How will the third edition of IEC 61000-4-3 affect your test facility?

Changes in the standard could mean that your amplifier is no longer powerful enough

Introduction

The third edition of IEC 61000-4-3 was published in 2006. This third edition cancels and replaces the first edition published in 2002 and its amendment 1 (2002).

Key areas changed in the Third Edition:

- The test frequency range is extended up to 6 GHz.
- The calibration of the uniform field is better defined.
- Verification of the power amplifier linearity and harmonics of the immunity chain is required.

The key changes in this standard are mainly to the field uniformity and system verification section. The changes were made to clarify and better define the measurement of field uniformity. One side effect of these changes will be that some existing systems may now fail to meet the requirements, due to the fact that the amplifier in use is being run near to saturation and consequently the modulated field is distorted. The new version of the standard requires the user to check both the linearity and harmonic performance of the test system.

Amplifier linearity

Over most of the operating range of an amplifier it is expected that there is a linear relationship between the input power and the output power. However as the power level rises, limitations in the supply voltage and/or current cause the output power to increase at a slower rate than the input. This is the start of the amplifier going into saturation. The relationship between input power and output power starts to roll off and eventually reaches a point where increases in the input power cause no change in the output power. This is the saturation point and is the maximum power that can be supplied by the amplifier at a given frequency (See figure 1). Note that this saturated power level will vary with frequency.

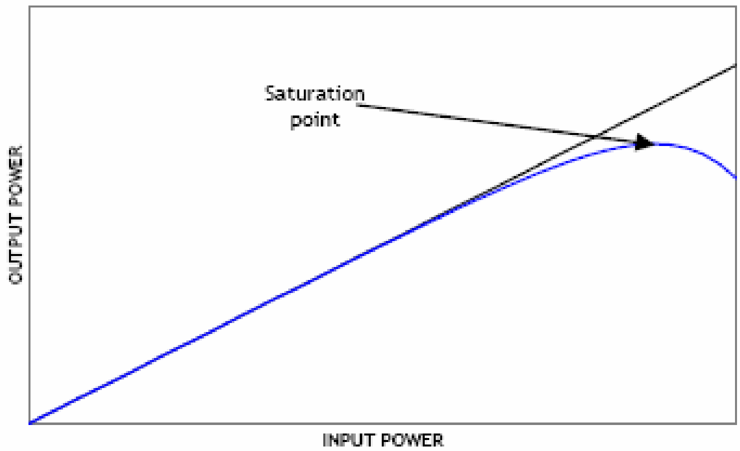

Figure 1 - Amplifier gain curve

Most amplifier suppliers use this saturated power figure to define the performance of the amplifier, however in the case of IEC61000-4-3 testing this figure is of no real interest. Since the test requires that the RF test field is sine wave amplitude modulated, the input level is effectively increasing and decreasing around the nominal test level. If the amplifier is, at any point, operating above the linear portion, the output modulated signal will be distorted (See figure 2). For a true reproduction of the modulation envelope the amplifier must be operating in its linear region (See figure 3).

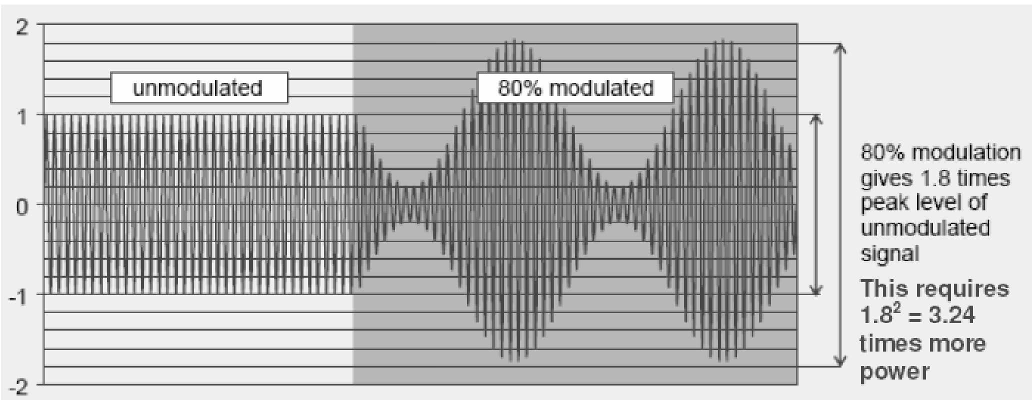

Diagram showing the relationship between the un-modulated test level and the modulated signal as described in IEC 61000-4-3

