ISO11451-1-2005

INTERNATIONAL STANDARD

ISO 11451-1

文件受控 EMC

编号 JCI/EMC0513 (1)

IS

Third edition
2005-02-15

20050297

Road vehicles — Vehicle test methods for electrical disturbances from narrowband radiated electromagnetic energy —

Part 1:
General principles and terminology

Véhicules routiers — Méthodes d'essai d'un véhicule soumis à des perturbations électriques par rayonnement d'énergie électromagnétique en bande étroite —

Partie 1:Principes généraux et terminologie

Reference number
ISO 11451-1:2005(E)

Contents

Page

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 11451-1 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 3, *Electrical and electronic equipment.*

This third edition cancels and replaces the second edition (ISO 11451-1:2001), which has been technically revised.

ISO 11451 consists of the following parts, under the general title *Road vehicles — Vehicle test methods for electrical disturbances from narrowband radiated electromagnetic energy*:

— *Part 1: General principles and terminology*

— *Part 2: Off-vehicle radiation source*

— *Part 3: On-board transmitter simulation*

— *Part 4: Bulk current injection (BCI)*

Introduction

In recent years, an increasing number of electronic devices for controlling, monitoring and displaying a variety of functions have been introduced into vehicle designs. It is necessary to consider the electrical and electromagnetic environment in which these devices operate.

Electrical and radio-frequency disturbances occur during the normal operation of many items of motor vehicle equipment. They are generated over a wide frequency range with various electrical characteristics and can be distributed to on-board electronic devices and systems by conduction, radiation or both. Narrowband signals generated from sources on or off the vehicle can also be coupled into the electrical and electronic system, affecting the normal performance of electronic devices. Such sources of narrowband electromagnetic disturbances include mobile radios and broadcast transmitters.

The characteristics of the immunity of a vehicle to radiated disturbances have to be established. ISO 11451 provides various test methods for the evaluation of vehicle immunity characteristics. Not all methods need be used for a given vehicle.

ISO 11451 is not intended as a product specification and cannot function as one (see A.1). Therefore, no specific values for the test severity level are given.

Annex A of this part of ISO 11451 specifies a general method for function performance status classification (FPSC), while Annex B explains the principle of constant peak test level. Typical severity levels are included in an annex of each of the other parts of ISO 11451.

Protection from potential disturbances needs to be considered in a total system validation, and this can be achieved using the various parts of ISO 11451.

NOTE Immunity measurements of complete vehicles are generally able to be carried out only by the vehicle manufacturer, owing to, for example, high costs of absorber-lined shielded enclosures, the desire to preserve the secrecy of prototypes or a large number of different vehicle models. ISO 11452 specifies test methods for the analysis of component immunity, which are better suited for supplier use.

Road vehicles — Vehicle test methods for electrical disturbances from narrowband radiated electromagnetic energy —

Part 1:
General principles and terminology

1 Scope

This part of ISO 11451 specifies general conditions, defines terms, gives practical guidelines and establishes the basic principles of the vehicle tests used in the other parts of ISO 11451 for determining the immunity of passenger cars and commercial vehicles to electrical disturbances from narrowband radiated electromagnetic energy, regardless of the vehicle propulsion system (e.g. spark-ignition engine, diesel engine, electric motor).

The electromagnetic disturbances considered are limited to continuous narrowband electromagnetic fields. A wide frequency range (0,01 MHz to 18 000 MHz) is allowed for the immunity testing in this and the other parts of ISO 11451.

2 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

2.1
absorber-lined shielded enclosure
shielded enclosure/screened room with radio frequency-absorbing material on its internal ceiling and walls

NOTE The common practice is for the room to have a metallic floor, but absorbing material may also be used on the floor.

2.2
amplitude modulation
AM
process by which the amplitude of a carrier wave is varied following a specified law, resulting in an AM signal

2.3
bulk current
total amount of common mode current in a harness

2.4
compression point
input signal level at which the measurement system becomes non-linear, when the output value will deviate from the value given by an ideal linear system

2.5
coupling
means or device for transferring power between systems

NOTE Adapted from IEC 60050-726.

2.6
current injection probe
device for injecting current in a conductor without interrupting the conductor and without introducing significant impedance into the associated circuits

2.7
current (measuring) probe
device for measuring the current in a conductor without interrupting the conductor and without introducing significant impedance into the associated circuits

[IEC 60050-161]

2.8
degradation (of performance)
undesired departure in the operational performance of any device, equipment or system from its intended performance

NOTE The term "degradation" can apply to temporary or permanent failure.

