BUREAU OF INDIAN STANDARDS

DRAFT FOR COMMENTS ONLY

Draft Indian Standard

VOLTAGE BANDS FOR ELECTRICAL INSTALLATIONS INCLUDING PREFERRED VOLTAGE AND FREQUENCY

(First Revision)

ICS 29.020

Basic Electrotechnical Standards and Power Quality Sectional Committee, ETD 01

Last Date for comments 27-11-2024

FOREWORD

This Indian Standard (First Revision) was adopted by the Bureau of Indian Standards after the draft finalized by the Basic Electrotechnical Standards and Power Quality Sectional Committee had been approved by the Electrotechnical Division Council.

This standard was originally published in 1988 as IS 12360: 1988 ‘Voltage Bands for Electrical Installations including Preferred Voltages and Frequency’ based on IEC 60038: 1983. IEC 60038 was later revised in 2009. This first revision has been brought out to change the rated voltage levels and to align to the latest version of IEC 60038: 2009.

The design conditions for electrical installations, the choice of equipment to be used there-in and the protective measures to be taken depend on the system voltage of these installations. The framing of installation rules, specially the measures to be applied for protection against electric shock, depend on the value of the voltage. Since it is neither possible nor necessary to consider each individual voltage value occurring in particular applications, common requirements are established for groups of equipment/installations, functioning in each particular 'band’. This standard is intended to furnish the basis for and the fixing of such voltage bands.

The limits of voltage bands not only help in framing rules for protection to be complied within the installation design but can also be used for preparing safety prescriptions and other related requirements for individual equipment. The limits of voltage bands also indicate that the safety rules corresponding to one band are fundamentally different from those corresponding to the other, thereby facilitating their

proper understanding. It is hoped that laying down of clear guidelines on voltage bands in consonance with this philosophy would also help in identifying the relevant statutory provisions needed.

It should, however, be borne in mind that the purpose of defining voltage bands are not for decimating the zones in which only particular types of equipment may be used but rather in specifying zones in which identical or nearly identical rules to be complied with exist.

However, in view of the adoption of IEC publications in a big way in national standardization work in the area of electrotechnology not only in terms of requirements of electrical equipment but also in terms of safety provisions in installation rules, it has become necessary to define voltage bands (ranges) in line with international guidelines as far as possible. While doing so, it is necessary to avoid contradiction between the meaning attached to terms such as 'low' or 'high' voltage and those normally understood by them in practice. It is also felt necessary to replace the usage of descriptive terms such as these with suitably designated voltage bands so that they are uniformly understood by practising engineers.

Besides variance in terminology, there is also observed differences in actual limits applicable to each band in different fields. For example, , in the switchgear field, 1000 V ac usually forms the boundary between low voltage (LV) and high voltage (HV) since from the insulation coordination point of view, the safety requirements in equipment corresponding to these two ranges are fundamentally different. This is now applicable to all equipment. The changing pattern in the usage of electric power has also brought in the conventional 'medium' voltage installations for domestic application (which is a traditionally 'low' voltage application), calling for the same or comparable safety provisions to be laid down for both.

All these factors have necessitated the need for establishing a logical approach to defining voltage bands (ranges) in the form of a standard which would in turn facilitate laying down of appropriate guidelines for equipment and installations. This approach should also go hand in hand with recommending the substitution of terms like 'low', 'medium' and 'high' by band designations which are better understood. It is emphasized that this approach would not in any manner contradict the provisions of the Central Electricity Authority (Measures relating to Safety and Electric Supply) Regulations, 2023.

In identifying the various voltage bands for the purpose of this standard, the following broad criteria have been followed:

a) *The Significant Voltage* — In normal circumstances, the human being is at earth potential and so, when it comes to questions concerning insulation design with due regard to safety, the significant voltage is the voltage to earth. Line to line voltage is solely a question of functional insulation. This criterion applies both for ac or dc.

b) *The Dividing Line* — In electricity usage, we employ certain common voltage values known as nominal voltages but the actual voltage available at the consumers' point in a location is subject to tolerances. It is, therefore, most desirable that the dividing line between the bands should be well removed from any nominal value in vogue.

c) *The Number of Bands* — For practical reasons, the number of bands should not be too large. However, to avoid unnecessary expense of space and material for lower values of voltage within a given range, the difference between the upper and the lower limits of each band shall not be excessive.

