UL 60034-2-1

STANDARD FOR SAFETY

Rotating Electrical Machines – Part 2-1: Standard methods for determining losses and efficiency from tests (excluding machines for traction vehicles)

ULSE INC. COPYRIGHTED MATERIAL – NOT AUTHORIZED FOR FURTHER
REPRODUCTION OR DISTRIBUTION WITHOUT PERMISSION FROM ULSE INC.

UL Standard for Safety for Rotating Electrical Machines – Part 2-1: Standard methods for determining losses and efficiency from tests (excluding machines for traction vehicles), UL 60034-2-1

Second Edition, Dated November 15, 2024

Summary of Topics

This new Second Edition of ANSI/UL 60034-2-1 dated November 15, 2024 is an Adoption of IEC 60034-2-1, Rotating Electrical Machines – Part 2-1: Standard methods for determining losses and efficiency from tests (excluding machines for traction vehicles) (Third Edition, issued March 2024) as a new IEC-based UL standard. Please note that there are no US National Differences.

The requirements are substantially in accordance with Proposal(s) on this subject dated August 9, 2024.

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form by any means, electronic, mechanical photocopying, recording, or otherwise without prior permission of ULSE Inc. (ULSE).

ULSE provides this Standard "as is" without warranty of any kind, either expressed or implied, including but not limited to, the implied warranties of merchantability or fitness for any purpose.

In no event will ULSE be liable for any special, incidental, consequential, indirect or similar damages, including loss of profits, lost savings, loss of data, or any other damages arising out of the use of or the inability to use this Standard, even if ULSE or an authorized ULSE representative has been advised of the possibility of such damage. In no event shall ULSE's liability for any damage ever exceed the price paid for this Standard, regardless of the form of the claim.

Users of the electronic versions of UL's Standards for Safety agree to defend, indemnify, and hold ULSE harmless from and against any loss, expense, liability, damage, claim, or judgment (including reasonable attorney's fees) resulting from any error or deviation introduced while purchaser is storing an electronic Standard on the purchaser's computer system.

ULSE INC. COPYRIGHTED MATERIAL – NOT AUTHORIZED FOR FURTHER REPRODUCTION OR DISTRIBUTION WITHOUT PERMISSION FROM ULSE INC.

No Text on This Page

ULSE INC. COPYRIGHTED MATERIAL – NOT AUTHORIZED FOR FURTHER REPRODUCTION OR DISTRIBUTION WITHOUT PERMISSION FROM ULSE INC.

UL 60034-2-1

Standard for Rotating Electrical Machines – Part 2-1: Standard methods for determining losses and efficiency from tests (excluding machines for traction vehicles)

First Edition – February, 2017

Second Edition

November 15, 2024

This ANSI/UL Standard for Safety consists of the Second Edition.

The most recent designation of ANSI/UL 60034-2-1 as an American National Standard (ANSI) occurred on November 15, 2024. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, Title Page, or Preface. The IEC Foreword is also excluded from the ANSI approval of IEC-based standards.

Comments or proposals for revisions on any part of the Standard may be submitted to ULSE at any time. Proposals should be submitted via a Proposal Request in the Collaborative Standards Development System (CSDS) at https://csds.ul.com.

Our Standards for Safety are copyrighted by ULSE Inc. Neither a printed nor electronic copy of a Standard should be altered in any way. All of our Standards and all copyrights, ownerships, and rights regarding those Standards shall remain the sole and exclusive property of ULSE Inc.

© 2024 ULSE Inc. All rights reserved.

ULSE INC. COPYRIGHTED MATERIAL – NOT AUTHORIZED FOR FURTHER REPRODUCTION OR DISTRIBUTION WITHOUT PERMISSION FROM ULSE INC.

No Text on This Page

ULSE INC. COPYRIGHTED MATERIAL – NOT AUTHORIZED FOR FURTHER REPRODUCTION OR DISTRIBUTION WITHOUT PERMISSION FROM ULSE INC.

