

Australian/New Zealand Standard™

Electromagnetic compatibility (EMC)

**Part 2.7: Environment—Low frequency
magnetic fields in various environments**



AS/NZS IEC/TR 61000.2.7:2009

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Part 2.7: Environment—Low frequency magnetic fields in various environments

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PREFACE

This Technical Report was prepared by the Joint Standards Australia/Standards New Zealand Committee EL-034, Power Quality. This document is informative and of a more descriptive nature than a normative Standard.

The objective of this Technical Report is to provide users of electromagnetic emissions Standards with reference values on low-frequency magnetic fields produced by some electrical equipment (particularly video display units) in various environments such as industrial, commercial office, residential and hospital.

This Technical Report is identical with, and has been reproduced from IEC/TR 61000-2-7, Ed. 1.0 (1998), *Electromagnetic compatibility (EMC)—Part 2: Environment—Section 7: Low frequency magnetic fields in various environments*.

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- (b) A full point should be substituted for a comma when referring to a decimal marker.

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INTRODUCTION

IEC 61000 is published in separate parts according to the following structure:

- Part 1: General
 - General considerations (introduction, fundamental principles)
 - Definitions, terminology
- Part 2: Environment
 - Description of the environment
 - Classification of the environment
 - Compatibility levels
- Part 3: Limits
 - Emission limits
 - Immunity limits (in so far as they do not fall under responsibility of product committees)
- Part 4: Testing and measurement techniques
 - Measurement techniques
 - Testing techniques
- Part 5: Installation and mitigation guidelines
 - Installation guidelines
 - Mitigation methods and devices
- Part 6: Generic standards
- Part 9: Miscellaneous

Each part is further subdivided into sections which are to be published either as International Standards or as technical reports.

These standards and reports will be published in chronological order and numbered accordingly.

This section is a technical report of type 3.

STANDARDS AUSTRALIA/STANDARDS NEW ZEALAND

Australian/New Zealand Standard

Electromagnetic compatibility (EMC)

Part 2.7: Environment—Low frequency magnetic fields in various environments

1 Scope

Interest in magnetic fields has been stimulated in recent years by concern over the physiological effects they may have on humans and animals and the deleterious effects they have on the performance of some electrical equipment, particularly video display units. Investigations have yielded results which are presented in this report as reference values.

Note 1 – The European Union EMC Directive has prompted magnetic field measurements, particularly in respect of the commercial office environments associated with supply authority substations and electrical distribution systems within buildings. Supply authorities have sponsored most of the work and the results are generally within the frequency range of 50 Hz to 2 kHz, and presented as r.m.s. values. There is, however, a need to have some knowledge about d.c. fields and the fields up to 150 kHz as they may interfere with some types of equipment.

Note 2 – Most of the magnetic field data in this report is associated with sinusoidal current sources and r.m.s. values may be assumed unless otherwise stated.

Power supply systems operating at voltages less than or equal to 1 000 V are designated low-voltage, those above 1 000 V and up to 35 kV are designated medium-voltage, and those in excess of 35 kV are designated high-voltage.

2 Normative reference

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

IEC 60050(161):1990, *International Electrotechnical Vocabulary (IEV) – Chapter 161: Electro-magnetic compatibility*.

3 Units

Magnetic field values in this report are either expressed in field strengths of amperes per metre, A/m, or in flux densities of microtesla, μT . Where the older flux density unit of milligauss, mG, has appeared in reference documents it has been converted to μT by the following relationship:

$$1 \mu\text{T} = 10 \text{ mG} \approx 0,796 \text{ A/m}$$

The following units are applied in the present report:

Magnetic field strength: H in A/m

Magnetic flux density: $B = \mu \times H$ in T (Tesla)

whereby the permeability $\mu = \mu_r \times \mu_0$ and $\mu_0 = 1,256 \cdot 10^{-6}$ (Wb/Am)

in air the relative permeability $\mu_r = 1$ and $B (\mu\text{T}) = 1,256 H (\text{A/m})$