Further, the definition of nominal voltage of an installation depends on its situation in relation with earth which determines the requirements concerning insulation and protection. Therefore, classification of systems within a given 'band' in two types is proposed according to whether they are directly earthed or not.

For directly earthed systems, even though the significant voltage for defining safety is the line to earth voltage, value of voltage between lines is also given for guidance.

The limits of voltage bands should be considered as values which shall not be exceeded in normal operating conditions taking into account normal tolerances on nominal voltages.

It has been observed that theoretically from the point of view of personal safety, the ratio between ac and dc voltages vary with the voltage, decreasing with increasing voltage. From the point of view of voltage bands, this correspondence is of importance (for all practical purposes), only in Band I (separated extra low voltage). It has been internationally accepted that this ratio U_{dc}/U_{ac} in Band I should not exceed 2.5. The ratio of 1.5 between dc and ac voltages is used in a number of countries. This ratio of 1.5 is the rounded value$\sqrt{2}$ corresponding to the ratio between the ac peak value and the dc value at which equivalent dielectric stresses occur. On the other hand, the ratio of 1.2 has been conventionally accepted in the switchgear field, as well as for the determination of clearances and creepage distances. This ratio of 1.2 provides a safety margin, in respect of the equivalence of the peak values of about percent taking into account, variations when dc is produced from rectified alternating current without smoothing elements. For the purpose of this standard, the ratio 1.5 has been chosen for bands other than Band I.

This standard, however, recognizes that some of the conditions to be prescribed may, however, vary as a function of the voltage even within the same voltage band. It may, therefore, be necessary to introduce additional limits for particular applications or installations (for example, welding, electroplating, etc). Its felt that this applies only to a few of the requirements and could be specially considered and catered to individual specifications wherever necessary. This standard does not deal with such special cases.

While identifying the various voltage bands, the need for specifying standard values of nominal voltages in each band (wherever applicable) has also been felt. IS 585-1962 ‘Voltages and Frequency for Transmission and Distribution Systems (*Revised*)’ covered the standard values of voltages and frequency recommended for transmission and distribution systems. Since its contents have now been suitably incorporated in this standard, IS 585 stands withdrawn.

In the case of voltages above 1 kV, the importance of the highest system voltage in the design of transmission lines, transformers, switchgear, generators, etc has been recognized. In line with international practice, a set of nominal voltages corresponding to the highest system voltage have, therefore, been specified in this standard in Table 2.

The standard values of nominal voltages indicated in this standard are based on actual voltages in use in India, and on economic and other considerations. It is intended, therefore, that as far as possible, the values shown as preferred be followed.

The system frequency of 50 Hz is virtually the only frequency used in this country. Certain small isolated systems using other frequencies namely, 25, 40 and 60 Hz do exist but these are being changed over to 50 Hz. In view of this for general power applications, a frequency of 50 Hz has been taken as standard for ac systems. This standard does not, however, cover frequencies for special power applications.

In the preparation of this standard, assistance has been derived from the following international standards:

International Standard	*Title*
IEC 60038: 2009	IEC Standard Voltages
IEC 61140: 2016	Protection against electric shock - Common aspects for installation and equipment

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS 2-2022 'Rule for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1. SCOPE

1.1 This standard covers the voltage bands for electrical installations.

1.2 The voltage bands defined are intended mainly for use in connection with installation rules but may also be used when preparing requirements for electrical equipment.

1.3 This standard also covers standard values of nominal voltage of systems (in each voltage band) and frequency.

1.4 This standard does not include frequencies other than 50 Hz meant for special power application.

2. TERMINOLOGY

2.1 System - A system in which all the conductors and apparatus are electrically connected and operated at common voltages. The term includes all the conductors and apparatus.

2.2 Earthed Systems - Systems in which a point, generally the neutral point, is directly connected to earth without any intentional impedance.

2.3 Isolated Non-effectively Earthed Systems - Systems in which no point is connected to earth or in which a point, generally the neutral point, is connected to earth by a limiting impedance.