[IEC 60050-161]

2.9
dual directional coupler
four-port device consisting of two transmission lines coupled together in such a manner that a single travelling wave in any one transmission line will induce a single travelling wave in the other, the direction of propagation of the latter wave being dependent upon that of the former

NOTE Adapted from IEC 60050-726.

2.10
electromagnetic compatibility
EMC
ability of equipment or system to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbance to anything in that environment

[IEC 60050-161]

2.11
electromagnetic disturbance
any electromagnetic phenomenon which may degrade the performance of a device, equipment or system, or adversely affect living or inert matter

EXAMPLE An electromagnetic disturbance may be an electromagnetic noise, an unwanted signal or a change in the propagation medium itself.

[IEC 60050-161]

2.12
electromagnetic interference
EMI
degradation of the performance of equipment, transmission channel or system caused by electromagnetic disturbance

NOTE The English words "interference" and "disturbance" are often used indiscriminately.

[IEC 60050-161]

2.13
forward power
power supplied by the output of an amplifier or generator

2.14
functional status
performance level agreed between the customer and the supplier which is specified in the test plan

2.15
ground (reference) plane
flat conductive surface whose potential is used as a common reference

[IEC 60050-161]

2.16
immunity (to a disturbance)
ability of a device, equipment or system to perform without degradation in the presence of an electromagnetic disturbance

[IEC 60050-161]

2.17
immunity level
maximum level of a given electromagnetic disturbance incident on a particular device, equipment or system for which it remains capable of operating at a required degree of performance

[IEC 60050-161]

2.18
narrowband emission
emission which has a bandwidth less than that of a particular measuring apparatus or receiver

[IEC 60050-161]

2.19
polarization
property of sinusoidal electromagnetic wave or field vector defined at a fixed point in space by the direction of the electric field strength vector or of any specified field vector

NOTE 1 When this direction varies with time, the property may be characterized by the locus described by the extremity of the considered field vector.

NOTE 2 Adapted from IEC 60050-726.

2.20
pulse modulation
PM
process by which the amplitude of a carrier wave is varied following a specified law, resulting in an PM signal

2.21
electromagnetic radiation
phenomenon by which energy in the form of electromagnetic waves emanates from a source into space

NOTE By extension, the term "electromagnetic radiation" sometimes also covers induction phenomena.

[IEC 60050-161]

2.22
electromagnetic radiation
energy transferred through space in the form of electromagnetic waves

[IEC 60050-161]

2.23
reflected power
power reflected by the load due to impedance mismatch between RF source and the load

2.24
shielded enclosure
screened room
mesh or sheet metallic housing designed expressly for the purpose of separating electromagnetically the internal and external environment

[IEC 60050-161]

2.25
standing wave ratio
SWR
voltage standing wave ratio
VSWR
ratio, along a transmission line, of a maximum to an adjacent minimum magnitude of a particular field component of a standing wave

NOTE 1 SWR is expressed by the equation:

$$\mathrm{SWR} = \frac{(1+r)}{(1-r)}$$

where r is the absolute value of the coefficient of reflection.

NOTE 2 Adapted from IEC 60050-726.

2.26
(electromagnetic) susceptibility
inability of a device, equipment or system to perform without degradation in the presence of an electromagnetic disturbance

NOTE Susceptibility is the lack of immunity.

[IEC 60050-161]

2.27
transmission line system
TLS
field-generating device that works in a similar way to a TEM (transverse electromagnetic) wave generator

EXAMPLE Stripline, TEM cell, parallel plate.

3 General aim and practical use

The test methods, procedures, test instrumentation and levels specified in ISO 11451 are intended to facilitate vehicle specification for electrical disturbances by narrowband radiated electromagnetic energy. A basis is provided for mutual agreement between vehicle manufacturers and component suppliers intended to assist rather than restrict.

Certain devices are particularly susceptible to some characteristics of electromagnetic disturbance, such as frequency, severity level, type of coupling or modulation.

