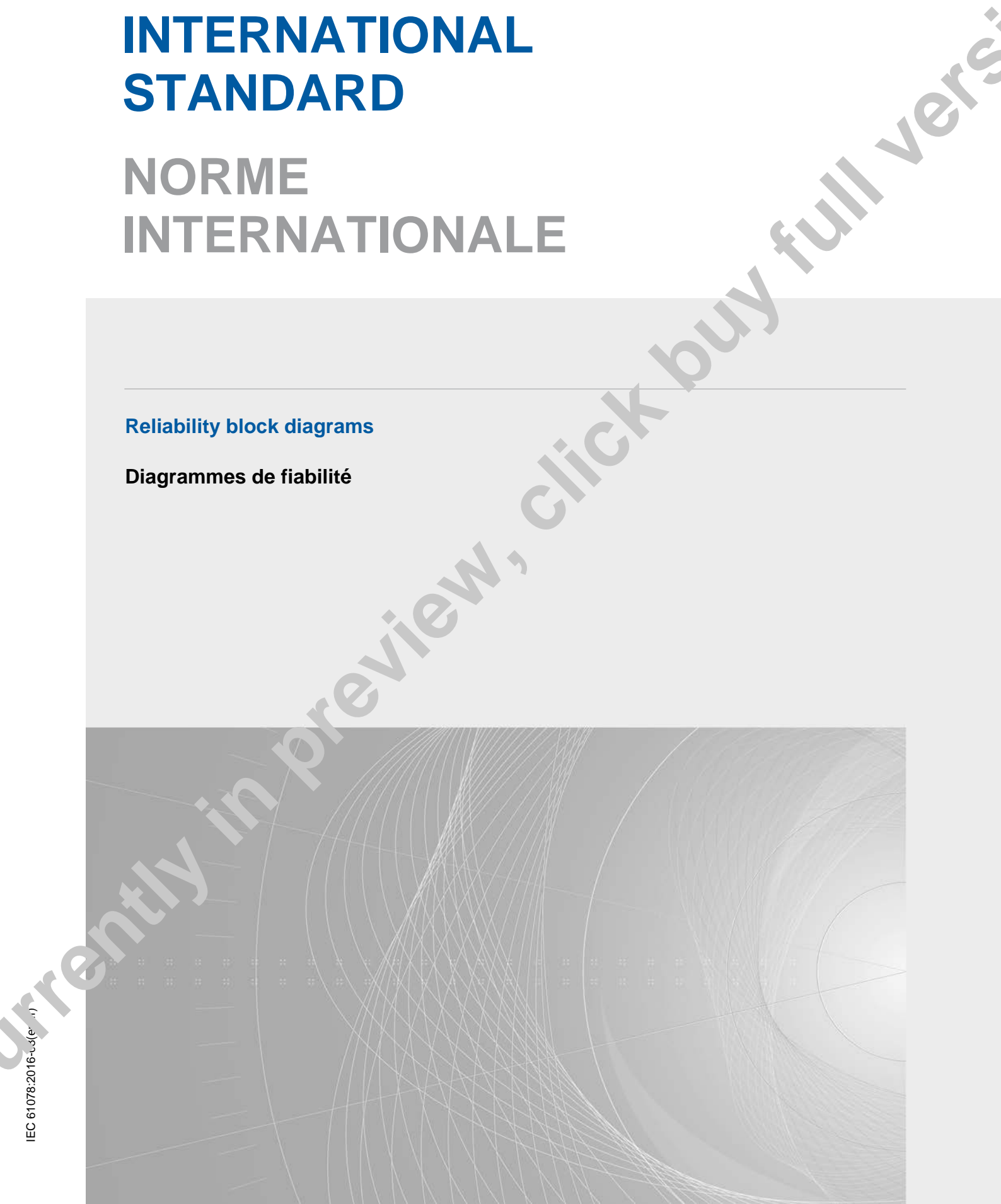


INTERNATIONAL STANDARD

NORME INTERNATIONALE

Reliability block diagrams

Diagrammes de fiabilité





THIS PUBLICATION IS COPYRIGHT PROTECTED
Copyright © 2016 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 l'IEC ou du Comité national de l'IEC du pays du demandeur. Si vous avez des questions sur le copyright de l'IEC ou si vous désirez obtenir des droits supplémentaires sur cette publication, utilisez les coordonnées ci-après ou contactez le Comité national de l'IEC de votre pays de résidence.