2.4 Voltage

2.4.1 *Declared Voltage* —The voltage at the consumers terminals declared by the supplier of electrical energy.

2.4.2 *Nominal Voltage* — Voltage by which an installation (or a part of an installation) is designated.

NOTES

1 Declared supply voltage is usually equal to the nominal voltage but it may differ by agreement between the network user and the network operator.

2 The actual value of the voltage in the installation may differ from the nominal voltage by a quantity within normal tolerances. The nominal voltage of a system is not necessarily the rated voltage of every piece of apparatus connected. to the system.

3 Voltage transients such as those due to switching, or temporary voltage variations due to abnormal operation, such as those due to fault conditions in the system supplying the installation, are not taken into consideration.

2.4.3 *Standard Nominal Voltage* — The nominal voltage recommended in this standard.

2.4.4 *Rated Voltage (of Equipment)* — The voltage assigned by the manufacturer for the designed operating condition of a component, device or equipment.

2.4.5 *Highest Voltage of the System* — The highest rms line-to-line voltage which is sustained under normal operating conditions at any time and at any point of the system. It excludes temporary voltage variations due to fault conditions.

2.4.6 *Lowest Voltage of the System* — The lowest rms line-to-line voltage which is sustained under normal operating conditions at any time and at any point of the system. It excludes temporary voltage variations due to fault conditions.

3. AC SYSTEMS

3.1 AC Voltage Bands

3.1.1 Voltage bands in which the ac installations shall be classified according to their nominal voltage are given in Table 1:

a) For earthed systems (**2.2**), by the rms values of the voltages between phase and earth and between phases; and

b) For isolated or not effectively earthed systems (**2.3**), by the rms value of the voltage between phases.

TABLE 1
AC VOLTAGE BANDS

Sl No.	BANDS	EARTHED SYSTEMS		ISOLATED OR NON - EFFECTIVE EARTHED SYSTEMS
		Phase to Earth	Between Phases	
(1)	(2)	(3)	(4)	(5)
i.	I	$u \leq 50$V	$u \leq 50$V	$u \leq 50$V
ii.	II	50 V < $u \leq$ 600 V	50 V < $u \leq$ 1000 V	50 V < $u \leq$ 1000 V
iii.	IIIA	1kV < $u \leq$ 52kV		
iv.	IIIB	52kV < $u \leq$ 300kV		
v.	IIIC	300kV < u		

u = nominal voltage of the installation.

NOTE—This classification of voltage bands does not exclude the possibility of introducing intermediate values for some particular rules.

*If the neutral is distributed, electrical equipment supplied between phase and neutral is to be chosen so that its insulation corresponds to the voltage

3.1.2 *AC System Voltage* — The preferred values of ac nominal system voltages including maximum permissible variations shall be as given in Table 2.

Table 2 AC System Voltage

Sl No.	AC Voltage	Preferred ac system	Nominal Voltage	Highest System Voltage	Lowest System Voltage
(1)	(2)	(3)	(4)	(5)	(6)
	I	Not Specified			
	II	**Three Phase**	**230V/400V**	**253V/440V**	**207V/360V**
		Single Phase	**230V**	**253V**	**207V**
	IIIA	**Three Phase**	**3.3kV**	**3.6kV**	**3.0kV**
			6.6kV	**7.2kV**	**6.0kV**
	IIIA		**11kV**	**12kV**	**10kV**
			33kV	**36kV**	**30kV**
	IIIB		**66kV**	**72.5kV**	**60kV**
			132kV	**145kV**	**120kV**
			220kV	**245kV**	**200kV**
	IIIC		**400kV**	**420kV**	**380kV**

NOTES

1 The lower value in columns 4, 5 and 6 of AC Band II are voltage between phase and neutral and higher values are voltage between phases. Where only one value is indicated it refers to three phase, three wire system and specified value is voltage between phases.

2 This standard recognizes that 100 kV and 110 kV system is already in existence though it is not a preferred system voltage.

3 During the transition period both the system voltage of 240/415 and 230/400 will prevail till 1 year from the date of publication of IS 12360: 2024.

