



Approved as an American National Standard
ANSI Approval Date: May 14, 2021

ANSI/NEMA 61800-1-2021 Edition 2

Adjustable Speed Electrical Power Drive Systems

*Part 1: General Requirements—Rating Specifications for
Low Voltage Adjustable Speed DC Power Drive Systems*

Published by

National Electrical Manufacturers Association
Rosslyn, Virginia 2209

www.nema.org

© 2021 National Electrical Manufacturers Association. All rights including translation into other languages, reserved under the Universal Copyright Convention, the Berne Convention for the Protection of Literary and Artistic Works, and the International and Pan American Copyright Conventions.

These materials are subject to copyright claims of IEC and NEMA. No part of this publication may be reproduced in any form, including an electronic retrieval system, without the prior written permission of NEMA. All requests pertaining to the ANSI/NEMA 61800-9-1-2017 standard should be submitted to NEMA.

NOTICE AND DISCLAIMER

The information in this publication was considered technically sound by the consensus of persons engaged in the development and approval of the document at the time it was developed. Consensus does not necessarily mean that there is unanimous agreement among every person participating in the development of this document.

The National Electrical Manufacturers Association (NEMA) standards and guideline publications, of which the document contained herein is one, are developed through a voluntary consensus standards development process. This process brings together volunteers and/or seeks out the views of persons who have an interest in the topic covered by this publication. While NEMA administers the process and establishes rules to promote fairness in the development of consensus, it does not write the document and it does not independently test, evaluate, or verify the accuracy or completeness of any information or the soundness of any judgments contained in its standards and guideline publications.

NEMA disclaims liability for any personal injury, property, or other damages of any nature whatsoever, whether special, indirect, consequential, or compensatory, directly or indirectly resulting from the publication, use of, application, or reliance on this document. NEMA disclaims and makes no warranty or warranty, expressed or implied, as to the accuracy or completeness of any information published herein, and disclaims and makes no warranty that the information in this document will fulfill any of your particular purposes or needs. NEMA does not undertake to guarantee the performance of any individual manufacturer or seller's products or services by virtue of this standard or guideline.

In publishing and making this document available, NEMA is not undertaking to render professional or other services for or on behalf of any person or entity, nor is NEMA undertaking to perform any duty owed by any person or entity to someone else. Anyone using this document should rely on his or her own independent judgment or, as appropriate, seek the advice of a competent professional in determining the exercise of reasonable care in any given circumstances. Information and other standards on the topic covered by this publication may be available from other sources, which the user may wish to consult for additional views or information not covered by this publication.

NEMA has no power, nor does it undertake to police or enforce compliance with the contents of this document. NEMA does not certify, test, or inspect products, designs, or installations for safety or health purposes. Any certification or other statement of compliance with any health or safety-related information in this document shall not be attributable to NEMA and is solely the responsibility of the certifier or maker of the statement.

Currently in preview, click buy full version

CONTENTS

FOREWORD	vii
INTRODUCTION	x
0.1 General	x
0.2 Consistency of requirement	x
0.3 Tool for agreement between <i>customer</i> and <i>manufacturer</i>	x
1 Scope	1
2 Normative references	1
3 Terms and definitions	3
3.1 System elements	4
3.2 Converters and circuit elements (see Table 2)	9
3.3 Drive system operating characteristics (see Table 3)	11
3.4 Input ratings of <i>BDM/CDM/PDS</i> (see Table 4)	13
3.5 Output ratings of <i>BDM/CDM</i> (see Table 5)	18
3.6 <i>Motor</i> ratings (see Table 6)	21
3.7 Control systems (see Table 7)	24
3.8 Tests (see Table 8)	25
4 Ratings and specifications for the act of installing, commissioning and operation	26
4.1 General	26
4.2 <i>BDM/CDM/PDS</i> characteristics and topology	26
4.2.1 General	26
4.2.2 <i>BDM/CDM/PDS</i> characteristics	27
4.2.3 Basic topology for <i>BDM/CDM/PDS</i> 's	27
4.3 Ratings	32
4.3.1 General	32
4.3.2 Input ratings	33
4.3.3 Output ratings	35
4.3.4 Operating quadrants	38
4.3.5 Ratings, properties and functionalities of the <i>BDM/CDM/PDS</i>	38
4.3.6 Special ratings related to <i>BDM/CDM/PDS</i> or <i>motor</i>	38
4.4 Performance	39
4.4.1 Operational	39
4.4.2 Fault supervision and protection	49
4.4.3 Minimum status indication required	51
4.4.4 I/O devices	51
4.5 General safety	53
4.6 Functional safety	53
4.7 EMC	54
4.8 Ecodesign	54
4.8.1 General	54
4.8.2 Energy <i>efficiency</i> and power losses	54
4.8.3 Environmental impact	55