CONTENTS

Preface (UL)....5

FOREWORD....7

1 Scope....9
2 Normative references....9
3 Terms and definitions....9
4 Symbols and abbreviated terms....15
4.1 Symbols....15
4.2 Additional subscripts....16
5 Basic requirements....17
5.1 Direct and indirect efficiency determination....17
5.2 Uncertainty....17
5.3 Preferred methods and methods for customer-specific acceptance tests, field-tests or routine-tests....18
5.4 Power supply....18
5.5 Instrumentation....18
5.6 Units....20
5.7 Resistance....20
5.8 State of the machine under test and test categories....21
5.9 Excitation circuit measurements....22
5.10 Ambient temperature during testing....23
6 Test methods for the determination of the efficiency of induction machines....23
6.1 Preferred testing methods....23
6.2 Testing methods for field or routine-testing....39
7 Test methods for the determination of the efficiency of synchronous machines....58
7.1 Preferred testing methods....58
7.2 Testing methods for field or routine testing....70
8 Test methods for the determination of the efficiency of DC machines....81
8.1 Testing methods for field or routine testing....81
8.2 Method 2-1-3A – Direct measurement of input and output....81
8.3 Method 2-1-3B – Summation of losses with a load test and DC component of additional load losses from test....83
8.4 Method 2-1-3C – Summation of losses with a load test and DC component of additional load losses from assigned value....91
8.5 Method 2-1-3D – Summation of losses without a load test....94
8.6 Method 2-1-3E – Single supply back-to-back test....97

Annex A (normative) Calculation of values for the Eh-star method

Annex B (informative) Types of excitation systems

Annex C (informative) Induction machine slip measurement

Annex D (informative) Test report template for method 2-1-1B

Bibliography

ULSE INC. COPYRIGHTED MATERIAL – NOT AUTHORIZED FOR FURTHER REPRODUCTION OR DISTRIBUTION WITHOUT PERMISSION FROM ULSE INC.

No Text on This Page

ULSE INC. COPYRIGHTED MATERIAL – NOT AUTHORIZED FOR FURTHER REPRODUCTION OR DISTRIBUTION WITHOUT PERMISSION FROM ULSE INC.

Preface (UL)

This UL Standard is based on IEC Publication 60034-2-1: third edition, Rotating electrical machines – Part 2-1: Standard methods for determining losses and efficiency from tests (excluding machines for traction vehicles). IEC publication 60034-2-1 is copyrighted by the IEC.

This edition has been issued to satisfy UL Standards policy.

This UL Standard 60034-2-1, Standard for Rotating Electrical Machines – Part 2-1: Standard methods for determining losses and efficiency from tests (excluding machines for traction vehicles), is to be used in conjunction with the Third Edition of UL 60034-1. The requirements are therefore contained in this Part 2 Standard and UL 60034-1.

Requirements of this Part 2 Standard, where stated, amend the requirements of UL 60034-1.

Where a particular subclause of UL 60034-1 is not mentioned in UL 60034-2-1, the UL 60034-1 subclause applies.

These materials are subject to copyright claims of IEC and ULSE. No part of this publication may be reproduced in any form, including an electronic retrieval system, without the prior written permission of ULSE. All requests pertaining to the Rotating electrical machines – Part 2-1: Standard methods for determining losses and efficiency from tests (excluding machines for traction vehicles), 60334-2-1 Standard should be submitted to ULSE.

Note – Although the intended primary application of this Standard is stated in its Scope, it is important to note that it remains the responsibility of the users of the Standard to judge its suitability for their particular purpose.

ULSE INC. COPYRIGHTED MATERIAL – NOT AUTHORIZED FOR FURTHER REPRODUCTION OR DISTRIBUTION WITHOUT PERMISSION FROM ULSE INC.

No Text on This Page

ULSE INC. COPYRIGHTED MATERIAL – NOT AUTHORIZED FOR FURTHER REPRODUCTION OR DISTRIBUTION WITHOUT PERMISSION FROM ULSE INC.

FOREWORD

INTERNATIONAL ELECTROTECHNICAL COMMISSION

ROTATING ELECTRICAL MACHINES – Part 2-1: Standard methods for determining losses and efficiency from tests (excluding machines for traction vehicles)

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.

2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.

3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.

4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.

5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.

6) All users should ensure that they have the latest edition of this publication.

7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.

8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.

9) IEC draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). IEC takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, IEC had not received notice of (a) patent(s), which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at https://patents.iec.ch. IEC shall not be held responsible for identifying any or all such patent rights.

IEC 60034-2-1 has been prepared by IEC technical committee 2: Rotating machinery. It is an International Standard.

This third edition cancels and replaces the second edition of IEC 60034-2-1 published in 2014. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

Harmonization of layout and requirements with IEC 60034-2-2 and IEC 60034-2-3.

The text of this International Standard is based on the following documents:

ULSE INC. COPYRIGHTED MATERIAL – NOT AUTHORIZED FOR FURTHER REPRODUCTION OR DISTRIBUTION WITHOUT PERMISSION FROM ULSE INC.

