Requirements of the generic and product immunity standards

EN	EN 61000-6-1: 2001	EN 61000-6-2: 2001	EN 301 489-1: v1.4.1	EN 55014-2: 1997 + A1	EN 55020: 2002 + A1 + A2	EN 55024: 1998 + A1 + A2	EN 50130-4: 1995 + A1 + A2	EN 61326-1: 2006	EN 61547: 1995 + A1
Related IEC	IEC 61000-6-1	IEC 61000-6-2	-	CISPR 14-2	CISPR 20	CISPR 24	-	IEC 61326-1	IEC 61547
Scope	Residential, commercial, light industry generic	Industrial generic	Radio comms equipment: common requirements	Household appliances, electric tools and similar	Broadcast receivers and associated equipment	Information technology equipment	Fire, intruder and social alarm system components	Equipment for measurement, control and laboratory use	Equipment for general lighting purposes
Test	Requirements								
Radiated RF	3V/m 80% AM 80-1000MHz to EN 61000-4-3	10V/m 80% AM 80-1000MHz to IEC 61000-4-3, except broadcast bands where level is 3V/m (2005 version adds tests up to 2.7GHz)	3V/m 80% AM 80-1000MHz to EN 61000-4-3, with exclusion band, disregarding narrowband responses	3V/m 80% AM 80-1000MHz to EN 61000-4-3, only category IV apparatus, and ride on toys with electronics in category III	125dBmV/m (1.78V/m) 80% AM 0.15-150MHz in open stripline, reductions at some frequencies for receivers and VTRs; plus 900MHz 3V/m 200Hz keyed carrier	3V/m 80% AM dBD-1000MHz to EN 61000-4-3, extra spot frequency functional test for TTE	10V/m 80% 1kHz AM 80-2000MHz to EN61000-4-3, extra 1Hz pulse modulation required; exclusion bands as in EN 301489 for radio link components	Part 1 gives general requirements: 3V/m 80% AM to EN 61000-4-3 over 80–1000MHz and 1.4–2.0GHz, 1V/m from 2 to 2.7GHz, Part 2 gives particular requirements	3V/m 80% 1kHz AM 80-1000MHz to IEC 61000-4-3, only for electronic lighting equipment
Conducted RF	3V rms 80% AM 0.15-80MHz to EN 61000-4-6 on AC power and functional earth ports, and all signal, control and DC power ports > 3m	10V rms 80% AM 0.15-80MHz to ENV 50141, except 47-68MHz where level is 3V rms: all ports except signal lines < 3m	3V rms 80% AM 0.15-80MHz to EN 61000-4-6 on AC power, and signal, telecomm, control and DC power ports > 3m, with exclusion band, disregarding narrowband responses	3V rms 80% AM 0.15-80MHz to EN 61000-4-6 on AC power ports, 1V rms on DC and signal ports > 3m, category IV extending to 230MHz for cats. II and III	RF common mode 125dBmV emf 26-30MHz, antenna terminal; induced voltages at mains and audio terminals, 0.15-150MHz 80% AM up to 130dBmV emf	3V rms 80% AM 0.15-80MHz to EN 61000-4-6 on power and all signal cable ports > 3m, extra spot frequency functional test for TTE	10V (140dBmV) rms 80% 1kHz AM 0.15-100MHz to EN61000-4-6, extra 1Hz pulse modulation required; test not required for cable ports of 3m, except AC mains supply	Part 1 gives general requirements, 3V rms 80% AM to EN 61000-4-6 over 0.15–80MHz except signal/control lines < 3m; Part 2 gives particular requirements	3V rms 80% AM 0.15-80MHz to IEC 61000-4-6 on power and all signal cable ports > 1m, only for electronic lighting equipment
LF magnetic eld	3A/m to EN 61000-4-8, susceptible devices only	30A/m to EN 61000-4-8, susceptible devices only	Not applicable	Not applicable	Not applicable	1A/m to EN 61000-4-8, susceptible devices only	Not applicable	30A/m to EN 61000-4-8, susceptible devices in industrial locations only	3A/m to EN 61000-4-8, susceptible devices only

Check the published standard for detailed application.

