative dielectric constant, μ is the relative magnetic permeability, λ is the wavelength in a vacuum and $\tan \delta$ is the dissipation factor. This expression is valid for dielectric in free space or a coaxial transmission line, but must be modified if the wave is in a dielectric filled wave guide.

Dielectric Dispersion. The phenomenon in which the magnitude of the dielectric constant of a material decreases or increases with increasing frequency.

Dielectric Dissipation Factor. The ratio of ϵ'' to ϵ' . See Relative Complex Dielectric Constant.

Dielectric Loss. The time rate at which electric energy is transformed into heat in a dielectric when it is subjected to a changing electric field. The heat generated per unit volume of material upon the application of a sinusoidal electric field is given by the expression:

$$W = \frac{5}{9} \epsilon'' f E^2 \times 10^{-12} \text{ watts/cm}^3$$

where E is the root-mean-square field strength in volts per centimeter, f is the frequency, and ϵ'' is the loss factor.

Dielectric Loss Angle. The angle whose tangent is the

dissipation factor, or $\arctan \epsilon''/\epsilon'$. See Dielectric Dissipation Factor and Relative Complex Dielectric Constant.

Dielectric Loss Factor*. See Dielectric Loss Index.

Dielectric Loss Index ϵ'' (Dielectric Loss Factor)*. Of a homogeneous isotropic material, the negative of the imaginary part of the relative complex dielectric constant. See Relative Complex Dielectric Constant.

* Depreciated.

Dielectric Phase Angle. The angle whose cotangent is the dissipation factor, or $\arctan \epsilon''/\epsilon'$. See Dielectric Dissipation Factor and Relative Complex Dielectric Constant.

Dielectric Phase Constant. Per unit of length in a dielectric, 2π divided by the wavelength of the electromagnetic wave in the dielectric. The phase constant is related to the dielectric constant by the following equation:

$$\beta = \frac{2\pi}{\lambda} \left[\frac{\epsilon' \mu}{2} (\sqrt{1 + \tan^2 \delta} + 1) \right]^{1/2} \text{ (radians/meter)}$$

where λ is the wavelength of the wave in a vacuum, ϵ' is the relative dielectric constant, μ is the relative magnetic permeability, and $\tan \delta$ is the dissipation factor. This expression is valid for dielectric in free space or a coaxial transmission line, but must be modified if the wave is in a dielectric filled wave guide.

Dielectric Power Factor. The cosine of the dielectric phase angle (or the sine of the dielectric loss angle).

Dielectric Strength (Electric Strength) (Breakdown Strength). Of a material, the potential gradient at which electric failure or breakdown occurs. To obtain the true dielectric strength the actual maximum gradient must be considered, or the test piece and electrodes must be designed so that uniform gradient is obtained. The value obtained for the dielectric strength in practical tests will usually depend on the thickness of the material and on the method and conditions of test.

Differential Permeability. The derivative of the scalar magnitude of the magnetic flux density with respect to the scalar magnitude of the magnetizing force. *Note 1*: This term has also been used for the slope of the normal induction curve. *Note 2*: In anisotropic media, differential permeability becomes a matrix.

Differentiating Circuit (Differentiator) (Differentiating Network). A transducer whose output wave form is substantially the time derivative of its input wave form. *Note*: Such a transducer preceding a frequency modulator makes the combination a phase modulator; or, following a phase detector makes the combination a frequency detector. Its ratio of output amplitude to input amplitude is proportional to frequency and its output phase leads its input phase by 90 degrees.

Differentiating Network. See Differentiating Circuit.

Differentiator. See Differentiating Circuit.

Differentiator (in electronic computers). A device, usually of the analog type, whose output is proportional to the derivative of an input signal.

Diffusion Capacitance (of a semiconductor junction). The rate of change of stored minority-carrier charge with the voltage across the junction.

Diffusion Constant, Charge-Carrier. In a homogeneous semiconductor, the magnitude of the quotient of diffusion current density by the charge-carrier charge concentration gradient.

Diffusion Length, Charge-Carrier. In a homogeneous

semiconductor, the average distance to which minority carriers diffuse between generation and recombination. *Note*: The diffusion length is equal to the square root of the product of the charge-carrier diffusion constant and the volume lifetime.

Digit. See Positional Notation.

Digital Computer. A computer which operates with information, numerical or otherwise, represented in a digital form.

Dimension. In a given dimensional system, a dimension of a physical quantity is a convenience label which is determined by the kind of quantity (e.g., mass, length, voltage) and which is an element of multiplicative group. *Note 1*: The product of any pair of dimensions is a dimension. *Note 2*: The unit element of the group is "numeric" or "pure number" which is therefore a dimension.

