

ANSI/IEC/ASQ D61078-1997

Analysis techniques for dependability—reliability block diagram method

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Approved as an American National Standard by:

American Society for Quality

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AMERICAN NATIONAL STANDARD

Analysis Techniques for Dependability— Reliability Block Diagram Method

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American Society for Quality

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Analysis Techniques for Dependability— Reliability Block Diagram Method

Foreword

- 1) The formal decisions or agreements of the IEC on technical matters, prepared by Technical Committees on which all the National Committees having a special interest therein are represented, express, as nearly as possible, an international consensus of opinion on the subjects dealt with.
- 2) They have the form of recommendations for international use and they are accepted by the National Committees in that sense.
- 3) In order to promote international unification, the IEC expresses the wish that all National Committees should adopt the text of the IEC recommendation for their national rules in so far as national conditions will permit. Any divergence between the IEC recommendation and the corresponding national rules should, as far as possible, be clearly indicated in the latter.

This International Standard has been prepared by IEC Technical Committee No. 56: Dependability.

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

Six Months' Rule	Report on Voting
56(CO)137	56(CO)145

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

Annex A forms an integral part of this International Standard.

Annex B is for information only.

ANSI/IEC/ASQ D61078-1997**Introduction**

Different analytical methods of dependability analysis are available, of which the Reliability Block Diagram (RBD) is one. The purposes of each method and their individual or combined applicability in evaluating the reliability and availability of a given system or component should be examined by the analyst prior to starting work on 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.

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Analysis Techniques for Dependability— Reliability Block Diagram Method

1 Scope

This International Standard describes procedures for modelling the dependability of a system and for using the model in order to calculate reliability and availability measures.

A standard set of symbols related to reliability parameters is given in annex A. Some formulae are given in Annex B.

2 Normative references

The following normative document contains provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the edition indicated was valid. All normative documents are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent edition of the normative document listed below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 60050 (191): 1990, *International Electrotechnical Vocabulary (IEV), Chapter 191: Dependability and quality of service*.

3 Definitions

Terms and definitions are in accordance with the International Electrotechnical Vocabulary (IEV), Chapter 191.

4 Symbols

Symbols and abbreviations are given in annex A.

5 Applicability

An RBD is a pictorial representation of a system's reliability performance. It shows the logical connection of (functioning) components needed for system success.

The modelling techniques described are intended to be applied primarily to systems without repair and where the order in which failures occur does not matter. For systems where the order of failures must be taken into account or where repairs are to be carried out, other modelling techniques, such as Markov analysis, are more suitable. At any instant in time, an item is considered to be in only one of two possible states: operational or faulty.

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In the symbolic representation, no distinction is made between open circuit, short circuit or other fault modes; however, in the numerical evaluation this is possible.

6 System fault definitions and reliability requirements**6.1 General considerations**

A prerequisite for constructing system reliability models is a sound understanding of the ways in which the system can operate. Systems often require more than one fault definition. These should be defined and listed.

In addition there should be clear statements concerning:

- functions to be performed;
- performance parameters and permissible limits on such parameters;
- environmental and operating conditions.

Various qualitative analysis techniques may be employed in the construction of an RBD. Therefore the system's fault definition has to be established. The system success is dependent on one or more system failures. For each system fault definition the next step is to divide the system into logical blocks appropriate to the purpose of the reliability analysis. Particular blocks may represent system substructures, which in turn may each be represented by other RBDs (system reduction).

For the quantitative evaluation of an RBD, various methods are available. Depending on the type of structure, simple Boolean techniques and/or path and cut set analyses may be employed. Calculations may be made using basic component reliability/availability data.

It should be noted that a reliability block diagram does not necessarily represent the way the hardware is physically connected. While this is obvious to experienced reliability engineers, it may not be so to others.

6.2 Detailed considerations**6.2.1 System operation**

It may be possible to use a system for more than one functional mode. If separate systems were used for each mode, such modes should be treated independently of the rest, and separate reliability models should be used accordingly. If the same system were used to perform all these functions, then separate diagrams should be used for each type of operation. Clear statements of the reliability requirements associated with each aspect of system operation is a prerequisite.