Electronic devices are sometimes more susceptible to modulated, as opposed to unmodulated, radio-frequency (RF) signals. The reason is that high-frequency disturbances may be demodulated by semiconductors. In the case of unmodulated signals, this leads to a continuous shift of, for example, a voltage;

in the case of amplitude-modulated signals, the resulting low-frequency fluctuations may be interpreted as intentional signals (e.g. speed information) and therefore disturb the function of the device under test (DUT) more severely.

A single standard test may not reveal all the needed information about the DUT. It is thus necessary for users of ISO 11451 to anticipate the appropriate test conditions, select applicable parts of ISO 11451 and define function performance objectives. The main characteristics of each test method in ISO 11451-2 to ISO 11451-4 are presented in Table 1.

Table 1 — Main characteristics of test methods in ISO 11451

Part of ISO 11451	Applicable frequency range MHz	Coupling to	Test severity parameter and unit	Provisions
ISO 11451-2 Off-vehicle radiation source	0,01 to 18 000	DUT and wiring harness	Electric field (V/m)	Absorber-lined shielded enclosure required
ISO 11451-3 On-board transmitter simulation	1,8 to 18 000	DUT and wiring harness	Power (W)	Absorber-lined shielded enclosure recommended
ISO 11451-4 Bulk current injection(BCI)	1 to 400	Wiring harness	Current (mA)	Shielded enclosure recommended

4 General test conditions

4.1 General

Unless otherwise specified, the following test conditions are common to all parts of ISO 11451:

— test temperature;

— supply voltage;

— modulation;

— dwell time;

— frequency step sizes;

— definition of test severity level;

— test signal quality.

NOTE The use of the same parameters as for the component test methods given in the corresponding parts of ISO 11452 will achieve better correlation.

Unless otherwise specified, the variables used shall have the following tolerances:

— ± 10 % for durations and distances;

— ± 10 % for resistances and impedances;

— ± 1 dB for power meter;

— ± 3 dB for field probe.

4.2 Test temperature

Heat is generated in the test facility when the vehicle is operated during the performance of the test. Sufficient cooling shall be provided to ensure that the engine does not overheat.

The ambient temperature during the test shall be (23 ± 5) °C. If another value is agreed by users of ISO 11451, the value shall be recorded in the test report.

4.3 Supply voltage

For tests that require the vehicle engine to be running, the electrical charging system shall be functional.

For tests where the vehicle engine is not required to be running, unless other values are specified in the test plan, the battery voltage shall be maintained above 12 V for 12 V systems and above 24 V for 24 V systems.

4.4 Modulation

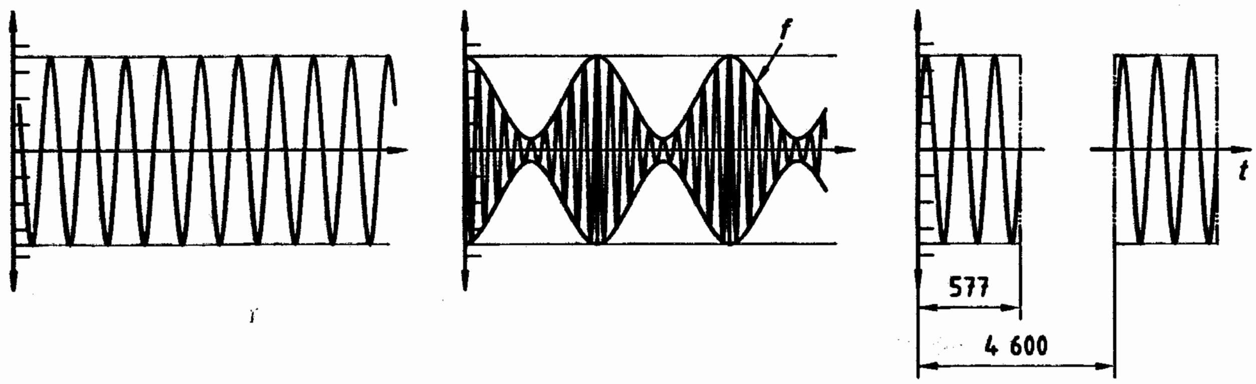
The characteristics of the DUT determine the type and frequency of modulation to be used. If no values or specific modulation techniques are agreed between the users of ISO 11451, the following shall be used.

— Unmodulated sine wave (CW). See Figure 1 a).

— Sine wave amplitude modulated (AM) by 1 kHz sine wave at 80 % (modulation index $m = 0{,}8$). See Annex B and Figure 1 b).