IEC Central Office
3, rue de Varembe
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00
info@iec.ch
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.

IEC Catalogue - webstore.iec.ch/catalogue

The stand-alone application for consulting the entire bibliographical information on IEC International Standards, Technical Specifications, Technical Reports and other documents. Available for PC, Mac OS, Android Tablets and iPad.

IEC publications search - www.iec.ch/searchpub

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 It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished

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

Electropedia - www.electropedia.org

The world's leading online dictionary of electronic and electrical terms containing 20 000 terms and definitions in English and French, with equivalent terms in 15 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC Glossary - std.iec.ch/glossary

65 000 electrotechnical terminology entries in English and French extracted from the Terms and Definitions clause of IEC publications issued since 2002. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.

IEC Customer Service Centre - webstore.iec.ch/csc

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: csc@iec.ch.

A propos de l'IEC

La Commission Electrotechnique Internationale (IEC) 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 IEC

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

Catalogue IEC - webstore.iec.ch/catalogue

Application autonome pour consulter tous les renseignements bibliographiques sur les Normes internationales, Spécifications techniques, Rapports techniques et autres documents de l'IEC. Disponible pour PC, Mac OS, tablettes Android et iPad.

Recherche de publications IEC - www.iec.ch/searchpub

La recherche avancée permet de trouver des publications IEC en utilisant différents critères (numéro de référence, texte, comité d'études,...). Elle donne aussi des informations sur les projets et les publications remplacées ou retirées.

IEC Just Published - webstore.iec.ch/justpublished

Restez informé sur les nouvelles publications IEC. Just Published détaille les nouvelles publications parues. Disponible en ligne et aussi une fois par mois par email.

Electropedia - www.electropedia.org

Le premier dictionnaire en ligne de termes électroniques et électriques. Il contient 20 000 termes et définitions en anglais et en français, ainsi que les termes équivalents dans 15 langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (IEV) en ligne.

Glossaire IEC - std.iec.ch/glossary

65 000 entrées terminologiques électrotechniques, en anglais et en français, extraites des articles Termes et Définitions des publications IEC parues depuis 2002. Plus certaines entrées antérieures extraites des publications des CE 37, 77, 86 et CISPR de l'IEC.

Service Clients - webstore.iec.ch/csc

Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions contactez-nous: csc@iec.ch.

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Reliability block diagrams

Diagrammes de fiabilité

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

ICS 03.120.01; 03.120.99

ISBN 978-2-8322-3561-4

**Warning! Make sure that you obtained this publication from an authorized distributor.
Attention! Veuillez vous assurer que vous avez obtenu cette publication via un distributeur agréé.**

CONTENTS

FOREWORD.....	8
INTRODUCTION.....	10
1 Scope.....	11
2 Normative references.....	11
3 Terms and definitions	11
4 Symbols and abbreviated terms	18
5 Preliminary considerations, main assumptions, and limitations.....	22
5.1 General considerations.....	22
5.2 Pre-requisite/main assumptions.....	23
5.3 Limitations	23
6 Establishment of system success/failed states	24
6.1 General considerations.....	24
6.2 Detailed considerations	24
6.2.1 System operation	24
6.2.2 Environmental conditions	25
6.2.3 Duty cycles	25
7 Elementary models	25
7.1 Developing the model.....	25
7.2 Series structures.....	25
7.3 Parallel structures	26
7.4 Mix of series and parallel structures.....	26
7.5 Other structures	27
7.5.1 <i>m</i> out of <i>n</i> structures.....	27
7.5.2 Structures with common blocks	28
7.5.3 Composite blocks	29
7.6 Large RBDs and use of transfer gates	29
8 Qualitative analysis: minimal tie sets and minimal cut sets.....	30
8.1 Electrical analogies.....	30
8.2 Series-parallel representation with minimal success path and cut sets.....	32
8.3 Qualitative analysis from minimal cut sets.....	33
9 Quantitative analysis: blocks with constant probability of failure/success	33
9.1 Series structures.....	33
9.2 Parallel structures	34
9.3 Mix of series and parallel structures.....	34
9.4 <i>m/n</i> architectures (identical items).....	35
10 Quantitative analysis: blocks with time dependent probabilities of failure/success	35
10.1 General.....	35
10.2 Non-repaired blocks	36
10.2.1 General	36
10.2.2 Simple non-repaired block.....	36
10.2.3 Non-repaired composite blocks.....	36
10.2.4 RBDs with non-repaired blocks.....	37
10.3 Repaired blocks	37
10.3.1 Availability calculations	37
10.3.2 Average availability calculations.....	40

