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IRE STANDARDS ON CIRCUITS: DEFINITIONS OF TERMS FOR LINEAR PASSIVE RECIPROCAL TIME INVARIANT NETWORKS 1960

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INTRODUCTION

IRE Standards on Circuits: Definitions of Terms for Linear Passive Reciprocal Time Invariant Networks, 1960[1]

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[1]Approved by the IRE Standards Committee, January 14, 1960. Reprints of IRE Standard 60 IRE 4.S2, may be purchased while available from the Institute of Radio Engineers, 1 East 79th Street, New York, N. Y. at $0.50 per copy. A 20 per cent discount will be allowed for 100 or more copies mailed to one address.

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All of the terms in this Standard apply to mathematical concepts which represent idealizations of physical phenomena. Thus the definitions apply to idealized models which are useful in describing properties of physical networks. However, the question of whether or not a certain term is applicable to a particular physical situation must be answered by the user.

Accordingly, the terms *impedance* and *admittance* are more properly thought of as *impedance function* and *admittance function*. Similarly, where the term *network* is used, reference is to an idealized model. Because of well-established usage, however, the shortened forms are preferred and are used in this set of definitions.

The functions to which the definitions apply are functions of the complex frequency, $s = \sigma + j\omega$, and are formed by taking specified ratios of the Laplace transforms (or other appropriate transforms) of the excitation and response. For signals which are simple exponential functions of time the ratios of the complex signal amplitudes can be used.

Wherever possible, the definitions apply to both lumped-parameter and distributed-parameter networks. The additional restrictions that apply when the networks are of the lumped-parameter type, are specified in a note associated with the particular definition.

The concept of realizability is used in some of the definitions, but no attempt has been made to include detailed properties of realizable functions.

CLAUSE PAGE

DEFINITIONS 1

DEFINITIONS

All-Pass Function: A *transmittance* which provides only phase shift, its *magnitude characteristic* being constant.

NOTES:

1 — For lumped-parameter networks, this is equivalent to specifying that the zeros of the function are the negatives of the poles.

2 — A realizable *all-pass function* exhibits non-decreasing phase lag with increasing frequency.

3 — A trivial *all-pass function* has zero phase at all frequencies.

Complementary Functions: Two *driving-point functions* whose sum is a positive constant.

Constant-Resistance (Conductance) Network: A network having at least one *driving-point impedance (admittance)* that is a positive constant.

Driving-Point Admittance: A *driving-point function* for which the excitation is a voltage and the response is a current.

Driving-Point Function: A *response function* for which the variables are measured at the same port (terminal pair).

Driving-Point Impedance: A *driving-point function* for which the excitation is a current and the response is a voltage.

Immittance: A *response function* for which one variable is a voltage and the other a current.

NOTE — *Immittance* is a general term for both impedance and admittance, used where the distinction is irrelevant.

Magnitude Characteristic: The absolute value of a *response function* evaluated on the imaginary axis of the complex-frequency plane.

Minimum Conductance Function: See *Minimum Resistance (Conductance) Function*.

Minimum-Driving-Point Function: A *driving-point function* that is a *minimum-resistance, minimum-conductance, minimum-reactance* and *minimum-susceptance function*.

Minimum-Phase Function: A *transmittance* from which a nontrivial realizable *all-pass function* cannot be factored without leaving a nonrealizable remainder.

NOTE — For lumped-parameter networks, this is equivalent to specifying that the function has no zeros in the interior of the right half of the complex-frequency plane.

Minimum-Reactance Function: A *driving-point impedance* from which a *reactance function* cannot be subtracted without leaving a nonrealizable remainder.

NOTES:

1 — For lumped-parameter networks, this is equivalent to specifying that the impedance function has no poles on the imaginary axis of the complex-frequency plane, including the point at infinity.

2 — A *driving-point impedance (admittance)* having neither poles nor zeros on the imaginary axis is both a *minimum-reactance* and a *minimum-susceptance function*.

Minimum-Resistance (Conductance) Function: A *driving-point impedance (admittance)* from which a positive constant cannot be subtracted without leaving a non-realizable remainder.

Minimum-Susceptance Function: A *driving-point admittance* from which a *susceptance function* cannot be subtracted without leaving a nonrealizable remainder.

NOTES:

1 — For lumped-parameter networks, this is equivalent to specifying that the admittance function has no poles on the imaginary axis of the complex-frequency plane, including the point at infinity.

2 — A driving-point *immittance* having neither poles nor zeros on the imaginary axis is both a *minimum-susceptance* and a *minimum-reactance function*.

Phase Characteristic: The angle of a *response function* evaluated on the imaginary axis of the complex-frequency plane.

Reactance Function: The *driving-point impedance* of a lossless network.

NOTE — This is an odd function of the complex frequency.

Realizable Function: A response function which can be realized by a network containing only positive resistance, inductance, capacitance, and ideal transformers.

NOTE — This is the sense of realizability in the theory of linear, passive, reciprocal, time-invariant networks.

Response Function: The ratio of response to excitation, both expressed as functions of the complex frequency, $s = \sigma + j\omega$.

NOTE — The response function is the Laplace transform of the response due to unit impulse excitation.

Susceptance Function: The *driving-point admittance* of a lossless network.

NOTE — This is an odd function of the complex frequency.

Transfer Admittance: A *transmittance* for which the excitation is a voltage and the response is a current.

(Transfer) Current Ratio: A *transmittance* for which the variables are currents.

NOTE — The word “transfer” is frequently dropped in current usage.

Transfer Function: A relationship between one system variable and another that enables the second variable to be determined from the first. See also *Transmittance*.

Transfer Immittance: See *Transmittance*.

Transfer Impedance: A *transmittance* for which the excitation is a current and the response is a voltage.

(Transfer) Voltage Ratio: A *transmittance* for which the variables are voltages.

NOTE — The word “transfer” is frequently dropped in current usage.

Transmittance (Transfer Function): A *response function* for which the variables are measured at different ports (terminal pairs).