Draft	Report on voting
2/2165/FDIS	2/2177/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

A list of all parts in the IEC 60034 series, published under the general title *Rotating electrical machines*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

• reconfirmed,

• withdrawn, or

• revised.

ULSE INC. COPYRIGHTED MATERIAL – NOT AUTHORIZED FOR FURTHER REPRODUCTION OR DISTRIBUTION WITHOUT PERMISSION FROM ULSE INC.

ROTATING ELECTRICAL MACHINES – Part 2-1: Standard methods for determining losses and efficiency from tests (excluding machines for traction vehicles)

1 Scope

This part of IEC 60034 is intended to establish methods of determining efficiencies from tests, and also to specify methods of obtaining specific losses.

This document applies to DC machines and to AC synchronous and induction machines of all sizes within the scope of IEC 60034-1 rated for mains operation.

NOTE These methods may be applied to other types of machines such as rotary converters, AC commutator motors and single-phase induction motors.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60027-1, *Letter symbols to be used in electrical technology – Part 1: General*

IEC 60034-1:2022, *Rotating electrical machines – Part 1: Rating and performance*

IEC 60034-4-1:2018, *Rotating electrical machines – Part 4-1: Methods for determining electrically excited synchronous machine quantities from tests*

IEC 60034-19, *Rotating electrical machines – Part 19: Specific test methods for DC machines on conventional and rectifier-fed supplies*

IEC 60034-29, *Rotating electrical machines – Part 29: Equivalent loading and superposition techniques – Indirect testing to determine temperature rise*

IEC 60034-30-1, *Rotating electrical machines – Part 30-1: Efficiency classes of line operated AC motors (IE code)*

IEC 60051 (all parts), *Direct acting indicating analogue electrical measuring instruments and their accessories*

IEC 60051-1, *Direct acting indicating analogue electrical measuring instruments and their accessories – Part 1: Definitions and general requirements common to all parts*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60034-1, IEC 60051-1 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

ULSE INC. COPYRIGHTED MATERIAL – NOT AUTHORIZED FOR FURTHER REPRODUCTION OR DISTRIBUTION WITHOUT PERMISSION FROM ULSE INC.

• IEC Electropedia: available at http://www.electropedia.org/

• ISO Online browsing platform: available at http://www.iso.org/obp

3.1
efficiency
ratio of output power to input power expressed in the same units and usually given as a percentage

3.2
direct efficiency determination
method by which the determination of efficiency is made by measuring directly the input power and the output power

3.3
dual-supply back-to-back test
test in which two identical machines are mechanically coupled together, and the total losses of both machines are calculated from the difference between the electrical input to one machine and the electrical output of the other machine

3.4
indirect efficiency determination
method by which the determination of efficiency is made by measuring the input power or the output power and determining the total losses. Those losses are added to the output power, thus giving the input power, or subtracted from the input power, thus giving the output power

3.5
single-supply back-to-back test
test in which two identical machines are mechanically coupled together and are both connected electrically to the same power system. The total losses of both machines are taken as the input power drawn from the system

3.6
no-load test
test in which a machine is run as a motor providing no useful mechanical output from the shaft, or if run as a generator with its terminals open-circuited

3.7
zero power factor test
no-load test on a synchronous machine, which is over-excited and operates at a power factor very close to zero

3.8
equivalent circuit method
test on an induction machine in which the losses are determined by help of an equivalent circuit model

3.9
test with rotor removed and reverse rotation test
combined test on an induction machine in which the additional load losses are determined from a test with rotor removed and a test with the rotor running in reverse direction to the rotating magnetic field of the stator

3.10
short-circuit test
test on a synchronous machine in which a machine is run as a generator with its terminals short-circuited

ULSE INC. COPYRIGHTED MATERIAL – NOT AUTHORIZED FOR FURTHER REPRODUCTION OR DISTRIBUTION WITHOUT PERMISSION FROM ULSE INC.

3.11
locked rotor test
test in which the rotor is locked to prevent rotation

3.12
Eh-star test
test in which the motor is run in star connection on unbalanced voltage

3.13
losses

3.13.1
total losses
P_T
difference between the input power and the output power, equivalent to the sum of the constant losses (see 3.13.2), the load losses (see 3.13.4), the additional load losses (see 3.13.5) and the excitation circuit losses (see 3.13.3)

3.13.2
constant losses
P_c
losses incorporating the sum of windage, friction and iron losses

Note 1 to entry: Although these losses change with voltage and load, they are historically called “constant” losses and the name is retained in this document.