— Sine wave pulse modulated (PM) with t_{on} = 577 µs and period = 4 600 µs. See Figure 1 c).

In practice, PM modulation should not be obtained using either the blanking of the amplifier or a 100 % (modulation index $m = 1$) AM modulation type.



a) CW signal   b) AM signal   c) PM signal

Key

f frequency: 1 kHz

t time, µs

Figure 1 — Modulation

The following frequency ranges should be used for all applicable parts of ISO 11451:

CW: 0,01 MHz to 18 GHz

AM: 0,01 MHz to 800 MHz

PM: 800 MHz to 18 GHz.

4.5 Dwell time

At each frequency, the DUT shall be exposed to the test level for the minimum response time needed to control it. In all cases, this time of exposure shall not be less than 1 s.

4.6 Frequency step sizes

All tests in ISO 11451 shall be conducted with frequency step sizes (logarithmic or linear) not greater than those specified in Table 2. The step sizes agreed upon by the users of this standard shall be documented in the test report.

Table 2 — Maximum frequency step sizes

Frequency band MHz	Linear steps MHz	Logarithmic steps %
0,01 to 0,1	0,01	10
> 0,1 to 1	0,1	10
> 1 to 10	1	10
> 10 to 200	5	5
> 200 to 400	10	5
> 400 to 1 000	20	2
> 1 000 to 18 000	40	2

If it appears that the susceptibility thresholds of the DUT are very near to the chosen test level, these frequency step sizes should be reduced in the frequency range concerned in order to find the minimum susceptibility thresholds.

4.7 Definition of test severity levels

The user should specify the test severity level or levels over the frequency range. The concept of FPSC is detailed in Annex A. For both the substitution and closed loop levelling methods, and for tests with unmodulated and amplitude modulated signals, the test severity levels of ISO 11451 (electric field, current, voltage or power) are expressed in terms of the equivalent root-mean-square level value of the unmodulated wave.

Both these methods use a constant peak test level for tests with unmodulated and amplitude-modulated signals. The relationship between the mean power for the amplitude-modulated signal and the mean power for the unmodulated signal results from this principle (see Annex B).

$$P_{\mathrm{AM}} = \frac{\left(2+m^2\right)}{2\left(1+m\right)^2} P_{\mathrm{CW}} \qquad (1)$$

where

P_{AM} is the mean power for the amplitude-modulated signal;

P_{CW} is the mean power for the unmodulated signal;

m is the modulation index ($0 \leqslant m \leqslant 1$).

EXAMPLE A test severity level of 20 V/m means that the unmodulated and amplitude modulated tests will be conducted with a 28 V/m peak value.

4.8 Disturbance application

For disturbance application, see 6.4.

5 Instrumentation — Test signal quality

In the frequency range limited by the bandwidth of both the amplifier and the antenna (transducer) in use, the amplifier output harmonics content (up to the fifth harmonic) shall be limited to – 12 dB (– 6 dB for frequencies above 1 GHz) relative to the carrier wave unless otherwise specified for a particular test method or in the test plan. This characteristic is to be verified only during calibration testing.

6 Test procedure

6.1 Test plan

Prior to performing the tests, a test plan shall be drawn up which shall include

— vehicle test severity levels,

— vehicle/component monitoring conditions,

— frequency band(s),

— method(s) to be used,

— vehicle mode of operation,

— vehicle acceptance criteria,

— polarization,

— vehicle orientation,

— antenna location,

— test report content, and

— any special instructions and changes from the standard test.

NOTE Some of these items might not be applicable to all test methods.

6.2 Test methods

6.2.1 General

CAUTION — Hazardous voltages and fields can exist within the test area. Take care to ensure that the requirements for limiting the exposure of humans to RF energy are met.

The following two methodologies are used in certain parts of ISO 11451.

6.2.2 Substitution

The substitution method is based upon the use of forward power as the reference parameter for calibration and testing. With this method, the specific test level (electric field, current, voltage or power) shall be calibrated prior to the actual testing.

The test is conducted by subjecting the vehicle to the test signals based on the calibrated values as predetermined in the test plan.

During calibration and testing, both forward and reflected power shall be recorded.