NOTE – $1 \text{ T} = 1 \text{ Wb/m}^2 = 10^4 \text{ G}$ and $B = 1,256 \cdot 10^{-9} \text{ G}$ (in air)

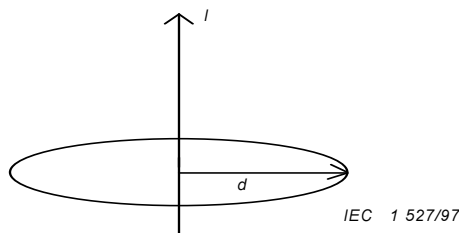
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Example: Magnetic field of a single conductor

The relationship between the magnetic field strength and magnetic induction at a distance d from a single conductor carrying a current I is given by the following expressions:

$$H = \frac{I}{2\pi d} \text{ (A/m)}$$

$$B = 1,256 \frac{I}{2\pi d} \text{ (}\mu\text{T)}$$



An alternating current produces an alternating magnetic field, and in the case of a multi-phase cable or overhead line, the alternating magnetic field rotates as it results from the vector sum of the fields produced by individual phase currents.

An alternating magnetic field will induce an electromotive force in any electrical conductor to which it is exposed. This effect is utilised by meters which have search coils. Such meters are in common use.

Other types of meter used for low frequency measurements utilise the Hall effect. These meters are not so good for measuring the fields from environmental sources, but they are very useful when measuring points in space and static magnetic fields.

4 Natural phenomena

Three kinds of natural magnetic fields have to be considered:

- the earth's magnetic field (a static field);
- magnetic fields produced by thunderstorms and solar activity (time-varying with very low frequencies);
- magnetic fields caused by lightning strokes (pulses).

The first measurements and use of magnetic fields related to navigation and intense study of the earth's magnetic fields has resulted in the production of field maps, an example of which is given in figure 1 [1]*. All unscreened conductors moving in the earth's magnetic field will generate a voltage across their ends of a magnitude related to the speed and direction of movement. Such voltage may disturb sensitive electronic devices in associated circuits. Static electrical equipment is not normally affected by the earth's field.

The earth's static magnetic field is nearly always present as a steady state background reading at 0 Hz to site measurements. Near the poles flux densities are as high as 60 μT whilst at the equator they are only 30 μT .

* Figures in square brackets refer to the bibliography.

A normal value assumed for the purpose of calculations is $50 \mu\text{T}$ [1]. See figure 1.