10.3.3	Reliability calculations.....	42
10.3.4	Frequency calculations.....	43
11	Boolean techniques for quantitative analysis of large models.....	43
11.1	General.....	43
11.2	Method of RBD reduction	44
11.3	Use of total probability theorem	45
11.4	Use of Boolean truth tables	46
11.5	Use of Karnaugh maps	47
11.6	Use of the Shannon decomposition and binary decision diagrams	49
11.7	Use of Sylvester-Poincaré formula.....	50
11.8	Examples of RBD application.....	51
11.8.1	Models with repeated blocks	51
11.8.2	m out of n models (non-identical items).....	54
12	Extension of reliability block diagram techniques.....	54
12.1	Non-coherent reliability block diagrams.....	54
12.2	Dynamic reliability block diagrams	57
12.2.1	General	57
12.2.2	Local interactions.....	58
12.2.3	Systemic dynamic interactions.....	59
12.2.4	Graphical representations of dynamic interactions.....	59
12.2.5	Probabilistic calculations	62
Annex A (informative)	Summary of formulae.....	63
Annex B (informative)	Boolean algebra methods.....	67
B.1	Introductory remarks	67
B.2	Notation.....	67
B.3	Tie sets (success paths) and cut sets (failure paths) analysis.....	68
B.3.1	Notion of cut and tie sets.....	68
B.3.2	Series-parallel representation using minimal tie and cut sets.....	69
B.3.3	Identification of minimal cuts and tie sets.....	70
B.4	Principles of calculation.....	71
B.4.1	Series structures.....	71
B.4.2	Parallel structures.....	71
B.4.3	Mix of series and parallel structures	73
B.4.4	m out of n architectures (identical items).....	73
B.5	Use of Sylvester Poincaré formula for large RBDs and repeated blocks.....	74
B.5.1	General	74
B.5.2	Sylvester Poincaré formula with tie sets.....	74
B.5.3	Sylvester Poincaré formula with cut sets.....	76
B.6	Method for disjointing Boolean expressions	77
B.6.1	General and background	77
B.6.2	Disjointing principle.....	78
B.6.3	Disjointing procedure	79
B.6.4	Example of application of disjointing procedure.....	79
B.6.5	Comments	81
B.7	Binary decision diagrams	82
B.7.1	Establishing a BDD	82
B.7.2	Minimal success paths and cut sets with BDDs	84
B.7.3	Probabilistic calculations with BDDs	86

B.7.4	Key remarks about the use of BDDs	87
Annex C (informative)	Time dependent probabilities and RBD driven Markov processes	88
C.1	General.....	88
C.2	Principle for calculation of time dependent availabilities	88
C.3	Non-repaired blocks	89
C.3.1	General	89
C.3.2	Simple non-repaired blocks	89
C.3.3	Composite block: example on a non-repaired standby system	89
C.4	RBD driven Markov processes.....	91
C.5	Average and asymptotic (steady state) availability calculations	92
C.6	Frequency calculations.....	93
C.7	Reliability calculations.....	94
Annex D (informative)	Importance factors	96
D.1	General.....	96
D.2	Vesely-Fussell importance factor	96
D.3	Birnbaum importance factor or marginal importance factor	96
D.4	Lambert importance factor or critical importance factor	97
D.5	Diagnostic importance factor	97
D.6	Risk achievement worth	98
D.7	Risk reduction worth.....	98
D.8	Differential importance measure	98
D.9	Remarks about importance factors.....	99
Annex E (informative)	RBD driven Petri nets	100
E.1	General.....	100
E.2	Example of sub-PN to be used with RBD driven PN models.....	100
E.3	Evaluation of the DRBD state	102
E.4	Availability, reliability, frequency and MTTF calculations	104
Annex F (informative)	Numerical examples and curves	105
F.1	General.....	105
F.2	Typical series RBD structure	105
F.2.1	Non-repaired blocks	105
F.2.2	Repaired blocks	106
F.3	Typical parallel RBD structure	107
F.3.1	Non-repaired blocks	107
F.3.2	Repaired blocks	108
F.4	Complex RBD structures	109
F.4.1	Non series-parallel RBD structure.....	109
F.4.2	Convergence to asymptotic values versus MTTR	110
F.4.3	System with periodically tested components	111
F.5	Dynamic RBD example.....	113
F.5.1	Comparison between analytical and Monte Carlo simulation results	113
F.5.2	Dynamic RBD example.....	113
	Bibliography	116
	Figure 1 – Shannon decomposition of a simple Boolean expression and resulting BDD	18
	Figure 2 – Series reliability block diagram	25
	Figure 3 – Parallel reliability block diagram	26