6.2.2 Environmental conditions

The system performance specifications should be accompanied by a description of the environmental conditions under which the system is designed to operate. This should include a description of all the conditions to which the system will be subjected during transportation, storage and use.

A particular piece of equipment is often used in more than one environment, for example on board ship, in an aircraft or on the ground. When this is so, reliability evaluations may be carried out using the same reliability block diagram each time but using the appropriate failure rates for each environment.

6.2.3 Duty cycles

The relationship between calendar time, operating time and on/off cycles should be established. When it can be assumed that the process of switching equipment on and off does not in itself promote failures, and that the failure rate of equipment in storage can be negligible, then only the actual operational time of the equipment need be considered.

However, in some instances the process of switching on and off is in itself the prime cause of equipment failure, and equipment may have a higher failure rate in storage than when operational. In complex cases where only parts of the system are switched on and off, modelling techniques other than reliability block diagrams (e.g. Markov analysis) may be more suitable.

7 Elementary models

7.1 Developing the model

The first step is to select a system success definition. If more than one definition is possible a separate reliability block diagram may be required for each. The next step is to divide the system into blocks of equipment to reflect its logical behaviour of the system so that each block is statistically independent and as large as possible. At the same time each block should contain (where possible) no redundancy. For ease of numerical evaluation, each block should contain only those items which follow the same statistical distributions for times to failure.

In practice it may be necessary to make repeated attempts at constructing the block diagram (each time bearing in mind the steps referred to above) before a suitable block diagram is finalized.

The next step is to refer to the system fault definition and construct a diagram that connects the blocks to form a "success path." As indicated in the diagrams that follow, the various paths, between the input and output ports of the diagram, pass through those combinations of blocks which must function in order that the system functions. If all the blocks are required to function for the system to function then the corresponding block diagram will be one in which all the blocks are joined in series as illustrated in figure 1.

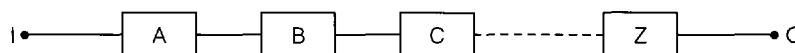


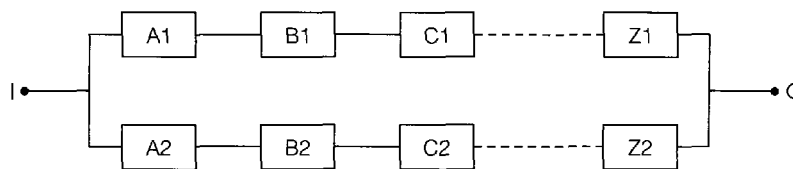
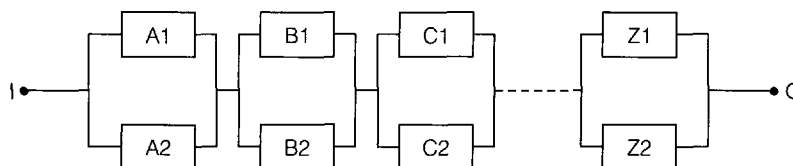
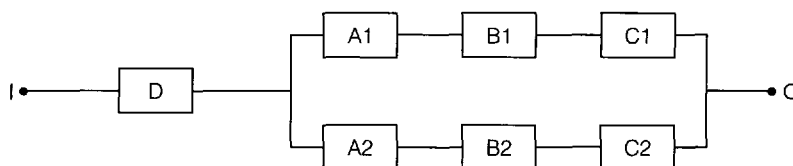
Figure 1

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In this diagram "I" is the input port, "O" the output port and A, B, C . . . Z are the blocks which together constitute the system. Diagrams of this type are known as "series reliability block diagrams."

A different type of block diagram is needed when failure of one component or "block" does not affect system performance as far as the system fault definition is concerned. If in the above instance the entire link is duplicated (made redundant), then the block diagram is as illustrated by figure 2. If, however, each block within the link is duplicated the block diagram is as illustrated by figure 3.

Diagrams of this type are known as parallel reliability block diagrams. Block diagrams used for modeling system reliability are often mixtures of series and parallel diagrams. Such a diagram would arise if we were to consider an example consisting of a duplicated communication link comprising three repeaters A, B and C, and a common power supply item (D). The resulting diagram would become as illustrated in figures 4 and 5.

**Figure 2****Figure 3****Figure 4**