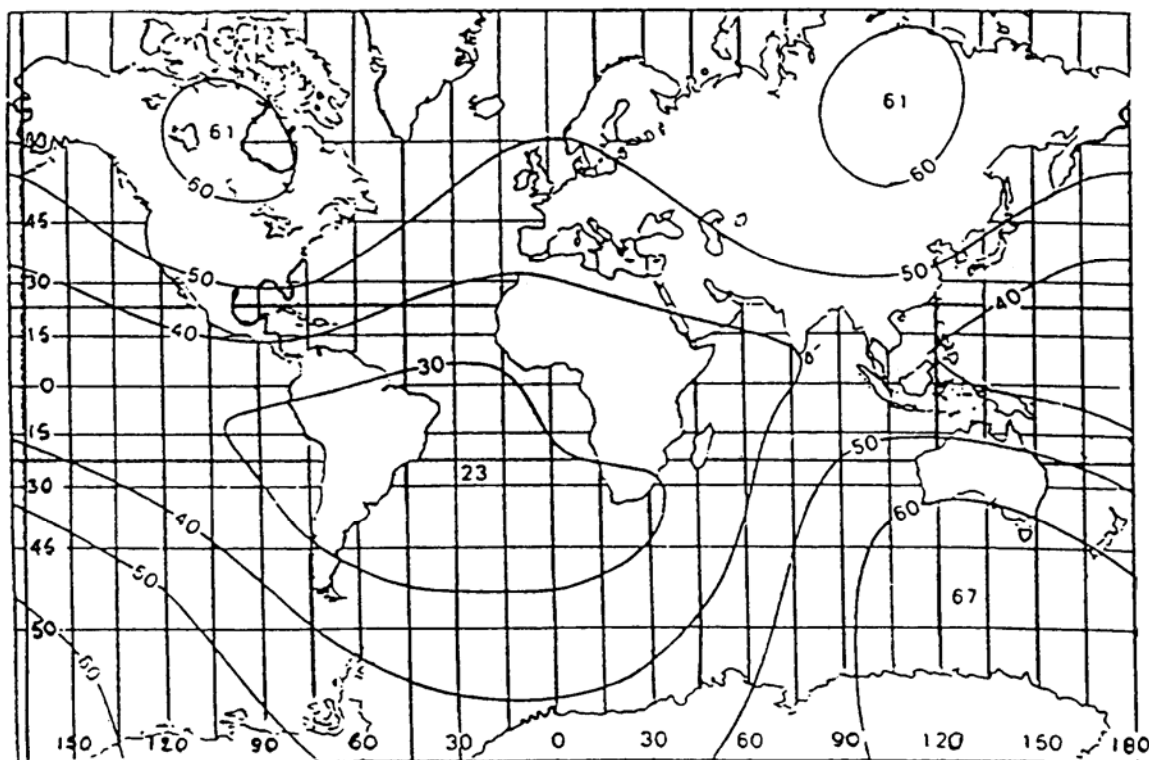
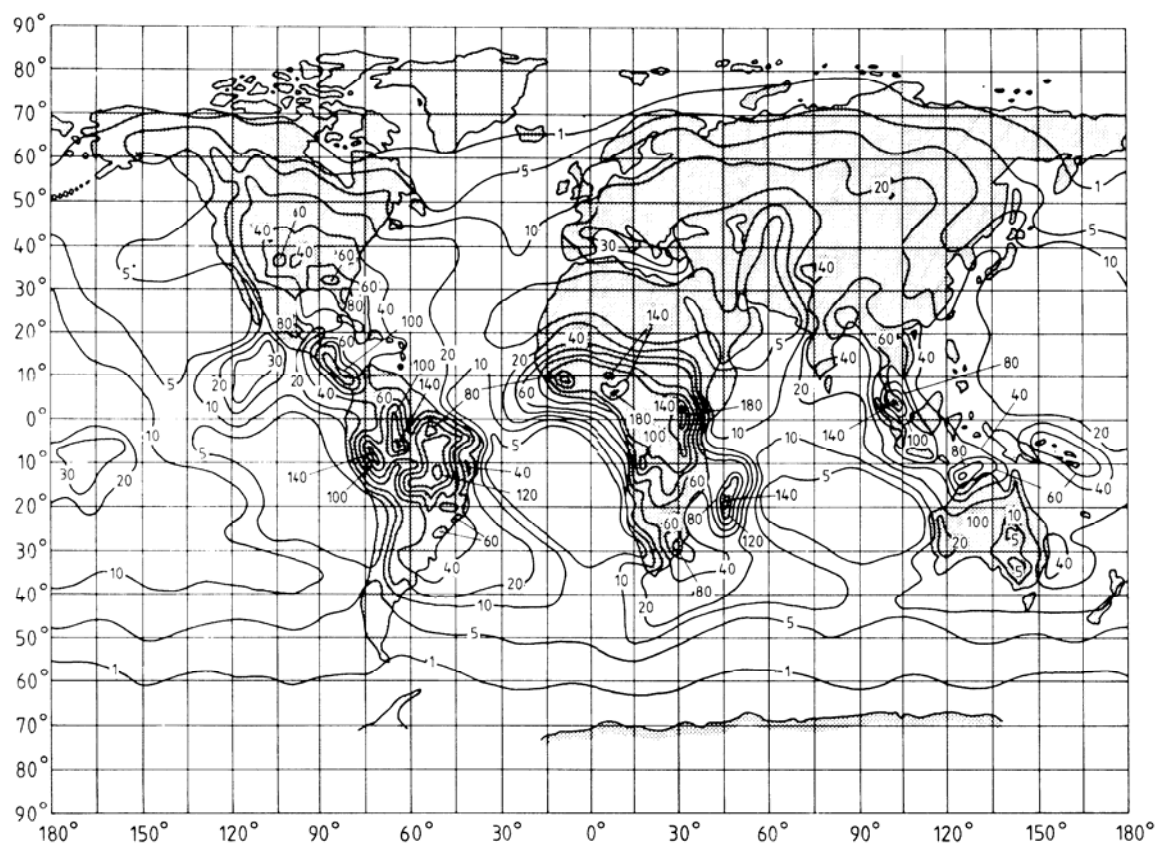


