

INTERNATIONAL STANDARD

NORME INTERNATIONALE

**Electric power engineering – Modal components in three-phase a.c. systems –
Quantities and transformations**

**Energie électrique – Composantes modales dans les systèmes a.c. triphasés –
Grandeurs et transformations**



THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2008 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester.

If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

Droits de reproduction réservés. Sauf indication contraire, aucune partie de cette publication ne peut être reproduite ni utilisée sous quelque forme que ce soit et par aucun procédé, électronique ou mécanique, y compris la photocopie et les microfilms, sans l'accord écrit de la CEI ou du Comité national de la CEI du pays du demandeur.

Si vous avez des questions sur le copyright de la CEI ou si vous désirez obtenir des droits supplémentaires sur cette publication, utilisez les coordonnées ci-après ou contactez le Comité national de la CEI de votre pays de résidence.

IEC Central Office
3, rue de Varembe
CH-1211 Geneva 20
Switzerland
Email: inmail@iec.ch
Web: www.iec.ch

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

- Catalogue of IEC publications: www.iec.ch/searchpub

The IEC on-line Catalogue enables you to search by a variety of criteria (reference number, text, technical committee,...). It also gives information on projects, withdrawn and replaced publications.

- IEC Just Published: www.iec.ch/online_news/justpub

Stay up to date on all new IEC publications. Just Published details twice a month all new publications released. Available on-line and also by email.

- Electropedia: www.electropedia.org

The world's leading online dictionary of electronic and electrical terms containing more than 20 000 terms and definitions in English and French, with equivalent terms in additional languages. Also known as the International Electrotechnical Vocabulary online.

- Customer Service Centre: www.iec.ch/webstore/custserv

If you wish to give us your feedback on this publication or need further assistance, please visit the Customer Service Centre FAQ or contact us:

Email: csc@iec.ch

Tel.: +41 22 919 02 11

Fax: +41 22 919 03 00

A propos de la CEI

La Commission Electrotechnique Internationale (CEI) est la première organisation mondiale qui élabore et publie des normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

A propos des publications CEI

Le contenu technique des publications de la CEI est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

- Catalogue des publications de la CEI: www.iec.ch/searchpub/cur_fut-f.htm

Le Catalogue en-ligne de la CEI vous permet d'effectuer des recherches en utilisant différents critères (numéro de référence, texte, comité d'études,...). Il donne aussi des informations sur les projets et les publications retirées ou remplacées.

- Just Published CEI: www.iec.ch/online_news/justpub

Restez informé sur les nouvelles publications de la CEI. Just Published détaille deux fois par mois les nouvelles publications parues. Disponible en-ligne et aussi par email.

- Electropedia: www.electropedia.org

Le premier dictionnaire en ligne au monde de termes électroniques et électriques. Il contient plus de 20 000 termes et définitions en anglais et en français, ainsi que les termes équivalents dans les langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International en ligne.

- Service Clients: www.iec.ch/webstore/custserv/custserv_entry-f.htm

Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions, visitez le FAQ du Service clients ou contactez-nous:

Email: csc@iec.ch

Tél.: +41 22 919 02 11

Fax: +41 22 919 03 00



IEC 62428

Edition 1.0 2008-07

INTERNATIONAL STANDARD

NORME INTERNATIONALE

**Electric power engineering – Modal components in three-phase a.c. systems –
Quantities and transformations**

**Energie électrique – Composantes modales dans les systèmes a.c. triphasés –
Grandeurs et transformations**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