Dimensional System. A multiplicative group of dimensions characterized by the independent dimensions generating the group. *Note 1*: Derived dimensions are often given individual names (e.g., energy and speed, when mass, length, and time are the generators). *Note 2*: The basic dimensions and basic units may be chosen independently of each other. In the special case in which the basic dimensions are the dimensions of the quantities to which the basic units are assigned, dimensional analysis indicates the manner in which the measure of a quantity would change with an assumed virtual variation in the basic units.

Diode, Semiconductor. A semiconductor device having two terminals and exhibiting a nonlinear voltage-current characteristic; in more restricted usage, a semiconductor device which has the asymmetrical voltage-current characteristic exemplified by a single p-n junction.

Dipole Molecule. A molecule that possesses a dipole moment as a result of the permanent separation of the centroid of positive charge from the centroid of negative charge for the molecule as a whole.

Direct Capacitance Between Two Conductors. The ratio of the change in charge on one conductor to the corresponding change in potential of the second conductor when the second conductor is the only one whose potential is permitted to change. (See Direct Capacitances of a System of Conductors.)

Direct Capacitances of a System of Conductors. The direct capacitances of a system of n conductors such as that considered in Coefficients of Capacitance of a System of Conductors are the coefficients in the array of linear equations which express the charges on the conductors in terms of their differences in potential, instead of potentials relative to ground.

$$\begin{aligned} Q_1 &= 0 + C_{12}(V_1 - V_2) + C_{13}(V_1 - V_3) \dots \\ &\quad C_{1(n-1)}(V_1 - V_{n-1}) + C_{10}V_1 \\ Q_2 &= C_{21}(V_2 - V_1) + 0 + C_{23}(V_2 - V_3) \dots \\ &\quad C_{2(n-1)}(V_2 - V_{n-1}) + C_{20}V_2 \\ &\dots \\ Q_{n-1} &= C_{(n-1)1}(V_{n-1} - V_1) + C_{(n-1)2}(V_{n-1} - V_2) \dots \\ &\quad 0 + C_{(n-1)0}V_{n-1} \end{aligned}$$

with $C_{rp} = C_{pr}$ and C_{rr} not involved but defined as zero.

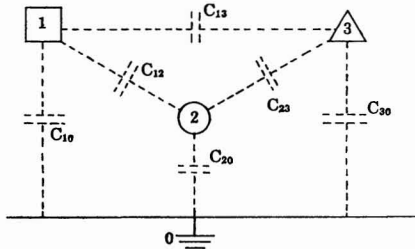
Note: The coefficients of capacitance (c) are related to the direct capacitances (C) as follows:

$$\begin{aligned} c_{rp} &= -C_{rp} \text{ for } r \neq p \text{ and } \\ c_{rr} &= \sum_{p=1}^n C_{rp} \end{aligned}$$

Note: The relationships of the direct capacitances in a four-conductor system to the other defined capacitances are given in the following table. As in the diagram, the direct capacitances between the conductors of the system, including ground, are indicated as C_{10} , C_{12} , C_{13} , etc. Here the subscript "0" is used to denote the ground (n -th) conductor.

Conductor	Self Capacitance
1	$C_{10} + C_{12} + C_{13}$
2	$C_{20} + C_{21} + C_{23}$
3	$C_{30} + C_{31} + C_{32}$

Capacitance Diagram—Showing the equivalent direct capacitance network of a 4-conductor system.



Pairs of Conductors—1-2.

Plenary Capacitance

$$C_{12} + \frac{C_{30}(C_{10} + C_{13})(C_{20} + C_{23}) + C_{10}C_{30}(C_{31} + C_{32}) + C_{21}C_{32}(C_{10} + C_{20})}{C_{30}(C_{10} + C_{13} + C_{20} + C_{23}) + (C_{10} + C_{20})(C_{31} + C_{32})}$$

Balanced Capacitance

$$C_{12} + \frac{(C_{13} + C_{10})(C_{23} + C_{20})}{C_{13} + C_{10} + C_{23} + C_{20}}$$

Pairs of Conductors—2-3.

Plenary Capacitance

$$C_{23} + \frac{C_{10}(C_{20} + C_{21})(C_{30} + C_{31}) + C_{20}C_{30}(C_{31} + C_{32}) + C_{31}C_{21}(C_{20} + C_{30})}{C_{10}(C_{20} + C_{21} + C_{30} + C_{31}) + (C_{20} + C_{30})(C_{31} + C_{32})}$$

Balanced Capacitance

$$C_{23} + \frac{(C_{21} + C_{20})(C_{31} + C_{30})}{C_{21} + C_{20} + C_{31} + C_{30}}$$

Pairs of Conductors—3-1.