Figure 4 – Parallel structure made of duplicated series sub-RBD	26
Figure 5 – Series structure made of parallel reliability block diagram.....	27
Figure 6 – General series-parallel reliability block diagram	27
Figure 7 – Another type of general series-parallel reliability block diagram	27
Figure 8 – 2 out of 3 redundancy.....	28
Figure 9 – 3 out of 4 redundancy.....	28
Figure 10 – Diagram not easily represented by series/parallel arrangement of blocks.....	28
Figure 11 – Example of RBD implementing dependent blocks	29
Figure 12 – Example of a composite block.....	29
Figure 13 – Use of transfer gates and sub-RBDs	30
Figure 14 – Analogy between a block and an electrical switch.....	30
Figure 15 – Analogy with an electrical circuit	31
Figure 16 – Example of minimal success path (tie set).....	31
Figure 17 – Example of minimal failure path (cut set).....	31
Figure 18 – Equivalent RBDs with minimal success paths.....	32
Figure 19 – Equivalent RBDs with minimal cut sets.....	33
Figure 20 – Link between a basic series structure and probability calculations	33
Figure 21 – Link between a parallel structure and probability calculations	34
Figure 22 – "Availability" Markov graph for a simple repaired block.....	38
Figure 23 – Standby redundancy.....	38
Figure 24 – Typical availability of a periodically tested block.....	39
Figure 25 – Example of RBD reaching a steady state.....	41
Figure 26 – Example of RBD with recurring phases	41
Figure 27 – RBD and equivalent Markov graph for reliability calculations	42
Figure 28 – Illustrating grouping of blocks before reduction.....	44
Figure 29 – Reduced reliability block diagrams.....	44
Figure 30 – Representation of Figure 10 when item A has failed	45
Figure 31 – Representation of Figure 10 when item A is working.....	45
Figure 32 – RBD representing three redundant items.....	46
Figure 33 – Shannon decomposition equivalent to Table 5.....	49
Figure 34 – Binary decision diagram equivalent to Table 5.....	49
Figure 35 – RBD using an arrow to help define system success	51
Figure 36 – Alternative representation of Figure 35 using repeated blocks and success paths.....	51
Figure 37 – Other alternative representation of Figure 35 using repeated blocks and minimal cut sets.....	52
Figure 38 – Shannon decomposition related to Figure 35.....	53
Figure 39 – 2-out-of-5 non-identical items	54
Figure 40 – Direct and inverted block	55
Figure 41 – Example of electrical circuit with a commutator A	55
Figure 42 – Electrical circuit: failure paths	55
Figure 43 – Example RBD with blocks with inverted states.....	56
Figure 44 – BDD equivalent to Figure 43	57
Figure 45 – Symbol for external elements.....	58

