

IEEE
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58-1956)

IEEE Standard Induction Motor Letter Symbols

Sponsor

**Rotating Machinery Committee of the
IEEE Power Engineering Society**

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Foreword

(This Foreword is not a part of IEEE Std 58-1978, Standard Induction Motor Letter Symbols.)

Originally issued as a trial-use standard in 1956, IEEE Standard Induction Motor Letter Symbols has been enlarged to reflect those additional symbols required by the state of the art, and it has been approved and published as a full-status IEEE Standard. It is expected that experience with the present document may generate interest in further additions or other modifications. Suggestions for changes should be forwarded to:

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IEEE Standard Induction Motor Letter Symbols

1. Introduction (2)

At present, technical papers on induction machinery use letter symbols selected by their authors. As a result, readers lose too much time becoming familiar with the symbols used by each author. It has long been felt by many in this field that a fair exchange of ideas on induction machinery would be promoted if all writers used the same letter symbols for the same quantities. A Working Group was set up by the Rotating Machinery Committee to develop a unified system of letter symbols that could be used for this purpose. This standard is the outcome of a trial period of several years as a proposed standard.

The standard usually applies only to steady-state or quasi-steady-state conditions. (4)

2. Scope

Section 8 gives the letter symbols for those quantities needed to define an induction motor in terms of a recognized equivalent circuit, with lumped constants or parameters. Section 9 gives the letter symbols for dimensional values. These symbols cover both polyphase and single-phase motors. Every effort has been made to avoid use of the same symbol for different meanings.

3. Guiding Principles

It is not intended to recommend or to favor any particular theoretical approach. The symbols developed are suitable for wide application.

Letter symbols have been selected on as logical a basis as possible. Recognizing typewriter limitations, Greek letters have been avoided as much as possible.

Some of the principles used to set up the system of symbols covered in this report follow:

3.1 All secondary quantities (such as impedances,¹ currents, etc) are understood to be in primary winding terms, unless otherwise specified. In the case of single-phase motors primary winding terms mean the main winding terms unless otherwise indicated.

3.2 Impedances of a single winding only—such as a primary or secondary—are written in lower case letters.

3.3 Impedances of a combination of primary and secondary winding (all secondary windings if there are more than one) are written in upper case letters. (Partial exception: Z_f and Z_b do not include primary leakage impedance.)

3.4 Impedances of external auxiliary devices, such as capacitors, for example, are written in upper case letters.

3.5 The sum of two or more like impedances, both of which are written in upper case letters, is usually indicated by use of the single upper case letter with the two or more applicable subscripts. (Example: $R_a + R_c = R_{ac}$.) This rule does not apply to lower case symbols.

3.6 All impedances for three-phase motors refer to line-to-neutral quantities or equivalents, unless otherwise specified. (3)

3.7 For polyphase single-cage and wound rotor motors, primary impedances are denoted by the subscript "1" and secondary impedances referred to the primary are denoted by a subscript "2."

3.8 For polyphase motors with more than one cage, the total impedance of all the secondary cages is denoted by a lower case letter with subscript "2." Leakage impedances of individual cages are denoted by single digits "3," "4,"

¹ The word "impedance" as used in these guiding principles is understood to include resistance, and reactance terms, which follow the same rules.

“5,” etc; “3” is used for the cage nearest the air gap, “4” for the next. That is, the cages are numbered consecutively starting at the air gap and working away from it. Mutual impedances between cages are denoted by use of multidigit (for example, two-digit) subscripts to indicate the cages concerned.

3.9 For single-phase motors, primary impedances of the main winding are denoted by the subscript “1”; those of the auxiliary winding by “1a.” Secondary impedances, referred to the main winding, are denoted the same as for polyphase motors. If secondary impedances are referred to the auxiliary winding, “a” is added to the subscript.

3.10 Magnetizing reactance is denoted by the symbol x_M which, in this report, means the apparent magnetizing reactance due to the space fundamental component of the mutual air-gap flux. For polyphase motors, this refers to the reactance voltage developed in each phase by the mutual air-gap flux set up by all the phases.

3.11 Total impedance, at any slip, is denoted by a single upper case letter with subscripts as follows:

- (a) Polyphase motors, line-to-neutral—no subscript.
- (b) Single-phase motors, main winding only—no subscript, or T . (When motor is running on main winding only, this is simply the ratio of impressed voltage divided by the current drawn; when both windings are energized, this is not true because of voltages induced from the other winding.)
- (c) Single-phase motors, auxiliary phase impedance— T_a .

3.12 Impressed voltages are denoted by an upper case V ,² with suitable subscripts as needed. Generally speaking, these are the same as for

impedances, so far as practicable. The positive direction of the voltage should be indicated.

3.13 Impedance drop and induced voltages are denoted by an upper case E , with suitable subscripts, generally paralleling the subscripts used for impedance quantities.

3.14 Root-mean-square currents are indicated by an upper case I with suitable subscripts, generally the same as the impedance through which the current flows.

3.15 Efforts have been made to keep to a minimum the number of subscripts. However, it is recognized that there are not enough single subscripts. Consequently, double subscripts are frequently used, and occasionally triple subscripts, particularly when the logic of the situation makes the double or triple subscript easier to learn.

3.16 Additional subscript letters can usually be avoided by use of explanatory notes. However, if necessary, they may be added to indicate quantities at specific slips as follows:

- (a) “L” for locked-rotor quantities,
- (b) “o” for no-load quantities,
- (c) “fl” for full-load quantities.

3.17 For certain other areas, some of which are covered explicitly in this standard, the following subscripts are recommended.

- (a) for shading-coil quantities in shaded-pole motors: s ;
- (b) for positive-sequence quantities: $^2 p$;
- (c) for negative-sequence quantities: $^2 n$;
- (d) for zero-sequence quantities: $^2 z$;
- (e) for direct-axis quantities (two-reaction theory): d ;
- (f) for quadrature-axis quantities (two-reaction theory): q .

The circuits employed to illustrate the letter symbols are not to be interpreted as official or necessarily recommended. They are merely typical and serve to illustrate the usage of the symbols. It is hoped that authors using other circuits will follow the guiding principles as far as possible. When other circuits are developed, using quantities not covered by the guiding principles of this standard, it is recommended that the author of the paper show the correlation between the new quantities he is establishing in terms of the quantities given in

² ANSI Y10.5-1968 recommends designating the symmetrical components of the currents and potential differences in unbalanced polyphase systems by adding double subscripts to the symbols. The first subscript designates phase and the second designates the sequence; 1 for positive, 2 for negative, and 0 for zero sequence. Subscripts 1 and 2 have been so firmly established in the literature of induction-motor theory as identification of primary and secondary quantities that the above shown usage of p , n , and z are herein recommended.