The forward power required to provide a specific test signal relative to a calibration level can be obtained from the following formula:

$$P_{\text{for}} = P_{\text{for cal}} \left(\frac{L_{\text{tss}}}{L_{\text{cal}}} \right)^{k}$$

where

$P_{\text{for cal}}$ is the forward power by calibration;

L_{tss} is the test signal severity level;

L_{cal} is the calibration level;

k is a factor equal to 1 for power test levels and to 2 for electric field, current or voltage test levels.

6.2.3 Closed loop levelling

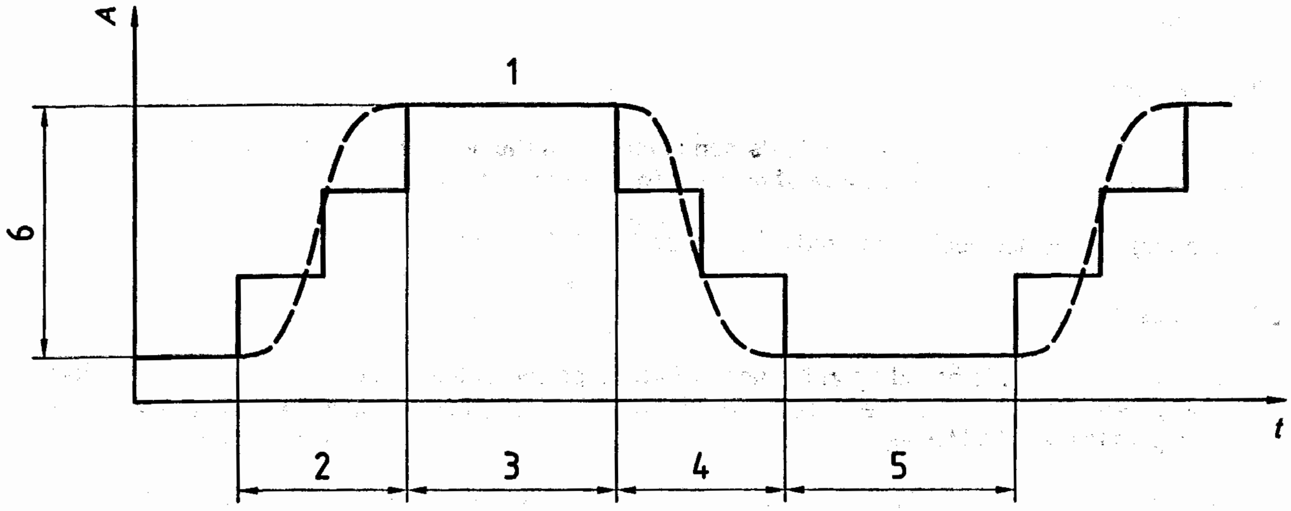
During actual testing with the vehicle, the test level (electric field, voltage, current or power) is measured using a calibrated device and fed back to the signal generator in order to either increase or decrease the test level until the predetermined level is achieved.

6.3 Calibration

Calibration shall be performed in accordance with the requirements of each individual test method. The test level versus frequency data shall be established using an unmodulated sine wave signal. The method and results for each calibration shall also be documented in the test report.

6.4 Vehicle immunity measurement

The disturbance signal may be maintained at the required test level during frequency transitions (provided the signal generation equipment is shown to be stable) or the disturbance signal level may be reduced before frequency transition using the following process (Figure 2). The method chosen and the associated parameters shall be defined in the test plan.



Key

A amplitude

t time

1 specified signal level

2 signal rise time to be defined in test plan (levelling algorithm to avoid overshooting is test-system-dependent)

3 dwell time (time of application ⩾ 1 s)

4 signal fall time to be defined in the test plan

5 recovery time ⩾ 0 s for DUT to be defined in test plan

6 reduction of test signal level for DUT recovery

Figure 2 — Example of disturbance application process

The users of this standard need to be aware of the following points to ensure that the tests are carried out satisfactorily:

— analog systems may be susceptible only at intermediate interference levels;

— sudden application of interference may cause errors;

— generator switching transients may cause faults in the DUT;

The characteristics of the interference signal may be modified depending on the test level due to limitations in the signal generation procedure (depth of amplitude modulation, rejection of harmonics, etc.)

6.5 Test report

As required by the test plan, a test report shall be submitted detailing information regarding the DUT, test site, test set-up, systems tested, test signal quality information, frequencies, power levels, system interactions and any other information relevant to the test.