Modulation

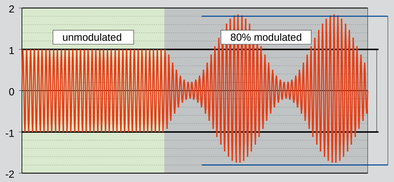
Modulating the applied RF signal increases the peak amplitude by a factor:

$$V_{mod} = (1 + M) \cdot V_{unmod}$$

where M is the *modulation index* or *modulation depth* (M = 0.8 for the usual RF immunity standards)

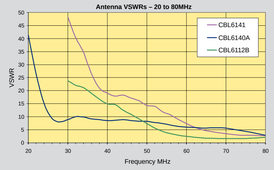
This increases the peak power requirement by 5.1dB or 3.24 times; for this reason later editions of the immunity standards require field strength or voltage level calibrations to be made at **1.8 times** the nominal unmodulated level, to confirm that the amplifier does not saturate on the modulation peak

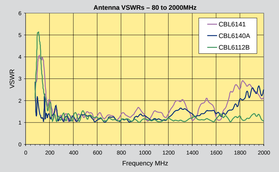
Field strength and power readings **should only be made on an *unmodulated* signal** because of the inaccurate response of the field strength or power meter when modulation is applied



80% modulation gives 1.8 times peak level of unmodulated signal

Antenna VSWR





Voltage Standing Wave Ratio (VSWR) K describes the match that an antenna or other load offers to its feed cable. A 1:1 VSWR is a perfect match, *i.e.* the load impedance is exactly 50 Ω. The higher the VSWR the worse the match, and the less power can be delivered to the antenna without being reflected. VSWR is always ≥ 1.

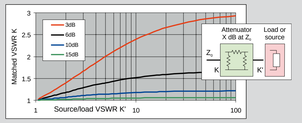
Voltage reflection coefficient (VRC) is always ≥ 1 and is the inverse ratio of the sum and difference of the line characteristic impedance Z_o and the antenna load impedance Z_L. A short circuit load produces a VRC of –1 and an open circuit produces +1; a VRC of 0 is a perfect match.

Return loss is the VRC expressed in dB.

The three parameters are related as shown:

$$VSWR\ K = \frac{1 + |}{1 - |} \qquad VRC = \frac{Z_L - Z_o}{Z_L + Z_o} = \frac{K - 1}{K + 1} \qquad R = -20\log(\ )$$

A poor VSWR can be improved by adding a matched attenuator in series, at the expense of some power loss. The higher the attenuation, the greater the improvement in VSWR. It can be shown that a 3dB pad will always provide a match better than 3:1, and a 6dB pad better than 1.67:1.



$$K = \frac{1}{\tanh\left(\text{atanh}\left(\frac{1}{K'}\right) + \frac{X}{8.686}\right)}$$

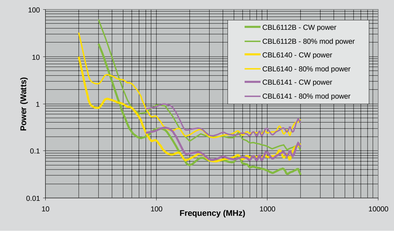
K is the wanted matched VSWR
K' is the source/load VSWR
X is the attenuation in dB

Required Power

Radiated testing: required power versus frequency, field strength and distance

These graphs show the required power versus frequency for 1V/m at 3m separation, calculated from the antenna gain as shown opposite. For higher field strengths *E*, multiply by E^2; for different distances *r*, multiply by $(r/3)^2$. The power required for 80% modulation is 5.1dB more than for an unmodulated CW signal.