3.13.2.1
iron losses
P_{fe}
losses in active iron and additional no-load losses in other magnetic and conductive parts

3.13.2.2
friction and windage losses P_{fw}
losses incorporating the sum of windage and friction

3.13.2.2.1
friction losses
losses due to friction (bearings and brushes, if not lifted at rated conditions) not including any losses in a separate lubricating system

3.13.2.2.2
windage losses
total losses due to aerodynamic friction in all parts of the machine, including power absorbed in shaft mounted fans, and in auxiliary machines forming an integral part of the machine

Note 1 to entry: Losses in a separate ventilating system should be listed separately.

Note 2 to entry: For machines indirectly or directly cooled by hydrogen, see IEC 60034-1.

ULSE INC. COPYRIGHTED MATERIAL – NOT AUTHORIZED FOR FURTHER REPRODUCTION OR DISTRIBUTION WITHOUT PERMISSION FROM ULSE INC.

3.13.3
excitation circuit losses

3.13.3.1
excitation circuit losses
***P*$_e$**
sum of the excitation winding losses (see 3.13.3.2), the exciter losses (see 3.13.3.3) and, for synchronous machines, electrical brush loss (see 3.13.3.5), if any

3.13.3.2
excitation winding losses
***P*$_f$**
excitation (field) winding losses are equal to the product of the exciting current I_e and the excitation voltage U_e

3.13.3.3
exciter losses
***P*$_{Ed}$**
exciter losses for the different excitation systems (see Annex B) are defined as follows:

a) shaft driven exciter

exciter losses are the power absorbed by the exciter at its shaft (reduced by friction and windage losses) plus the power P_{1E} drawn from a separate source at its excitation winding terminals, minus the useful power which the exciter provides at its terminals. The useful power at the terminals of the exciter is equal to the excitation winding losses as per 3.13.3.2 plus (in the case of a synchronous machine) the electrical brush losses as per 3.13.3.5.

Note 1 to entry: If the exciter can be decoupled and tested separately its losses can be determined according to 7.1.3.2.1.5.

Note 2 to entry: Whenever the exciter makes use of separate auxiliary supplies, their consumptions are to be included in the exciter losses unless they are considered together with the main machine auxiliaries consumption.

b) brushless exciter

exciter losses are the power absorbed by the exciter at its shaft, reduced by friction and windage losses (when the relevant test is performed on the set of main machine and exciter), plus the electrical power P_{1E} from a separate source (if any) absorbed by its field winding or its stator winding (in the case of an induction exciter), minus the useful power which the exciter provides at the rotating power converter terminals.

Note 3 to entry: Whenever the exciter makes use of separate auxiliary supplies their consumptions are to be included in the exciter losses unless they are considered together with the main machine auxiliaries consumption.

Note 4 to entry: If the exciter can be decoupled and tested separately, its losses can be determined according to 7.1.3.2.1.

c) separate rotating exciter

exciter losses are the difference between the power absorbed by the driving motor, plus the power absorbed by separate auxiliary supplies, of both driving and driven machines, including the power supplied by separate source to their excitation winding terminals, and the excitation power supplied as per 3.13.3.2 and 3.13.3.4. The exciter losses may be determined according to 7.1.3.2.1.

ULSE INC. COPYRIGHTED MATERIAL – NOT AUTHORIZED FOR FURTHER REPRODUCTION OR DISTRIBUTION WITHOUT PERMISSION FROM ULSE INC.

d) static excitation system

static exciter

excitation system losses are the difference between the electrical power drawn from its power source, plus the power absorbed by separate auxiliary supplies, and the excitation supplied as per 3.13.3.2 and 3.13.3.4.

Note 5 to entry: In the case of systems fed by transformers, the transformer losses shall be included in the exciter losses.

e) excitation from auxiliary winding

auxiliary winding exciter

exciter losses are the copper losses in the auxiliary (secondary) winding and the additional iron losses produced by increased flux harmonics. The additional iron losses are the difference between the losses which occur when the auxiliary winding is loaded and when it is unloaded.

Note 6 to entry: Because separation of the excitation component of losses is difficult, it is recommended to consider these losses as an integral part of the stator losses when determining overall losses.

In the cases c) and d) no allowance is made for the losses in the excitation source (if any) or in the connections between the source and the brushes (synchronous machine) or between the source and the excitation winding terminals (DC machine).

If the excitation is supplied by a system having components as described in b) to e) the exciter losses shall include the relevant losses of the components pertaining to the categories listed in Annex B as applicable.