4.9	Environmental condition for service, transport and storage	55
4.9.1	General	55
4.9.2	Operation	55
4.9.3	Storage and transport of equipment	60
4.9.4	Mechanical conditions	61
4.9.5	Specific storage hazards	62
4.9.6	Environmental service tests (type test)	63
4.10	Types of load duty profiles	64
4.11	Generic interface and use of profiles for <i>PDS</i>	64
4.12	Voltage on <i>power interface</i>	65
4.13	Explosive environment	66
5	Test	66
5.1	General	66
5.2	Performance of tests	66
5.2.1	General conditions	66
5.2.2	Supply system earthing conditions	66
5.3	Standard tests for <i>BDM/CDM/PDS</i>	67
5.3.1	General	67
5.3.2	Test for mass produced products	68
5.3.3	Test for one-off products	69
5.4	Test specifications	69
5.4.1	Visual inspections (<i>type test, sample test and routine test</i>)	69
5.4.2	Performance and rating test	70
5.4.3	General safety	77
5.4.4	Functional safety	77
5.4.5	EMC	77
5.4.6	Energy <i>efficiency</i> and power losses determination	78
5.4.7	Environmental condition tests	78
5.4.8	Communication profiles	80
5.4.9	Explosive atmosphere environment	80
6	Information and marking requirements	80
6.1	General	80
6.2	Marking on product	82
6.3	Information to be supplied with the <i>PDS</i> or <i>BDM/CDM</i>	82
6.4	Information to be supplied or made available	82
6.5	Safety and warning information	83
6.5.1	Warning labels	83
6.5.2	Additional safety considerations of a <i>PDS</i>	83
A	Annex (informative) <i>Motor</i> considerations	84
A.1	General	84
A.2	Cooling considerations	84
A.3	Waveform <i>ripple</i> considerations	85
A.3.1	General	85
A.3.2	<i>Converter</i> topologies	85

A.3.3	Potentials to earth	85
A.4	Torsional considerations	86
A.4.1	General	86
A.4.2	Torsional analysis	86
A.4.3	Remedies to torsional problems (rare with DC drives)	86
A.4.4	Torque pulsation	86
A.5	Operational modes	86
A.5.1	General	86
A.5.2	Torque/speed characteristics	87
A.5.3	Considerations of drive regeneration	87
A.6	Acoustic noise	89
A.7	Service life of the <i>motor</i> insulation system	89
A.8	Shaft voltages	90
A.9	New drive systems	90
Annex B (informative)	Line-side considerations	91
B.1	General	91
B.2	AC power source earthing	91
B.3	Introduction to harmonics and inter-harmonics	92
B.4	Results for typical <i>converters</i> phase control	94
B.4.1	General	94
B.4.2	Square wave line current	96
B.4.3	Trapezoidal line current	96
B.4.4	Current harmonic with <i>DC current ripple</i>	96
B.4.5	Diode <i>rectifiers</i>	98
B.4.6	Diode <i>rectifiers</i> without <i>DC link</i> inductance	99
B.4.7	General	101
B.5	Example of assessment of harmonic effect of a <i>PDS</i>	102
B.6	Attenuation of emission of harmonics	104
B.7	Commutation notches	104
B.8	Protection against voltage dips and short interruptions	106
Annex C (informative)	Auxiliary equipment	108
C.1	General	108
C.2	Transformers	108
C.2.1	General	108
C.2.2	Voltage	108
C.2.3	Codes	108
C.2.4	Provide continuity of service for installations prone to nuisance grounding ..	109
C.2.5	Line voltage unbalance	109
C.2.6	Reduction of <i>converter</i> input harmonic currents	109
C.2.7	Reduction of prospective short-circuit current at <i>converter</i> input	109
C.2.8	Pulse number	110
C.3	Reactors	110
C.4	Switchgear	110
Annex D (informative)	Control strategies	111