$$P = \frac{(E \cdot r)^2}{30 \cdot G}$$



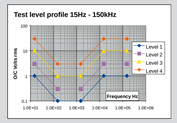
Conducted LF immunity

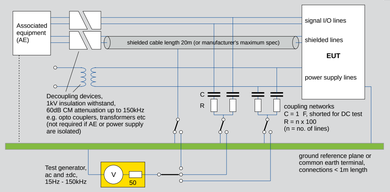
IEC 61000-4-16:2002 - Conducted common mode LF

Requirement Sinusoidal LF voltage swept at slower than 1 x 10^{-3} decades/s, or with a step size not exceeding 10% of fundamental and dwell time sufficient to allow complete verification of the EUT's performance, over the frequency range 15Hz to 150kHz. Short duration and continuous disturbances at DC and mains frequency

The signal is applied in common mode with respect to earth via coupling networks giving a 150 source impedance, to power supply, signal, control and communication cable ports of the EUT. Telecomm ports use a special T network for coupling (not shown). Any associated equipment should be decoupled via suitable decoupling devices

Levels Severity levels of 1 to 30V continuous, 10 to 300V short duration (1 second); frequency sweep follows profile as shown





Magnetic Field immunity

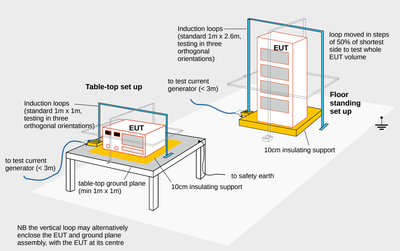
IEC61000-4-8:2001 Power frequency magnetic field

Requirement EUT immersed in a magnetic field of 50Hz or 60Hz sinusoidal (< 8% distortion) generated by an induction loop surrounding it, in three orthogonal orientations

Levels Severity levels of 1, 3, 10, 30 and 100A/m continuous, 300 and 1000A/m short duration (1 - 3 seconds)

Test volumes Single square loop, 1m side: 0.6m x 0.6m x 0.5m high
Double square loops, 1m side, 0.6m spaced: 0.6m x 0.6m x 1m high (0.8m spacing gives 1.2m height)
Single rectangular loop, 1m x 2.6m: 0.6m x 0.6m x 2m high
These figures give an acceptable variation of ±3dB within the stated volume
Loop factor (H/I, magnetic field/current injected) is calibrated at the centre of the loop

Magnetic fields		
1 Gauss = 100μTesla = 79.55 Amps/metre		
A/m	**mG**	**μT**
1	12.57	1.257
3	37.71	3.77
10	126	12.57
30	377	37.71
	G	
100	1.257	126
300	3.771	377
1000	12.57	1257



NB the vertical loop may alternatively enclose the EUT and ground plane assembly, with the EUT at its centre

TESEQ

Advanced Test Solutions for EMC

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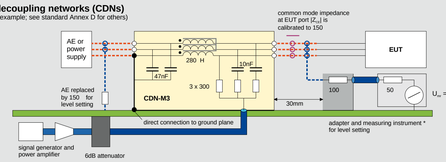
2 of a series of wallchart guides

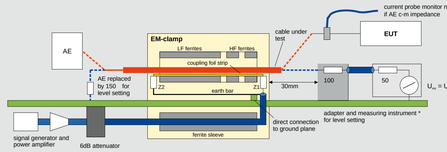
LF and RF immunity

IEC 61000-4-6 coupling devices

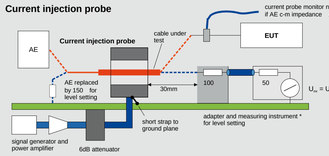
Coupling/decoupling networks (CDNs)
(M3 used as an example; see standard Annex D for others)



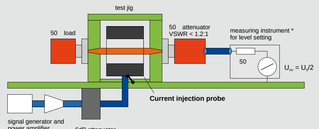
EM Clamp



Current injection probe



Alternative 50 Ω level setting for current injection probe



Level setting and choice of transducer

The applied stress level is set before the test by recording the power fed into the chosen transducer to create the required value U_c, when terminated in a 150 Ω load impedance. Since each transducer may have a frequency-sensitive attenuation, the power must be swept across the test frequency range and each transducer should have its own calibration file. This calibration file is then re-played during the test.