Figure 46 – Dynamic interaction between a CCF and RBDs' blocks.....	60
Figure 47 – Various ways to indicate dynamic interaction between blocks	60
Figure 48 – Dynamic interaction between a single repair team and RBDs' blocks	60
Figure 49 – Implementation of a PAND gate	61
Figure 50 – Equivalent finite-state automaton and example of chronogram for a PAND gate	61
Figure 51 – Implementation of a SEQ gate	61
Figure 52 – Equivalent finite-state automaton and example of chronogram for a SEQ gate	62
Figure B.1 – Examples of minimal tie sets (success paths)	68
Figure B.2 – Examples of non-minimal tie sets (non minimal success paths)	68
Figure B.3 – Examples of minimal cut sets	69
Figure B.4 – Examples of non-minimal cut sets.....	69
Figure B.5 – Example of RBD with tie and cut sets of various order	70
Figure B.6 – Reminder of the RBD in Figure 35	82
Figure B.7 – Shannon decomposition of the Boolean function represented by Figure B.6.....	82
Figure B.8 – Identification of the parts which do not matter	83
Figure B.9 – Simplification of the Shannon decomposition	83
Figure B.10 – Binary decision diagram related to the RBD in Figure B.5.....	84
Figure B.11 – Obtaining success paths (tie sets) from an RBD	84
Figure B.12 – Obtaining failure paths (cut sets) from an RBD	85
Figure B.13 – Finding cut and tie sets from BDDs	85
Figure B.14 – Probabilistic calculations from a BDD	86
Figure B.15 – Calculation of conditional probabilities using BDDs	87
Figure C.1 – Principle of time dependent availability calculations	88
Figure C.2 – Principle of RBD driven Markov processes	91
Figure C.3 – Typical availability of RBD with quickly repaired failures	91
Figure C.4 – Example of simple multi-phase Markov process	92
Figure C.5 – Typical availability of RBD with periodically tested failures	92
Figure E.1 – Example of a sub-PN modelling a DRBD block.....	100
Figure E.2 – Example of a sub-PN modelling a common cause failure.....	101
Figure E.3 – Example of DRBD based on RBD driven PN	101
Figure E.4 – Logical calculation of classical RBD structures.....	102
Figure E.5 – Example of logical calculation for an n/m gate	102
Figure E.6 – Example of sub-PN modelling a PAND gate with 2 inputs	103
Figure E.7 – Example of the inhibition of the failure of a block	104
Figure E.8 – Sub-PN for availability, reliability and frequency calculations.....	104
Figure F.1 – Availability/reliability of a typical non-repaired series structure	105
Figure F.2 – Failure rate and failure frequency related to Figure F.1	106
Figure F.3 – Equivalence of a non-repaired series structure to a single block	106
Figure F.4 – Availability/reliability of a typical repaired series structure	106
Figure F.5 – Failure rate and failure frequency related to Figure F.4	107
Figure F.6 – Availability/reliability of a typical non-repaired parallel structure	107
Figure F.7 – Failure rate and failure frequency related to Figure F.6	108
Figure F.8 – Availability/reliability of a typical repaired parallel structure	108

Figure F.9 – Vesely failure rate and failure frequency related to Figure F.8	109
Figure F.10 – Example 1 from 7.5.2	109
Figure F.11 – Failure rate and failure frequency related to Figure F.10.....	110
Figure F.12 – Impact of the MTTR on the convergence quickness.....	111
Figure F.13 – System with periodically tested blocks	112
Figure F.14 – Failure rate and failure frequency related to Figure F.13.....	112
Figure F.15 – Analytical versus Monte Carlo simulation results	113
Figure F.16 – Impact of CCF and limited number of repair teams	114
Figure F.17 – Markov graphs modelling the impact of the number of repair teams	115
Figure F.18 – Approximation for two redundant blocks.....	115
Table 1 – Acronyms used in IEC 61078	18
Table 2 – Symbols used in IEC 61078.....	19
Table 3 – Graphical representation of RBDs: Boolean structures	21
Table 4 – Graphical representation of RBDs: non-Boolean structures/DFBD	22
Table 5 – Application of truth table to the example of Figure 32	46
Table 6 – Karnaugh map related to Figure 10 when A is in up state	48
Table 7 – Karnaugh map related to Figure 10 when A is in down state	48
Table 8 – Karnaugh map related to Figure 35	53
Table A.1 – Example of equations for calculating the probability of success of basic configurations.....	63
Table F.1 – Impact of functional dependencies	114

INTERNATIONAL ELECTROTECHNICAL COMMISSION

RELIABILITY BLOCK DIAGRAMS

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 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) 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 61078 has been prepared by IEC technical committee 56: Dependability.

This third edition cancels and replaces the second edition published in 2006. This edition constitutes a technical revision.

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

- a) the structure of the document has been entirely reconsidered, the title modified and the content extended and improved to provide more information about availability, reliability and failure frequency calculations;
- b) Clause 3 has been extended and clauses have been introduced to describe the electrical analogy, the "non-coherent" RBDs and the "dynamic" RBDs;
- c) Annex B about Boolean algebra methods has been extended;
- d) Annex C (Calculations of time dependent probabilities), Annex D (Importance factors), Annex E (RBD driven Petri net models) and Annex F (Numerical examples and curves) have been introduced.

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

FDIS	Report on voting
56/1685/FDIS	56/1694/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 stability 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.