Figure 1 – The earth's total magnetic field at the surface in μT

Natural phenomena, such as thunderstorms and solar activity, produce time-varying magnetic fields in the extra-low-frequency range. Such fields are generally of low strength, up to $0,01 \mu\text{T}$ (8 mA/m), although during intense magnetic storms, they can reach intensities of about $0,5 \mu\text{T}$ (0,4 A/m).

Very little data is available regarding the number of lightning strokes that a particular location may receive in a year. However the ceraunic map in figure 2 [2] does indicate the level of activity and the probability of the highest fields being achieved.



IEC 1 529/97

Figure 2 – Map showing thunderstorm days per year throughout the world

NOTE – This map is based on information of the World Meteorological Organization for 1955.

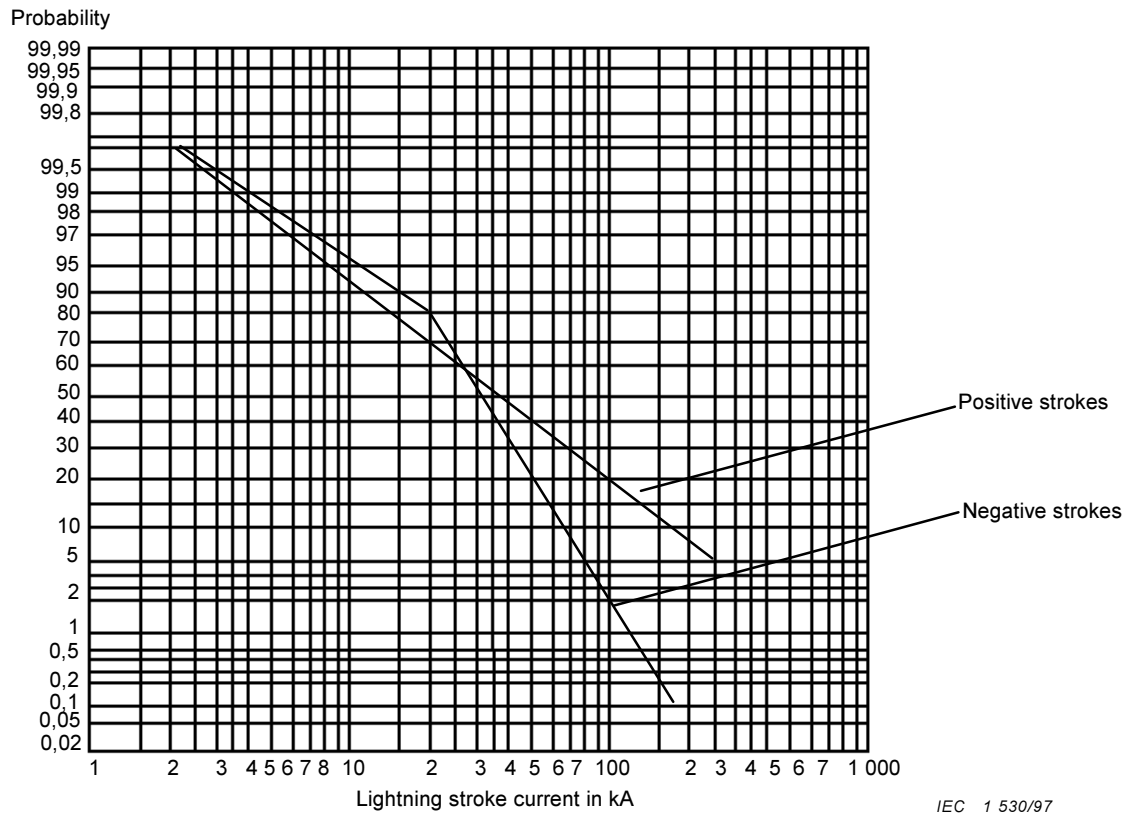


Figure 3 – Cumulative frequency of lightning current from IEC 61024-1-1

The following reference values for the cumulative frequency of lightning current (see figure 3):