D.1	General	111
D.2	Control configurations.....	111
D.2.1	General	111
D.2.2	Basic structure	112
D.2.3	Optional facilities.....	113
D.2.4	Digital and analog control.....	115
D.3	Control modes	116
D.3.1	Operating modes.....	116
D.3.2	Loop control	116
D.3.3	Accuracy and performance	117
D.4	Steady state and transient performance.....	117
D.4.1	Time response	117
D.4.2	Response time	117
D.4.3	Performances of particular functions	117
D.4.4	Speed ratio control.....	117
D.5	List of relevant control parameters.....	120
D.5.1	<i>BDM/CDM</i> control parameters	120
D.5.2	<i>Motor</i> parameters	120
D.5.3	Mechanical parameters	120
D.5.4	Supply parameters	120
D.6	Structures.....	121
D.6.1	Functional structures.....	121
D.6.2	Hardware structures	123
D.6.3	Important drive performances issues	123
D.6.4	Effect of torsional elasticity	123
D.6.5	Effects of the backlash	125
Annex E (informative)	Protection	126
E.1	General	126
E.2	Equipment availability.....	126
E.2.1	General.....	126
E.2.2	Equipment protection circuits	126
E.2.3	Types of equipment alarms and faults	126
E.2.4	Alarm and fault listing.....	127
E.3	System protection (features and devices)	129
E.4	Protection of the drive system	129
E.4.1	Protection included in the <i>BDM/CDM</i>	129
E.4.2	Specific <i>motor</i> protection.....	130
E.4.3	Specific transformer protection	130
Annex F (informative)	Monitoring features	131
F.1	General	131
F.2	Technology.....	131
	Bibliography	132

Figure 1 – <i>PDS</i> hardware configuration within an <i>installation</i>	5
Figure 2 – Example of function diagram of a <i>DC power drive system</i>	6
Figure 3 – <i>BDM/CDM/PDS manufacturer/customer</i> relationship.....	8
Figure 4 – Operating quadrants.....	12
Figure 5 – Main configurations for line-commutated <i>converters</i>	28
Figure 6 – Basic configurations of self-commutated <i>converters</i> (choppers).....	30
Figure 7 – Overview of input and output ratings of the <i>BDM/CDM/PDS</i>	33
Figure 8 – Example of operating region of a <i>PDS</i>	36
Figure 9 – Overload cycle example.....	37
Figure 10 – Deviation band.....	41
Figure 11 – Time response following a step change of reference input, no change in operating variables.....	44
Figure 12 – Time response following a change in an operating variable – No reference change.....	45
Figure 13 – Time response following a reference change at specified rate.....	46
Figure 14 – Frequency response of the control – Reference value as <i>stimulus</i>	47
Figure 15 – Example of relationship of IEC 61800-7 (all parts) to control system software and the <i>BDM/CDM/PDS</i>	65
Figure 16 – Measuring circuit of <i>PDS</i>	71
Figure A.1 – Torque and power output of a <i>DC motor</i>	88
Figure B.1 – Thyristor <i>rectifier</i> with a large DC inductance.....	96
Figure B.2 – Square wave line current.....	96
Figure B.3 – Trapezoidal line current.....	96
Figure B.4 – Major harmonic components of supply current considering square wave line current with idealized DC <i>ripple</i>	97
Figure B.5 – Power <i>converter</i> with a diode <i>rectifier</i> on the line-side and a DC/DC <i>converter</i>	98
Figure B.6 – Input voltage and current waveforms of the diode <i>rectifier</i>	99
Figure B.7 – Line-side voltage and current distortion factors of a diode <i>rectifier</i>	99
Figure B.8 – Diode <i>rectifier</i> without DC <i>link</i> inductance.....	100
Figure B.9 – Input harmonic current (AC and DC).....	101
Figure B.10 – <i>Input current</i> distortion.....	101
Figure B.11 – Example of simple structure.....	103
Figure B.12 – 3-phase, 6-pulse bridge <i>converter</i>	104
Figure B.13 – Commutation notches with a 3-phase, 6-pulse bridge <i>converter</i>	105
Figure B.14 – Equivalent circuit for assessment of commutation notch mitigation.....	106
Figure D.1 – Block diagram of feedback control system containing all basic elements.....	111
Figure D.2 – Functional block diagram.....	114
Figure D.3 – Master/follower drive system.....	118
Figure D.4 – Zero current inversion time.....	119
Figure D.5 – Structure of a drive system.....	122