INTRODUCTION

A reliability block diagram (RBD) is a pictorial representation of a system's successful functioning. It shows the logical connection of (functioning) components (represented by blocks) needed for successful operation of the system (hereafter referred to as "system success"). Therefore an RBD is equivalent to a logical equation of Boolean variables and the probabilistic calculations are primarily related to constant values of the block success/failure probabilities.

Many different analytical methods of dependability analysis are available, of which the RBD is one. Therefore, the purpose of each method and their individual or combined applicability in evaluating the availability, reliability, failure frequency and other dependability measures as may be applicable to a given system or component should be examined by the analyst prior to deciding to use the RBD. Consideration should also be given to the results obtainable from each method, data required to perform the analysis, complexity of analysis and other factors identified in this standard.

Provided that the blocks in the RBD behave independently from each other and that the order in which failures occur does not matter then the probabilistic calculations can be extended to time dependent probabilistic calculations involving non-repaired as well as repaired blocks (e.g. blocks representing non-repaired or repaired components). In this case three dependability measures related to the system successful functioning have to be considered: the reliability itself, $R_S(t)$, but also the availability, $A_S(t)$ and the failure frequency, $w_S(t)$. While, for systems involving repaired components, the calculations of $A_S(t)$ or $w_S(t)$ can be done quite straightforwardly, the calculation of $R_S(t)$ implies systemic dependencies (see definition 3.34) which cannot be taken into account within the mathematical framework of RBDs. Nevertheless, in particular cases, approximations of $R_S(t)$ are available.

The RBD technique is linked to fault tree analysis [1]¹ and to Markov techniques [2]:

- The underlying mathematics is the same for RBDs and fault tree analysis (FTA): when an RBD is focused on system success, the FT is focused on system failure. It is always possible to transform an RBD into an FT and vice versa. From a mathematical point of view, RBD and FT models share dual logical expressions. Therefore, the mathematical developments and the limitations are similar in both cases.
- When the availability $A_i(t)$ of one block can be calculated by using an individual Markov process [2] independent of the other blocks, this availability, $A_i(t)$, can be used as input for the calculations related to an RBD including this block. This approach where an RBD provides the logic structure and Markov processes numerical values of the availabilities of the blocks is called "RBD driven Markov processes".

For systems where the order of failures is to be taken into account, or where the repaired blocks do not behave independently from each other or where the system reliability, $R_S(t)$, cannot be calculated by analytical methods, Monte Carlo simulation or other modelling techniques, such as dynamic RBDs, Markov [2] or Petri net techniques [3], may be more suitable.

¹ Numbers in square brackets refer to the Bibliography.

RELIABILITY BLOCK DIAGRAMS

1 Scope

This International Standard describes:

- the requirements to apply when reliability block diagrams (RBDs) are used in dependability analysis;
- the procedures for modelling the dependability of a system with reliability block diagrams;
- how to use RBDs for qualitative and quantitative analysis;
- the procedures for using the RBD model to calculate availability, failure frequency and reliability measures for different types of systems with constant (or time dependent) probabilities of blocks success/failure, and for non-repaired blocks or repaired blocks;
- some theoretical aspects and limitations in performing calculations for availability, failure frequency and reliability measures;
- the relationships with fault tree analysis (see IEC 61025 [1]) and Markov techniques (see IEC 61165 [2]).

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60050-192, *International Electrotechnical Vocabulary – Part 192: Dependability* (available at <http://www.electropedia.org>)

IEC 61703, *Mathematical expressions for reliability, availability, maintainability and maintenance support terms*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-192 as well as the following apply.

NOTE Some terms have been taken from IEC 60050-192 and modified for the needs of this standard.

3.1

reliability block diagram

RBD

logical, graphical representation of a system showing how the success states of its sub-items (represented by blocks) and combinations thereof, affect system success state

Note 1 to entry: The RBD technique was developed a long time ago when the term “reliability” was used as an umbrella term for “successful functioning”. This umbrella term is now superseded by “dependability”. Nevertheless it is still in use in the vernacular language and terms like “reliability engineering”, “reliability studies” or “reliability block diagram”. Therefore the term “reliability” used in RBD does not mean that this technique allows to calculate the reliability of a complex system straightforwardly from reliabilities of its constituting blocks (see 10.3.1.4).

Note 2 to entry: An RBD is a directed acyclic graph (i.e. a graph without loops) representing the logical links between the success state of a system and the success states of its constituting blocks. This logical architecture is mainly represented by conventional series and parallel graphical structures (see Clause 4 and Clause 7).