* The measuring instrument can be an RF power meter, voltmeter or spectrum analyser.

The CDN method is preferred but clamps can be used if CDNs are not suitable. CDNs must meet the $|Z_{cm}|$ limits of 150 ±20 (0.15–26MHz), +60/–45 (26–80MHz) and +60/–60 (80–230MHz). Clamps cannot meet this requirement, but can be used on any cable as they are non-invasive.

Typical power requirement

NB U_i is the open circuit emf test voltage; multiply power by ($U_{cm}/10$)^2 for other test voltages

	CDN	EM Clamp	Current probe
Typical insertion loss	0dB	6dB	7dB
Power (W) for 10V emf U_i			
Base level	0.5	1.99	2.51
+5.1dB for modulation	1.65	6.57	8.1
+6dB for attenuator	6.6	26.3	32.4

Conducted RF immunity

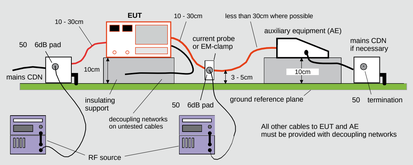
IEC 61000-4-6:2006 Edition 2 – Conducted RF test method

Requirement RF voltage swept with a step size not exceeding 1% of preceding frequency value; dwell time per step sufficient to allow the EUT to respond, minimum 0.5 sec., over the frequency range 150kHz to 80MHz or 230MHz. The range 80MHz to 230MHz overlaps with IEC 61000-4-3 and these tests may be used instead of the radiated tests, depending on the EUT dimensions.

The signal is applied via coupling/decoupling networks (CDNs) to cable ports of the EUT. When CDNs are not suitable, the alternative methods of EM-clamp or current injection probe can be used. Cables leaving the EUT in close proximity or in conduit are treated as one cable. One CDN is connected to the port to be tested and one CDN with 50 Ω termination is connected to another port, either at the EUT's earth terminal, or closest to the injection point or at the mains supply. All other ports with attached cables are isolated using decoupling networks, so that there is only one loop terminated with 150 Ω at each end.

When using clamp injection, the AE set-up must present the 150 Ω common mode impedance as closely as possible, typically by using a combination of decoupling networks and a terminated CDN. If this can't be achieved, the actual CM impedance must be less than the EUT's CM impedance and the applied stress current must be monitored and limited to U_c /150.

Levels Severity levels of 1, 3 or 10V emf unmodulated; actual applied signal is modulated to 80% with a 1kHz sinewave

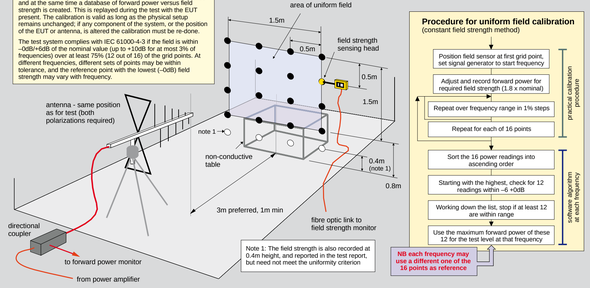


Field Uniformity

IEC 61000-4-3: 2006 Edition 3 field uniformity and level calibration

In the field calibration procedure, the ability of the test system to generate a uniform field in the absence of the EUT is demonstrated and at the same time a database of forward power versus field strength is created. This is replayed during the test with the EUT present. The calibration is valid as long as the physical setup remains unchanged; if any component of the system, or the position of the EUT or antenna, is altered the calibration must be re-done.