Figure D.6 – Mechanical diagram	124
Figure D.7 – Simple stability criterion	125
Figure E.1 – Protection classification	128
Table 1 – System elements	4
Table 2 – Converters and circuits elements	9
Table 3 – Drive system operating characteristics	11
Table 4 – Input ratings of <i>BDM/CDM/PDS</i>	13
Table 5 – Output ratings of <i>BDM/CDM</i>	17
Table 6 – <i>Motor</i> ratings.....	21
Table 7 – Control system and variables	24
Table 8 – Type of tests	25
Table 9 – Standard rated voltages as specified in IEC 60038	34
Table 10 – Example of reduced maximum continuous load as a function of an over load	37
Table 11 – Maximum deviation bands (%)	41
Table 12 – <i>PDS</i> protection functions.....	50
Table 13 – Environmental service conditions	56
Table 14 – Limit of temperature of the cooling medium for indoor equipment	57
Table 15 – Definitions of pollution degree	57
Table 16 – Environmental vibration limits for fixed <i>installation</i>	58
Table 17 – Environmental shock limits for fixed <i>installation</i>	58
Table 18 – Storage and transport limits	61
Table 19 – Transportation vibration limits	62
Table 20 – Transportation limits of free fall	62
Table 21 – Environmental service tests	63
Table 22 – Tests overview	67
Table 23 – Classification of commutation made by visual observation	69
Table 24 – Shock test.....	79
Table 25 – Information requirements	81
Table B.1 – Minimum <i>AC</i> requirements for low voltage systems	93
Table B.2 – Harmonic current – 6-pulse conversion	95
Table B.3 – Harmonic results for the drive contribution.....	103
Table D.1 – Typical control configurations	112
Table D.2 – Composition of the typical control configurations	115
Table D.3 – Drive system control strategies.....	117

INTERNATIONAL ELECTROTECHNICAL COMMISSION

ADJUSTABLE SPEED ELECTRICAL POWER DRIVE SYSTEMS –

**Part 1: General requirements –
Rating specifications for low voltage
adjustable speed DC power drive systems**

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 Publications"). 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 or 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 61800-1 has been prepared by subcommittee 22G: Adjustable speed electric power drive systems (PDS), of IEC technical committee 22: Power electronic systems and equipment.

This second edition cancels and replaces the first edition published in 1997. This edition constitutes a technical revision.

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

- a) the clause structure has been harmonized with IEC 61800-2;
- b) Clause 2 has been updated;

- c) Clause 3 has been updated including fundamental definitions to be used across IEC 61800 (all parts);
- d) Clause 4 has been updated with respect to:
 - 1) description of the basic topology for *BDM/CDM/PDS* (4.2);
 - 2) ratings and performance (4.3 and 4.4);
 - 3) reference to applicable standards within the IEC 61800 series with respect to EMC (IEC 61800-3), general safety (IEC 61800-5-1), functional safety (IEC 61800-5-2), load duty aspects (IEC TR 61800-6), communication profiles (IEC 61800-7 series), *power interface* voltage (IEC TS 61800-8), and ecodesign energy efficiency standards (IEC 61800-9) to avoid conflicting requirements (4.5, 4.6, 4.7, 4.10, 4.11, 4.12);
 - 4) update of requirement for ecodesign (4.8);
 - 5) update of requirement for environmental evaluation (4.9);
 - 6) implementation of requirement for explosive atmosphere (4.13);
- e) Clause 5 has been updated with test requirement in order to provide a clear link between design requirement and test requirement;
- f) Clause 6 has been updated to harmonize the marking and documentation requirement within IEC 61800 (all parts);
- g) the Annexes have been updated.

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

FDIS	Report on voting
22G/430/FDIS	22G/433/RVD

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

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

A list of all parts in the IEC 61800 series, published under the general title *Adjustable speed electrical power drive systems*, can be found on the IEC website.

In this document, the terms in *italics* are defined in Clause 3.

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

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

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

Note: The user's attention is called to the possibility that compliance with this standard could require use of an invention covered by patent rights.

By publication of this standard, no position is taken with respect to the validity of any such claim(s) or of any patent rights in connection therewith. If a patent holder has filed a statement of willingness to grant a license under these rights on reasonable and non-discriminatory terms and conditions to applicants desiring to obtain such a license, then details may be obtained from the Secretary.