Plenary Capacitance

$$C_{31} + \frac{C_{20}(C_{10} + C_{12})(C_{30} + C_{32}) + C_{10}C_{30}(C_{32} + C_{12}) + C_{12}C_{32}(C_{10} + C_{30})}{C_{20}(C_{10} + C_{12} + C_{30} + C_{32}) + (C_{10} + C_{30})(C_{12} + C_{32})}$$

Balanced Capacitance

$$C_{31} + \frac{(C_{32} + C_{30})(C_{12} + C_{10})}{C_{32} + C_{30} + C_{12} + C_{10}}$$

Direct Coupling. The association of two or more circuits by means of self inductance, capacitance, resistance, or a combination of these which is common to the circuits. **Note:** *Resistive coupling* is the case in which the common branch contains only resistance; *capacitive coupling* that

in which the branch contains only capacitance; *direct-inductive* or *self-inductive coupling* that in which the branch contains only self-inductance.

Direct Current (Continuous Current). A unidirectional current in which the changes in value are either zero or so small that they may be neglected. A given current would be considered a direct current in some applications, but would not necessarily be so considered in other applications.

Direct-Current Circuit. A circuit which includes two or more interrelated conductors intended to be energized by direct current.

Direction of Energy Flow. In a specified circuit, with reference to the boundary of a delimited region, the direction in which electric energy is being transmitted past the boundary, into or out of the region.

Direction of Propagation. See 65.34.102.

Discrimination. See 65.08.153.

Displacement Current. Through any surface, the integral of the normal component of the displacement current density over that surface. **Note:** Displacement current is a scalar and hence has no direction.

Displacement Current Density. At any point in an electric field, (in SI units) the time rate of change of the electric flux density vector at that point.

Dissymmetrical Transducer. See 65.06.463.

Distortion. An undesired change in wave form. (See 65.08.321.)

Distortion Power of a Polyphase Circuit. At the terminals of entry of a polyphase circuit, equal to the sum of the distortion powers for the individual terminals of entry. The distortion power for each terminal of entry is determined by considering each phase conductor, in turn, with the common reference point as a single-phase, two-wire circuit and finding the distortion power for each in accordance with the definition of Distortion Power of a Single-Phase, Two-Wire Circuit. The common reference terminal shall be taken as the neutral terminal of entry, if one exists, otherwise as the true neutral point. The sign given to the distortion power for each single-phase current, and therefore to the total for the polyphase circuit, shall be the same as that of the total active power. Distortion power is expressed in volt-amperes when the voltages are in volts and the current in amperes. **Note:** The distortion power is zero if each voltage has the same wave form as the corresponding current. This condition is fulfilled, of course, when all the currents and voltages are sinusoidal.

Distortion Power of a Single-Phase, Two-Wire Circuit. At the two terminals of entry of a single-phase, two-wire circuit into a delimited region, is a scalar quantity having an amplitude equal to the square root of the difference of the squares of the apparent power and the amplitude of the phasor power. Mathematically the amplitude of the distortion power D is given by the equation

$$D = \sqrt{U^2 - S^2} = \sqrt{U^2 - P^2 - Q^2}$$

$$= \sqrt{\sum_{r=1}^{\infty} \sum_{q=1}^{\infty} \{E_r^2 I_q^2 - E_r E_q I_r I_q \cos[(\alpha_r - \beta_r) - (\alpha_q - \beta_q)]\}}$$

where the symbols are as in Apparent Power of a Single-Phase, Two-Wire Circuit. If the voltage and current are quasi-periodic and the amplitudes are slowly varying, the distortion power at any instant may be taken as the value

derived from the amplitude of the apparent power and phasor power at that instant. By this definition the sign of distortion power is not definitely determined, and it may be given either sign. In the absence of other definite information, it is to be taken the same as for the active power. Distortion power is expressed in volt-amperes when the voltage is in volts and the current in amperes. *Note:* The distortion power is zero if the voltage and the current have the same wave form. This condition is fulfilled when the voltage and current are sinusoidal and have the same period, or when the circuit consists entirely of non-inductive resistors.

Divergence of a Vector Field. At a point, a scalar equal to the limit of the quotient of the outward flux through a closed surface which surrounds the point by the volume within the surface, as the volume approaches zero. If the vector, $\mathbf{A}$, of a vector field is expressed in terms of its three rectangular components A_x , A_y , A_z , so that the values of A_x , A_y , A_z are each given as a function of x , y , and z , the divergence of the vector field $\mathbf{A}$ (abbreviated $\nabla \cdot \mathbf{A}$) is the sum of the three scalars obtained by taking the derivatives of each component in the direction of its axis, or

$$\text{div } \mathbf{A} \equiv \nabla \cdot \mathbf{A} = \frac{\partial A_x}{\partial x} + \frac{\partial A_y}{\partial y} + \frac{\partial A_z}{\partial z}$$

Examples: If a vector field $\mathbf{A}$ represents velocity of flow such as the material flow of water or a gas or the imagined flow of heat or electricity, the divergence of $\mathbf{A}$ at any point is the net outward rate of flow per unit volume and per unit time. It is the time rate of decrease in density of the fluid at that point. Because the density of an incompressible fluid cannot change, the divergence of an incompressible fluid is always zero. The divergence of the flow of heat at a point in a body is equal to the rate of generation of heat per unit volume at the point. The divergence of the electric field strength at a point is proportional to the volume density of charge at the point.