Annex A
(normative)

Function performance status classification (FPSC)

A.1 General

This annex specifies a general method for the function performance status classification (FPSC) of the functions of automotive electronic devices when using the test methods and under the test conditions given throughout ISO 11451. The appropriate test signals and methods, functional status classification and test signal severity levels are specified in the individual parts of ISO 11451.

It must be emphasized that vehicles shall only be tested under those conditions, as specified in the appropriate parts of ISO 11451, which represent the simulated automotive electromagnetic environments to which the devices would be subjected were they in actual use. This will help to ensure a technically and economically optimized design for potentially susceptible components and systems.

It should also be noted that this annex is not intended to serve as a product specification and cannot function as one. It should be used in conjunction with a test procedure specified in the relevant part of ISO 11451. Therefore, no specific values for the test signal severity level are included, since they are to be determined by the vehicle manufacturer and supplier. Nevertheless, using the concepts described in this annex, and by careful application and agreement between manufacturer and supplier, the functional status requirements for a specific device can be determined. This annex can, in fact, serve as a statement of how a particular device could be expected to perform under the influence of the specified test signals.

A.2 Essential elements of FPSC

A.2.1 General

Three elements are required to determine an FPSC (see A.2.2 to A.2.4). These may be applied to all electromagnetic disturbance immunity test procedures given in ISO 11451.

A.2.2 Test signal and method

This element provides the reference to respective test signals applied to the vehicle for the chosen test method. It usually refers to a specific test procedure, i.e. to the appropriate part of ISO 11451.

A.2.3 Functional status classification

This element describes the operational status of a device during and after exposure to an electromagnetic environment.

— **Class A:** all functions of a device or system perform as designed during and after exposure to a disturbance.

— **Class B:** all functions of a device or system perform as designed during exposure; however, one or more of them may go beyond the specified tolerance. All functions return automatically to within normal limits after exposure is removed. Memory functions shall remain class A.

— **Class C:** one or more functions of a device or system do not perform as designed during exposure but return automatically to normal operation after exposure is removed.

— **Class D:** one or more functions of a device or system do not perform as designed during exposure and do not return to normal operation until exposure is removed and the device/system is reset by simple "operator/use" action.

— **Class E:** one or more functions of a device or system do not perform as designed during and after exposure and cannot be returned to proper operation without repairing or replacing the device/system.

A.2.4 Test severity level

This element contains the specification of severity level of essential test parameters. The test signal severity level is the test level (field strength, voltage, current or power) applied to the device under test for a given test method. The device under test shall perform according to its classification of functional status during and after the test. Typical severity level selection tables are included in annexes to the parts of ISO 11451. If the values listed in an annex are determined to be inappropriate, a new value shall be agreed between manufacturer and supplier, and shall be recorded in the test report.

A.3 Illustration of FPSC

Tables in an annex to each part of ISO 11451 give the suggested test levels and the frequency bands, as per Tables A.1 and A.2.

Table A.1 — Suggested test severity levels — Scheme of presentation

Test severity level	Value (e.g. V/m, mA, W)
I	.
II	..
III	...
IV	....
V	Specific value agreed between the users of this part of ISO 11451 if necessary.

Table A.2 — Frequency bands

Frequency band	Frequency range MHz
F1	⩾ . to ⩽ .
F2	> .. to ⩽ ...
F3	> ... to ⩽ ....
F4	> .... to ⩽ .....
F5	> ..... to ⩽ ......

Table A.3 is an example of test severity level according to functional status classification.

Table A.3 — Test severity level according to functional status classification

Frequency band	Test severity level				
	A	B	C	D	E
F1	I		II		
F2		II	III		IV
F3					V
F4		I			
..					
..					

Annex B
(informative)

Constant peak test level

B.1 General

This annex explains the principle of constant peak test level and its implications for power levels.

B.2 Unmodulated signal

The electric field strength of an unmodulated sine wave signal E_{CW} can be written as:

$$E_{CW} = E\cos(\omega t)$$

where

- E is the peak value of E_{CW};
- ω is the frequency of the unmodulated signal (CW) (e.g. RF carrier);
- t is time.

The mean power for the unmodulated signal, P_{CW}, is calculated using

$$P_{CW} = kE^2$$

where k is a proportionality factor which is constant for a specific test set-up.