INTRODUCTION

0.1 General

This document is part of the IEC 61800 series specifying requirements for adjustable *speed electrical power drive systems (PDSs)*. Since the publication of the first edition of IEC 61800-1, several documents of the IEC 61800 series have been developed and maintained, which has resulted in outdated references and conflicting requirements across the IEC 61800 series.

This document contains general requirements for *PDSs* intended to feed DC *motors* and with rated *converter* input voltages (line-to-line voltage) up to and including 1 000 V AC.

0.2 Consistency of requirement

This document specifies requirements for *PDSs* under its scope for the identified topics not covered by any other of the standards in the IEC 61800 series.

The following requirements are covered by other standards in the IEC 61800 series:

- AC *PDS* requirements are covered by IEC 61800-2;
- EMC requirements are covered by IEC 61800-3;
- general safety requirements are covered by IEC 61800-5-1;
- functional safety requirements are covered by IEC 61800-5-2;
- type of load duty guidance is covered by IEC TR 61800-6;
- interface and use profiles requirements are covered by IEC 61800-7 (all parts);
- *power interface* voltage specification is covered by IEC TS 61800-8;
- ecodesign energy *efficiency* requirements of drive system are covered by IEC 61800-9 (all parts).

NOTE IEC 61800-9 series only provides requirements for AC *PDS*. Requirements for the Energy *Efficiency* classification, the set of power losses limits and measurement methods from IEC 61800-9-2 cannot be directly applicable to DC *PDS*. The Extended product approach (EPA) and Semi analytic Model (SMA) from IEC 61800-9-1 are in principle applicable to DC *PDS*.

Generally, this document provides a basic description of topics and refers to the relevant standard for specific requirement. This is done in order to ensure consistency and avoid conflicting requirement within IEC 61800 (all parts) as well as minimize future maintenance of the documents.

As a result of the development of the IEC 61800 series of standards, the need to reference documents outside the series has decreased.

0.3 Tool for agreement between *customer* and *manufacturer*

This document is intended to be used to create a comprehensive list of requirements to be used as a specification between *customer* and *manufacturer*. The requirement in this document is in itself not applicable for the *BDM/CDM/PDS*. Instead, each topic should be specified by the *customer* as a compliance requirement.

The document may be useful as a specification tool, when *BDM/CDM/PDSs* are built into a final *installation* or application applied as a component. The following applications are considered

relevant: lift and hoist, machinery, conveyor, industrial switchgears applications, heating and ventilation, pump, excitation systems, tidal and marine applications.

In every application, an identification of the environmental conditions under which the product is stored, transported and operated is essential for the proper specification of the *BDM/CDM/PDSs*. The environmental conditions considered should include electrical, mechanical, thermal, pollution, explosive environmental conditions and humidity environmental condition.

< This page is intentionally left blank. >

ADJUSTABLE SPEED ELECTRICAL POWER DRIVE SYSTEMS –

Part 1: General requirements – Rating specifications for low voltage adjustable speed DC power drive systems

1 Scope

This part of IEC 61800 applies to adjustable *speed electric DC power drive systems*, which include semiconductor power conversion and the means for their control, protection, monitoring, measurement and the *DC motors*.

It applies to adjustable *speed electric power drive systems* intended to feed *DC motors* from a *BDM/CDM* connected to line-to-line voltages up to and including 1 kV AC 50 Hz or 60 Hz and/or voltages up to and including 1,5 kV DC input side.

NOTE 1 Adjustable *speed electric AC power drive systems* intended to feed *AC motors* are covered by IEC 61800-2.

NOTE 2 This document can be used as a reference for adjustable *speed electric power drive systems*, intended to feed *DC motors* from a *BDM/CDM* connected to line-to-line voltages up to and including 1,5 kV AC, 50 Hz or 60 Hz and/or voltages up to and including 2,25 kV DC input side.

Traction applications and electric vehicles are excluded from the scope of this document.

This document is intended to define the following aspects of a *DC power drive system (PDS)*:

- principal parts of the *PDS*;
- ratings and performance;
- specifications for the environment in which the *PDS* is intended to be installed and operated;
- other specifications which might be applicable when specifying a complete *PDS*.

This document provides minimum requirements, which may be used for the development of a specification between *customer* and *manufacturer*.

Compliance with this document is possible only when each topic of this document is individually specified by the *customer* developing specifications or by product standard committees developing product standards.

For some aspects which are covered by specific *PDS* product standards in the IEC 61800 series, this document provides a short introduction and reference to detailed requirements in these product standards.

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.