4 The historical development of the standard value for ac system voltages in Band II is given in Appendix A.

3.1.3 *Tolerance on Declared Voltage* — The voltage at any point of the system under normal conditions shall not depart from the declared voltage by more than the values given below:

Band I	Not specified
Band II	± 10 percent
Band IIIA	+6 percent
	-9 percent
Band IIIB and IIIC	± 12.5 percent

NOTE — It should be noted that the highest and the lowest system voltages given in Table 2 are meant for guidance to designers.

4. STANDARD SYSTEM FREQUENCY

4.1 The standard system frequency shall be 50 Hz.

4.2 The limits within which the frequency shall be maintained are governed by the Central Electricity Regulatory Commission (Indian Electricity Grid Code) Regulations, 2023 which is to be maintained at 49.900 – 50.050 Hz.

4.3 For frequencies higher than 50 Hz for special power applications, reference may be made to the relevant Indian Standard.

5. DC SYSTEM

5.1 DC Voltage Bands

5.1.1 DC voltage bands in which the installations shall be classified according to their nominal voltage are given in Table 3.

TABLE 3 DC VOLTAGE BANDS

(*Clause* 5.1.1)

Sl No.	BANDS	EARTHED SYSTEMS		ISOLATED OR NOT EFFECTIVELY EARTHED SYSTEMS* BETWEEN POLES
	(1)	(2)		(3)
		Pole to Earth	Between Poles	
i.	I	u ≤ 120 V	u ≤ 120 V	u ≤ 120 V
ii.	II	120 V <u< 900 V	120V < u < 1500 V	120 V <u≤ 1500 V

u=nominal voltage of the installation (volts).

NOTES

1 The values of this table relate to ripple free dc.
2 This classification of voltage bands does not exclude the possibility of introducing intermediate limits for some particular rules.
3 Higher voltages for DC applications are under consideration.

*If a middle wire is distributed, electrical equipment supplied between poles and middle wire is to be chosen so that its insulation corresponds to the voltage between the poles.

a) For earthed systems (**2.2**), by the values of the voltages between pole and earth and between poles; and
b) For isolated or not effectively earthed systems (**2.3**), by the value of the voltage between poles.

5.1.2 *DC System Voltages* —The preferred values of dc nominal system voltages shall be as given in Table 4.

TABLE 4 DC SYSTEM VOLTAGE

(*Clause* 5.1.2**)**

Sl No.	DC Voltage Band	Preferred Nominal DC System Voltage
(1)	(2)	(3)
i.	I	Not Specified
ii.	II	220 V 440V

APPENDIX A

(*Table 2*)

HISTORICAL DEVELOPMENT OF SYSTEM VOLTAGES IN AC BAND II

A-1. The generation and supply of electrical energy by licensed undertakings in this country is regulated by the Central Electricity Authority (Measures relating to Safety and Electric Supply) Regulations, 2023. These rules specify, however only the permissible variations in the nominal values of voltages and frequency. The actual nominal voltage of supply is declared by the electricity supply undertakings and these vary largely due to the influence of standard practices of the countries from which electrical plant and machinery have been imported in the past. Moreover, owing to actual transmission and distribution conditions, there is a considerable variation in the actual voltage available at the consumer's premises.

A-2. The desirability of uniformity in supply voltage is generally recognized, as such a step will not only be of advantage to the users of electrical energy but also of help to regulate the manufacture of electrical equipment for a standard voltage. At the international level also, this has been recognized and IEC Publication 38 IEC Standard Voltages had been issued in 1938, and this publication has been reviewed periodically towards arriving at a unified value. Even though no single value of voltage, especially in the low/medium voltage range could be recommended at the IEC level, owing to the divergence of the system parameters from one country to another, IEC Publication 38 recognizes a few limited nominal values as standard, out of which, individual countries could make a choice.

A-3. When IS 585* was first published in 1954, the recommended standard values of nominal voltages were 230 volts for single-phase system and 230/240 volts for three-phase system, these being the most common declared voltages throughout the country at this voltage level. At the international level, however, IEC had then recommended two sets of voltages, namely (a) 220 volts single-phase and 220/380 volts three-phase, and (b) 240 volts single-phase and 240/415 volts three-phase.

