

ITU-R

Radiocommunication Sector of ITU

Recommendation ITU-R V.574-5
(08/2015)

**Use of the decibel and the neper in
telecommunications**

V Series
Vocabulary and related subjects



Foreword

The role of the Radiocommunication Sector is to ensure the rational, equitable, efficient and economical use of the radio-frequency spectrum by all radiocommunication services, including satellite services, and carry out studies without limit of frequency range on the basis of which Recommendations are adopted.

The regulatory and policy functions of the Radiocommunication Sector are performed by World and Regional Radiocommunication Conferences and Radiocommunication Assemblies supported by Study Groups.

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Series of ITU-R Recommendations

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P	Radiowave propagation
RA	Radio astronomy
RS	Remote sensing systems
S	Fixed-satellite service
SA	Space applications and meteorology
SF	Frequency sharing and coordination between fixed-satellite and fixed service systems
SM	Spectrum management
SNG	Satellite news gathering
TF	Time signals and frequency standards emissions
V	Vocabulary and related subjects

Note: This ITU-R Recommendation was approved in English under the procedure detailed in Resolution ITU-R 1.

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RECOMMENDATION ITU-R V.574-5

Use of the decibel and the neper in telecommunications ****

(1978-1982-1986-1990-2000-2015)

Scope

This text recommends the symbols to be used for the logarithmic expression of quantities referring to power, and provides examples of the use as well as the relationship between the decibel and the neper.

Keywords

Decibel, neper

Related ITU Recommendations

Recommendation ITU-R V.430-4	Use of the international system of units (SI)
Recommendation ITU-R V.431-8	Nomenclature of the frequency and wavelength bands used in telecommunications
Recommendation ITU-R V.573-6	Radiocommunication vocabulary
Recommendation ITU-R V.665-3	Traffic intensity unit

The ITU Radiocommunication Assembly,

considering

- a) the frequent use by the ITU of the decibel and the neper for expressing quantities;
- b) the International Standard IEC 60027-3 of the International Electrotechnical Committee on “Logarithmic and related quantities, and their units”;
- c) International Standard ISO 80000 of the International Organization for Standardization on quantities and units;
- d) the convenience of using only one unit to express in logarithmic form the numerical values of international specifications and the results of measurements in exchanges at international level;
- e) the use in radiocommunications of the decibel alone to express the results of measurements in logarithmic form,

recommends

- 1 that symbols used for the logarithmic expression of quantities that directly or indirectly refer to power should be chosen with the guidance of Annex 1.

* This Recommendation should be brought to the attention of the ITU-T.

** In this Recommendation, the notation lg is used for the decimal logarithm in accordance with International Standards ISO 80000-2 and IEC 60027-3. The notation $\log_{10}$ is also used. The notation log can be used if there is no ambiguity.

Annex 1

Use of the decibel and the neper

1 Definition of the decibel

1.1 The *bel* (symbol B) expresses the ratio of two powers by the decimal logarithm of this ratio. This unit is not often used, having been replaced by the *decibel* (symbol dB) which is one-tenth of a bel.

1.2 The decibel also may be used to express the ratio of two *field quantities*, such as voltage, current, sound pressure, electric field, charge velocity or density, the square of which in linear systems is proportional to power. To obtain the same numerical value as a power ratio, the logarithm of the field quantity ratio is multiplied by the factor 20, assuming that the impedances are equal.

The relationship between a current or voltage ratio and that of the corresponding power ratio is impedance dependent. Use of the decibel when the impedances are not equal is not appropriate unless adequate information is given concerning the impedances involved.

For example, if P_1 and P_2 are two powers, their ratio expressed in decibels is:

$$10 \lg (P_1/P_2)$$

If P_1 and P_2 represent the powers dissipated by currents I_1 and I_2 in resistances R_1 and R_2 :

$$10 \lg \frac{P_1}{P_2} = 10 \lg \frac{I_1^2 R_1}{I_2^2 R_2} = 20 \lg \frac{I_1}{I_2} + 10 \lg \frac{R_1}{R_2}$$

1.3 The decibel may be used to express the ratio of two values of a quantity connected with power by a well-defined relationship. In this case, the logarithm of this ratio must be multiplied by a factor representing the relationship which connects the quantity with a power, and a term representing a multiplying factor may be added to it.

If the ratio of two powers P_1 and P_2 depends on the ratio of values X_1 and X_2 of another quantity X by a relationship of the form $P_1/P_2 = (X_1/X_2)^\alpha$, α being any real number, we can express it in decibels as:

$$10 \lg (P_1/P_2) = 10 \alpha \lg (X_1/X_2) \quad \text{dB}$$

2 Definition of the neper

The *neper* (symbol Np) expresses the ratio of two field quantities such as voltage or current, the square of which is proportional to power by the natural logarithm of this ratio. The value of a power ratio in nepers is one-half of the natural logarithm of the power ratio. The values in nepers of the ratio of two field quantities and of the corresponding powers are equal only if the impedances are equal.

One neper corresponds to the value of e of a field quantity ratio and to the value e^2 of a power quantity ratio.

Sub-multiples such as the decineper (dNp) are also used.

In some disciplines, nepers may be used to express the logarithm of a power ratio without the factor 1/2. An example is optical depth or attenuation in radiometry. Such usage is prohibited in telecommunications in order to prevent ambiguity. Under this definition, the neper would in fact be equal to 4.34 dB, instead of 8.68 dB as is traditionally the case.