Donor (in a semiconductor). *See* Impurity Donor.

Doping. The addition of an impurity to a semiconductor, or production of a deviation from stoichiometric composition, to achieve a desired characteristic.

Dot Product. *See* Scalar Product.

Dot-Product Line Integral. *See* Line Integral.

Double-Length Number (Double-Precision Number). A number having twice as many digits as are ordinarily used in a given computer.

Double-Precision Number. *See* Double-Length Number.

Double-Tuned Circuit. *See* 65.06.581.

Drift Mobility (in a homogeneous semiconductor). The ensemble average of the drift velocities of the charge-carriers per unit electric field. *Note:* In general, the mobilities of electrons and holes are different.

Driving-Point Impedance. *See* Input, Driving-Point or Sending-End Impedance.

Dual Networks. *See* Structurally Dual Networks.

Duty. A statement of the operating conditions to which the machine or apparatus is subjected, their respective durations and their sequence in time.

Dynamic Equilibrium of an Electromagnetic System. (a) Any two circuits carrying current tend so to dispose themselves that the magnetic flux linking the two will be a maximum. (b) Every electromagnetic system tends to change its configuration so that the magnetic flux will be

a maximum.

Dyne. The unit of force in the cgs systems. The dyne is 10^{-5} newtons.

Eddy Currents (Foucault Currents). Those currents that exist as a result of voltages induced in the body of a conducting mass by a variation of magnetic flux. *Note:* The variation of magnetic flux is the result of a varying magnetic field or of a relative motion of the mass with respect to the magnetic field.

Edison Effect. *See* Thermionic Emission.

Effective Cutoff. *See* Effective Cutoff Frequency.

Effective Cutoff Frequency (Effective Cutoff). Of an electric circuit, a frequency at which its insertion loss between specified terminating impedances exceeds by some specified amount the loss at some reference point in the transmission band. *Note:* The specified insertion loss is usually 3 dB.

Effective Pulse Amplitude*. *See* Root-Mean-Square Pulse Amplitude.

* Deprecated.

Effective Value*. *See* Root-Mean-Square Value of a Periodic Function.

* Deprecated.

Efficiency. The ratio of the useful output to the input (energy, power, quantity of electricity, etc.). Unless specifically stated otherwise, the term "efficiency" means efficiency with respect to power.

Elastance. The reciprocal of capacitance.

Elastances of a System of Conductors (Coefficients of Potential—Maxwell). A set of n conductors of any shape that are insulated from each other and that are mounted on insulating supports within a conducting shell, or on one side of a conducting sheet of infinite extent or above the surface of the earth, constitutes a system of n capacitors having mutual elastances and capacitances. If the shell (or the earth) is regarded as the electrode common to all n capacitors and the transfers of charge as taking place between shell and the individual electrodes, the sum of the charges on the conductors will be equal and opposite in sign to the charge on the common electrode. The shell (or the earth) is taken to be at zero potential. Let Q_r represent the value of the charge that has been transferred from the shell to the other electrode of the r th capacitor, and let V_r represent the algebraic value of the potential of this electrode resulting from the charges in all n capacitors. If the charges are known the values of the potentials can be computed from the equations:

$$\begin{aligned} V_1 &= S_{11}Q_1 + S_{12}Q_2 + S_{13}Q_3 + \dots \\ V_2 &= S_{21}Q_1 + S_{22}Q_2 + S_{23}Q_3 + \dots \\ V_3 &= S_{31}Q_1 + S_{32}Q_2 + S_{33}Q_3 + \dots \\ &\text{etc.} \end{aligned}$$

$$V_r = \sum_{c=1}^{c=n} S_{r,c}Q_c$$

The multiplying operators $S_{r,r}$ are the self elastances and the multipliers $S_{r,c}$ are the mutual elastances of the system. Maxwell termed them the coefficients of potential of the system. Their values can be measured by noting that the defining equation for the mutual elastance $S_{r,c}$ is,

$$S_{r,c} \text{ (daraf)} = \frac{V_r}{Q_c} \text{ (volt)}$$

(every Q except Q_c being zero).

It can be shown that $S_{r,c} = S_{c,r}$, and that under the con-