Subsequent to publication in 1954 of this standard, attention of chief engineers of important State Governments and electricity supply undertakings was drawn to the economic advantages of having 240 volts single-phase and 240/415 volts three-phase systems in this country, in addition to the desirability of our following the IEC recommendation. Most of them were in favour of adopting these voltages in India and had expressed the willingness to effect gradual changeover in their distribution systems to these voltages. On this basis, an amendment to the standard was issued in 1959 adopting 240 volts single-phase and 240/415 volts three-phase, as Indian Standard Voltages, in place of 230 volts single phase and 230/400 volts, three-phase, respectively.

A-4. The first revision of IS 585 was brought out in 1962, and it contained the amended proposal mentioned in A-3 and since then over a period of 2 decades, several utilities had effected the changeover to the new system voltages, namely 240/415 V. Barring exceptions which it is hoped would be temporary, these values are quoted as standard nominal ac system voltages throughout the country today, and product standards stipulate performance requirements with these values as the basis.

A-5. At the IEC level, however, since 1961, even though a choice between 220/380 V and 240/415 V was available in IEC Publication 38, proposals were being debated time and again to introduce 230/400 V in three-phase systems as the only final value, the ultimate simplification of standard voltages. The following process had been followed gradually towards this end by IEC:

a) Firstly, the envisaged unique value 230/400 V was announced in a note in the fifth edition of IEC Publication 38,
b) 230/400 V had been introduced subsequently together with the values 220/380 V and 240/415 V in Amendment No. 1 (1977), and
c) The previous values 220/380 V and 240/415 V were deleted and the value of 230/400 V chosen as standard in the sixth edition of IEC Pub 38.

d) Amendment No. 1 to IEC-38 was issued in 1994 suggesting the period of transition system voltage from 240/415 V to 230/400 V not to exceed the year 2003.

A-6. The present recommendations at IEC level include a proposal that, all the existing systems should evolve towards the IEC value of 230/400 V, over as short a transition period as possible, however not exceeding 20 years. During the interim period, for existing systems at 240/415 V (such as those in India) being operated with a tolerance of ± 6 percent, the value 230/400 V ±10% is suggested to be adopted for compliance with IEC Pub 38, provided the upper limit of 254/440 V is not exceeded which corresponds to 240/415 V + 5.4 percent.

A-7. In India, subsequent to the first revision of IS 585, all planning in the country had been made towards the value of 240/415 V recommended by IEC, primarily owing to the advantages of a higher system voltage and the ease with which the switchover from a lower system to a higher system is possible. India had therefore opposed the IEC proposals both during step (b) and step (c) (*see* **A.5**). As such, this standard continued to recommend the nominal values of 240/415 V with the allowable tolerances. However, in view of the latest international developments, it was decided to align Indian Standard Nominal System Voltages with IEC recommendations and accordingly revise the values of the ac Nominal System Voltage from 240/415 to 230/400 with a tolerance of ±10 percent and it was also decided to effect the complete transition.

A-8. Subsequent to publication of the first revision of IS 585 'Voltages and Frequency for Transmission and Distribution Systems *(Revised*)' in 1962, there has been a need to standardize the values of preferred voltages for dc systems. These systems are basically derived from the existing medium voltage and low voltage ac systems, and are intended to serve as a source of supply for dc drives and coils of switchgear and control gear at the plant level.

A-9. It has been noted from a survey of the existing practice that the values of 220/440 V dc were by and large adopted in the design of dc components of electrical equipment, particularly, switchgear and control gear, though the corresponding values for dc mill auxiliary motors are at variance from place-to-place owing to different patterns of existing dc networks at the plant level. It is observed that dc networks with nominal voltages of 230/460 V are also extensively in use alongside 220/440 V, particularly in steel plants for long periods of time.

A-10. In debating the choice between the two different dc voltages in vogue, namely, 230/460 V and 220/440 V, the Basic Electrotechnical Standards and Power Quality Sectional Committee, ETD 01 had thought it desirable to opt for the latter as the standard values to be recommended, not only keeping in view the international trend in this regard but also noting their acceptance by several organizations other than the steel plants in the country.

NOTE — It is stated, however, that this standard does not envisage an immediate changeover from 230/460 V dc to 220/440 V dc for plants using the former value, though progressively it would be desirable to adopt the values recommended herein.