	Negative stroke	Positive stroke
5 %	80 kA	250 kA
50 %	33 kA	35 kA
95 %	7 kA	5 kA

The lightning stroke creates magnetic field pulses with a rise time of about 1 μ s and a mid-magnetic duration of about 100 μ s.

The resulting magnetic field can be calculated according to the relationship:

$$H_{\text{peak}} = \frac{I}{2\pi d} \quad \text{e.g. with } I = 200 \text{ kA and } d = 1 \text{ km: } H = 32 \text{ A/m and } B = 40 \mu\text{T}$$

5 Power supply system environments – Power frequency magnetic fields

Magnetic field values relevant to power supply systems are dependent on the load current at the time measurements are taken, the system voltage, which determines the clearances of overhead line conductors to ground, and the depth and construction of underground cables. Wherever possible, the values stated in this section have been referenced to the system voltage and maximum load conditions, or expressed in terms per kiloampere, kA, of conductor current.

5.1 Overhead lines

Magnetic fields produced by current flowing through electricity distribution overhead lines are influenced principally by the magnitude of the current, the electrical phase configuration and the physical configuration of the conductors. The voltage at which a power line operates is significant because it determines the height of conductors above ground and also the phase separation between conductors and to earthed metal used for construction purposes.

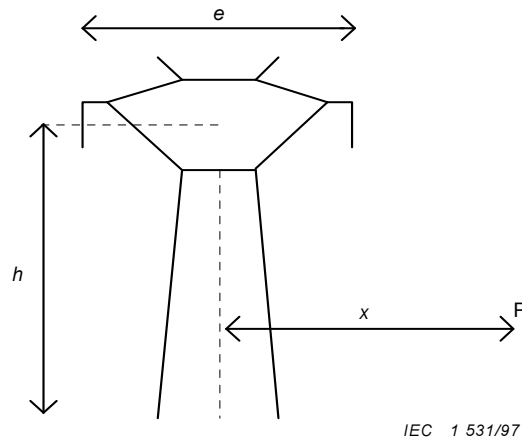
There are so many system voltages, conductor current ratings and construction standards in use throughout the world that magnetic field data cannot be provided for every particular type of installation. However, the typical installations and magnetic field characteristics that are defined in the following text are good models on which to base predictions of fields for other particular installations.

If detailed values of flux density for particular lines are required, it would be necessary to consider the conditions of the individual lines such as wire configurations, height above ground and line current. The following approximate formula applies:

$$H = 140 \frac{e}{h^2 + x^2} \text{ in A/m for 1 kA}$$

where:

- e is the distance between external conductors;
- h is the height above ground;
- x is the distance from central conductor to the point P to be considered.



5.1.1 AC, three-phase lines

As the flux densities associated with power lines are linearly related to line current it is easy to deduce values for particular values of current. The maximum line currents under normal operating conditions are approximately as follows:

- low voltage lines 0,4 kA
- medium voltage lines 0,6 kA
- 110 kV and 220 kV lines 1,0 kA
- 380 kV lines 2,0 kA
- 750 kV lines 3,0 kA

If necessary, more accurate current values may be obtained from supply utilities and railway companies. However, under fault conditions such as single phase or double phase short circuits, the magnetic fields of three conductors are not balanced, and the magnetic field may be increased by a factor of 20; such conditions may be expected to endure for a few seconds for low and medium voltage networks and for less than 0,2 seconds for high voltage networks.

Figure 4, left side, shows the envelope of the profile of the maximum magnetic flux density per kA of line current, for high voltage, single three-phase transmission lines, at mid-span at a distance x from the centre of the conductor system, and at a height of 1 m from ground level based on VDE data [3].