PRICE CODE
CODE PRIX

ICS 01.060; 29.020

ISBN 2-8318-9921-4

CONTENTS

FOREWORD.....	3
1 Scope.....	5
2 Normative references	5
3 Terms, definitions, quantities and concepts	5
3.1 General.....	5
3.2 Terms and definitions	5
4 Modal transformation.....	7
4.1 General.....	7
4.2 Power in modal components.....	8
4.3 Established transformations	10
5 Decoupling in three-phase a.c. systems	16
5.1 Decoupling in case of steady-state operation with sinusoidal quantities.....	16
5.2 Decoupling under transient conditions	19
Bibliography.....	23
Figure 1 – Circuit, fed by a three-phase voltage source with $\underline{U}_{L1Q}$, $\underline{U}_{L2Q}$, $\underline{U}_{L3Q}$ at the connection point Q and earthed at the neutral point N via the impedance $\underline{Z}_N = R_N + jX_N$	16
Figure 2 – Three decoupled systems which replace the coupled three-phase a.c. system of Figure 1 under the described conditions (see text).....	19
Table 1 – Power-variant form of modal components and transformation matrices.....	11
Table 2 – Power-invariant form of modal components and transformation matrices.....	12
Table 3 – Clark, Park and space phasor components – modal transformations in the power-variant form.....	13
Table 4 – Clark, Park and space phasor components – Modal transformations in the power-invariant form	14
Table 5 – Transformation matrices in the power-variant form for phasor quantities	15
Table 6 – Transformation matrices in the power-invariant form for phasor quantities.....	15
Table 7 – Modal voltages and impedances in case of phasor quantities.....	18
Table 8 – Modal voltages and inductances under transient conditions.....	22

INTERNATIONAL ELECTROTECHNICAL COMMISSION

**ELECTRIC POWER ENGINEERING –
MODAL COMPONENTS IN THREE-PHASE AC SYSTEMS –
QUANTITIES AND TRANSFORMATIONS**

FOREWORD

- 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 provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with an IEC Publication.
- 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) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 62428 has been prepared by IEC technical committee 25: Quantities and units.

The text of this standard is based on the following documents:

FDIS	Report on voting
25/382/FDIS	25/390/RVD

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

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "<http://webstore.iec.ch>" in the data related to the specific publication. At this date, the publication will be

- reconfirmed;
- withdrawn;
- replaced by a revised edition; or
- amended.

ELECTRIC POWER ENGINEERING – MODAL COMPONENTS IN THREE-PHASE AC SYSTEMS – QUANTITIES AND TRANSFORMATIONS

1 Scope

This International Standard deals with transformations from original quantities into modal quantities for the widely used three-phase a.c. systems in the field of electric power engineering.

The examination of operating conditions and transient phenomena in three-phase a.c. systems becomes more difficult by the resistive, inductive or capacitive coupling between the phase elements and line conductors. Calculation and description of these phenomena in three-phase a.c. systems are easier if the quantities of the coupled phase elements and line conductors are transformed into modal quantities. The calculation becomes very easy if the transformation leads to decoupled modal systems. The original impedance and admittance matrices are transformed to modal impedance and admittance matrices. In the case of decoupling of the modal quantities, the modal impedance and admittance matrices become diagonal matrices.

2 Normative references

The following referenced documents are indispensable for the application 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 60050-141, *International Electrotechnical Vocabulary (IEV) – Part 141: Polyphase systems and circuits*

3 Terms, definitions, quantities and concepts

3.1 General

Quantities in this standard are usually time-dependent. These quantities are for instance electric currents, voltages, linked fluxes, current linkages, electric and magnetic fluxes.

For quantities the general letter symbol g in case of real instantaneous values, $\underline{g}$ in case of complex instantaneous values and $\underline{\underline{G}}$ in case of phasors (complex r.m.s. values) are used.

NOTE Complex quantities in this standard are underlined. Conjugated complex quantities are indicated by an additional asterisk (*). Matrices and column vectors are printed in bold face type, italic.

3.2 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-141 and the following apply.

3.2.1

original quantities

quantities g or $\underline{\underline{G}}$ of a three-phase a.c. system

NOTE Subscripts 1, 2, 3 are generally used in this standard; additional letters may be put, for instance L1, L2, L3 as established in IEC 60909, IEC 60865 and IEC 61660.