The test system complies with IEC 61000-4-3 if the field is within –0dB/+6dB of the nominal value (up to +10dB for at most 3% of frequencies) over at least 75% (12 out of 16) of the grid points. At different frequencies, different sets of points may be within tolerance, and the reference point with the lowest (–0dB) field strength may vary with frequency.



Note 1: The field strength is also recorded at 0.4m height, and reported in the test report, but need not meet the uniformity criterion

Procedure for uniform field calibration
(constant field strength method)

- Position field sensor at first grid point, set signal generator to start frequency
- Adjust and record forward power for required field strength (1.8 x nominal)
- Repeat over frequency range in 1% steps
- Repeat for each of 16 points
- Sort the 16 power readings into ascending order
- Starting with the highest, check for 12 readings within –6 +0dB
- Working down the list, stop if at least 12 are within range
- Use the maximum forward power of these 12 for the test level at that frequency

practical calibration procedure

software algorithm at each frequency

NB each frequency may use a different one of the 16 points as reference

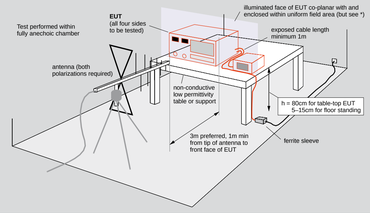
Radiated RF immunity

IEC 61000-4-3:2006 Edition 3 – Radiated RF test method

Requirement Radiated RF field generated by an antenna in a shielded anechoic enclosure over a pre-calibrated uniform field area, swept from 80MHz to 1000MHz with a step size not exceeding 1% of preceding frequency value; dwell time per step sufficient to allow the EUT to respond, minimum 0.5 sec. The antenna faces each of the four sides of the EUT in each polarization (and top and bottom if EUT can be used in any orientation), hence 8 or 12 tests in all. Tests are also included from 800–960MHz and 1.4–6GHz (though not necessarily the whole of this frequency range) for protection against digital mobile phones.

* Partial illumination, in which multiple sweeps are performed with the antenna or EUT in different relative positions, is acceptable for EUTs larger than the uniform field area; both this and use of independent smaller (0.5m x 0.5m) windows is acceptable for frequencies above 1GHz. Other test facilities, in particular TEM/GTEM cells and reverberation chambers, are not now covered by this standard; see IEC 61000-4-20 and -21.

Levels Severity levels of 1, 3, 10 or 30V/m unmodulated, pre-calibrated field level; actual applied signal is modulated to 80% with a 1kHz sinewave and the forward power, not the applied field strength, is controlled during the test



The near field transition

The near field/far field transition

There are two definitions for the transition between near and far field:

The Rayleigh criterion: determined by the maximum dimension D of the radiating structure (antenna or EUT), allowing the approximation of a point source in the far field

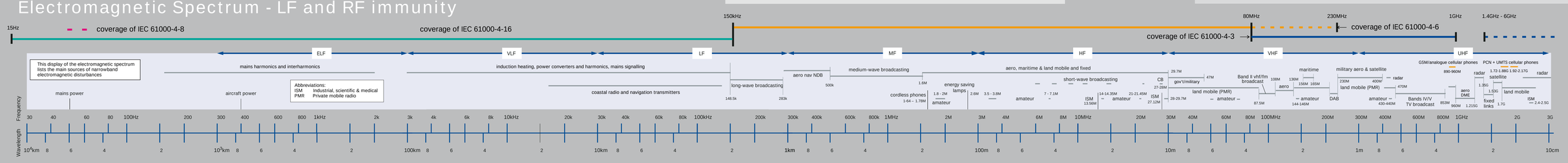
$$r = \frac{2D^2}{\lambda}$$

The Maxwell criterion: determined by the transition from the induction region to the plane wave region, giving differences in electromagnetic wave properties

$$r = \frac{\lambda}{2}$$

Near – far field transition distance

Electromagnetic Spectrum - LF and RF immunity



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