3.13.3.4
separately supplied excitation power
***P*$_{1E}$**
excitation power P_{1E} supplied from a separate power source is:

– for exciter types a) and b) the exciter excitation power (DC or synchronous exciter) or stator winding input power (induction exciter). It covers a part of the exciter losses P_{Ed} (and further losses in induction exciters) while a larger part of P_e is supplied via the shaft;

– for exciter types c) and d) equal to the excitation circuit losses, $P_{1E} = P_e$;

– for exciter type e) $P_{1E} = 0$, the excitation power being delivered entirely by the shaft. Also, $P_{1E} = 0$ for machines with permanent magnet excitation.

Exciter types shall be in accordance with 3.13.3.3.

3.13.3.5
brush losses (excitation circuit)
***P*$_b$**
electrical brush loss (including contact loss) of separately excited synchronous machines

ULSE INC. COPYRIGHTED MATERIAL – NOT AUTHORIZED FOR FURTHER REPRODUCTION OR DISTRIBUTION WITHOUT PERMISSION FROM ULSE INC.

3.13.4
load losses

3.13.4.1
load losses
***P*$_L$**
sum of the winding (I^2R) losses (see 3.13.4.2) and the electrical brush losses (see 3.13.3.5), if any

3.13.4.2
winding losses
winding losses are I^2R losses:

– in the armature circuit of DC machines;

– in the stator and rotor windings of induction machines;

– in the armature and field windings of synchronous machines

3.13.4.3
brush losses
***P*$_b$**
electrical brush loss (including contact loss) in the armature circuit of DC machines and in wound-rotor induction machines

3.13.5
additional load losses
***P*$_{LL}$**
losses produced in active iron and other magnetic and conductive parts by alternating stray fluxes when the machine is loaded; eddy current losses in winding conductors caused by load current-dependent flux pulsations and additional brush losses caused by commutation

Note 1 to entry: These losses do not include the additional no-load losses of 3.13.2.2.

3.13.6
short-circuit losses
***P*$_{sc}$**
current-dependent losses in a synchronous machine and in a DC machine when the armature winding is short-circuited

3.14
test quantities <polyphase AC machines>

3.14.1
terminal voltage
for polyphase AC machines, the arithmetic average of line voltages

3.14.2
line current
for polyphase AC machines, the arithmetic average of line currents

3.14.3
line-to-line resistance
for polyphase AC machines, the arithmetic average of resistances measured between each pair of terminals

ULSE INC. COPYRIGHTED MATERIAL – NOT AUTHORIZED FOR FURTHER REPRODUCTION OR DISTRIBUTION WITHOUT PERMISSION FROM ULSE INC.

Note 1 to entry: For Y-connected three-phase machines, the phase-resistance is 0,5 times the line-to-line resistance. For Δ-connected machines, the phase-resistance is 1,5 times the line-to-line resistance.

Note 2 to entry: In Clauses 6 and 7 explanations and formulae given are for three-phase machines, unless otherwise indicated.

3.14.4
temperature rise
is the machine temperature minus the cooling medium (coolant) temperature as defined by IEC 60034-1

4 Symbols and abbreviated terms

4.1 Symbols

cos φ	is the power factor[1]
f	is the supply frequency, Hz
I	is the line current (average of all phases), A
k_θ	is the temperature correction factor
n	is the operating speed, s^{-1}
p	is the number of pole pairs
P	is the power, W
P_0	is the input power at no-load, W
P_1	is the input power, excluding excitation[2], W
P_2	is the output power, W
P_b	is the brush loss, W
P_D	is the output power (shaft power) of a drive motor, W
P_e	is the excitation circuit losses, W
P_{1E}	is the excitation power supplied by a separate source, W
P_{Ed}	is the exciter losses, W
P_{el}	is the electrical power, excluding excitation, W
P_f	is the excitation (field) winding losses, W
P_{fe}	is the iron losses, W
P_{fw}	is the friction and windage losses, W
P_c	is the constant losses, W
P_L	is the load losses, W
P_{Lr}	is the residual losses, W
P_{LL}	is the additional-load losses, W
P_{sc}	is the short-circuit losses, W
P_{mech}	is the mechanical power, W
P_T	is the total losses, W
P_w	is the winding losses, W, where subscript w is generally replaced by a, f, e, s or r (see 4.2)
R	is a winding resistance, Ω
R_{eh}	is the actual value of the auxiliary resistor for the Eh-star test (see 6.2.5), Ω

ULSE INC. COPYRIGHTED MATERIAL – NOT AUTHORIZED FOR FURTHER REPRODUCTION OR DISTRIBUTION WITHOUT PERMISSION FROM ULSE INC.