B.3 Modulated signal

The electric field strength energy of an amplitude-modulated signal, E_{AM}, can be written in the form:

$$E_{AM} = E'\left[1 + m\cos(\theta t)\right]\cos(\omega t)$$

where

- E' is the peak amplitude of the unmodulated signal;
- $E'(1+m) = E_{AMpeak}$ is the peak value of the modulated signal;
- m is the modulation index ($0 \leqslant m \leqslant 1$);
- θ is the frequency of the modulating signal (i.e. voice, baseband, 1 kHz sine wave);
- ω is the frequency of the unmodulated signal (CW) (e.g. RF carrier).

The total mean power for the amplitude-modulated signal (P_{AM}) is the sum of the power in the carrier component, kE'^2, and the total power in the sidebands component

$$\frac{k}{2}E'^2m^2$$

The mean power for the amplitude-modulated signal P_{AM} is calculated using

$$P_{AM} = k\left(1+\frac{m^2}{2}\right)E'^2$$

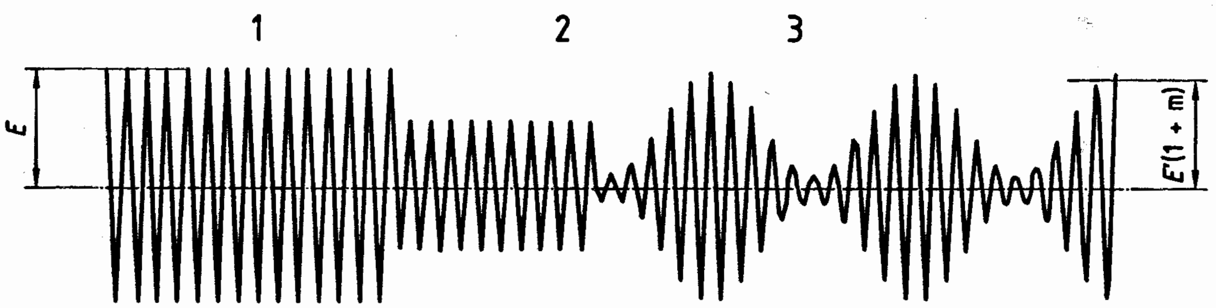
B.4 Peak conservation

B.4.1 General

For peak test level conservation, the peak amplitudes of the unmodulated and amplitude-modulated signals are defined to be identical:

$$E_{CWpeak} = E_{AMpeak}$$

See Figure B.1.



Key

1 CW signal

2 reduced CW signal before applying modulation (see B.4.3)

3 AM signal

Figure B.1 — Peak conservation

There are two ways of adjusting the signal to maintain peak conservation: by measuring the modulated power or by measuring the unmodulated power prior to modulation (see B.4.2 or B.4.3).

B.4.2 Measurement of modulated power

The relation between the mean power for the unmodulated signal, P_{CW}, and the mean power for the amplitude-modulated signal, P_{AM}, is then:

$$\frac{P_{AM}}{P_{CW}} = \frac{k\,(1+m^2/2)\,E'^2}{kE^2} = \left(1+\frac{m^2}{2}\right)\left(\frac{E'}{E}\right)^2 = \frac{1+m^2/2}{(1+m)^2}$$

Therefore:

$$P_{AM} = P_{CW} \frac{2+m^2}{2\,(1+m)^2}$$

For m = 0,8 (AM 1 kHz 80 %), this relation gives

Error! Objects cannot be created from editing field codes.

B.4.3 Measurement of unmodulated power prior to applying modulation

The relation between the mean power for the unmodulated signal, P_{CW}, and the mean power for the non-amplitude-modulated signal before applying modulation, P_{CWpm}, is then:

$$\frac{P_{CWpm}}{P_{CW}} = \left(\frac{1}{1+m}\right)^2$$

Therefore:

$$P_{CWpm} = P_{CW}\left(\frac{1}{1+m}\right)^2$$

For m = 0,8 (AM 1 kHz 80 %), this relation gives

$$P_{CWpm} = 0{,}309 P_{CW}$$

Bibliography

[1] ISO 11452 (all parts), *Road vehicles — Component test methods for electrical disturbances from narrowband radiated electromagnetic energy*

[2] IEC 60050-161, *International electrotechnical vocabulary — Chapter 161: Electromagnetic compatibility*

[3] IEC 60050-726, *International electrotechnical vocabulary — Transmission lines and waveguides*