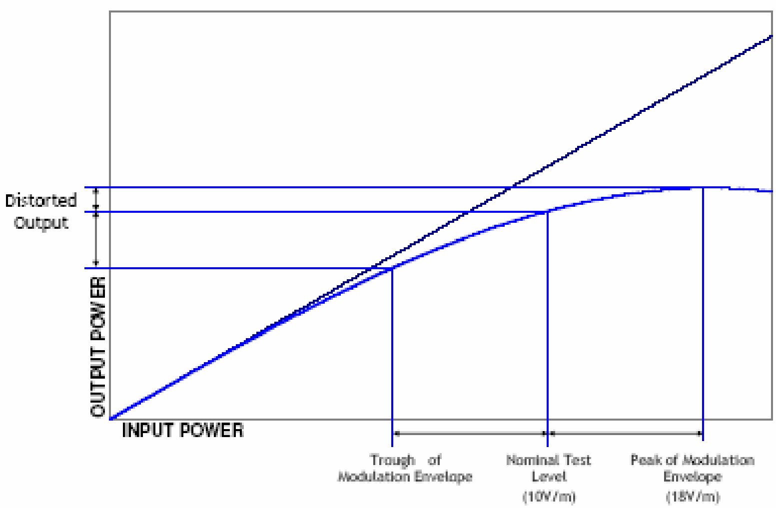

Figure 2 - Amplifier operated beyond linear range

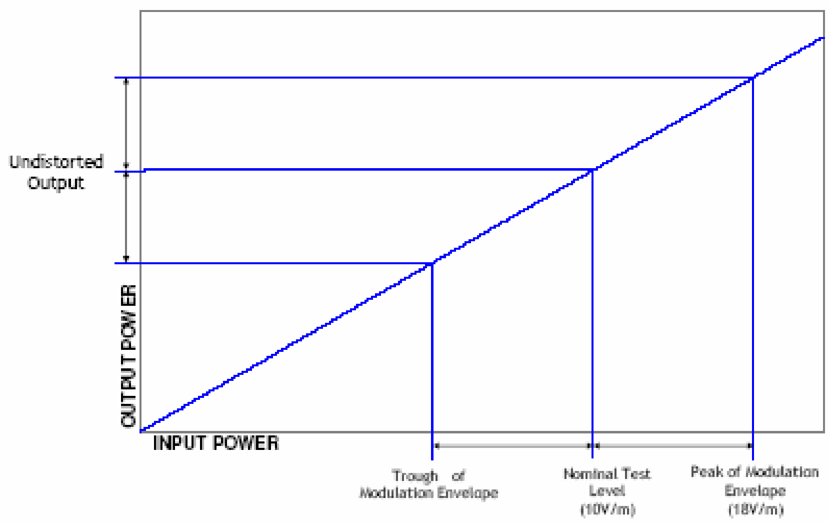

Figure 3 - Amplifier operated in linear range

Calibration

The IEC 61000-4-3 third edition now requires that the extra power required for modulation be taken into consideration. Previously, calibration was performed at the nominal test level and modulation was added later and so the user may not have been aware that saturation was occurring. The latest standard requires the user to show that the amplifier will be operating linearly, at the nominal test level including the peak of the modulation envelope, which is 1.8 times the nominal test level.

The IEC 61000-4-3 third edition does not insist that the output modulation waveform is completely undistorted but requires that the amplifier be not more than 2dB into compression at the peak of the modulation envelope. To show that this is the case, the user must first calibrate the chamber using the actual equipment that will be used for testing and at a level 1.8 times the specified test level (i.e. for 10V/m test the calibration is run at 18V/m). This calibration produces a list of powers required at each frequency to achieve at least 18V/m at one location in the uniform field with another 11 being in the range 0 to 6dB above this level (based on 16 point field uniformity, 75% of points must fall inside the 0 to 6dB range)

Subsequently, at each frequency the calibration power level is generated by the amplifier and then the signal generator level is reduced by 5.1dB. The power produced from the amplifier must fall by at least 3.1dB in order for the amplifier to be considered linear (meeting the 2dB linearity criteria) (See figure 4).

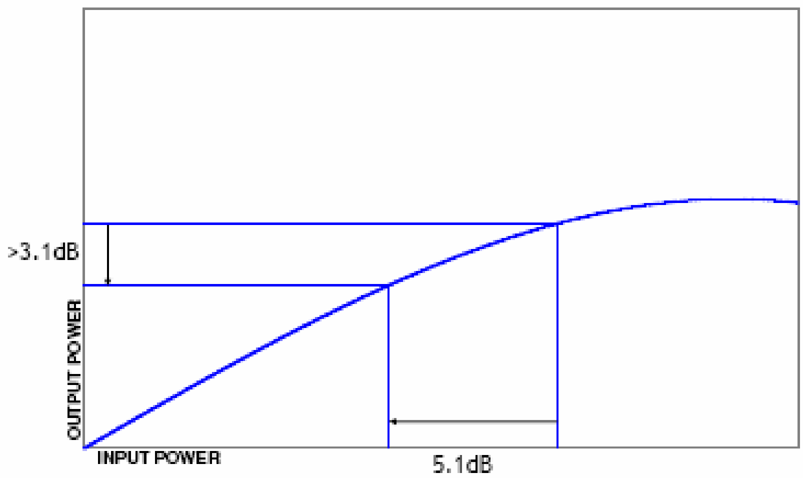

Figure 4 -2dB Linearity Criteria

If this cannot be achieved, improvement to the system is required. As previously stated, if linearity cannot be achieved it is necessary to operate the amplifier further down its gain curve. This may be achieved in a number of ways:

- By reducing the losses between the amplifier and antenna by the use of shorter or lower loss cables
- By using a higher gain antenna
- By improving the performance of the test chamber
- By using a higher power amplifier

Test distance

The original issue of IEC 61000-4-3 defined the test distance as 3m from the uniform plane to the tip of a log periodic antenna or to the balun of a biconical antennal. This did not allow for the concept of the combination antenna such as the Bilog. Many users opted to set the distance to the phase center of a Bilog (approximately half way along the Log Periodic section). This meant that the balun and hence the part of the antenna responsible for transmitting the lower frequencies, was approximately 3.5 meters from the uniform plane.

The third edition of IEC 61000-4-3 now defines the test distance for Combination (Bilog) type antennae as 3 meters to the tip of the antenna (see figure 5). This could increase the distance to the lower frequency radiating points of the antenna by up to 0.5 meters which could add 1.16dB to the power required at the lower frequencies, or 30% more power.

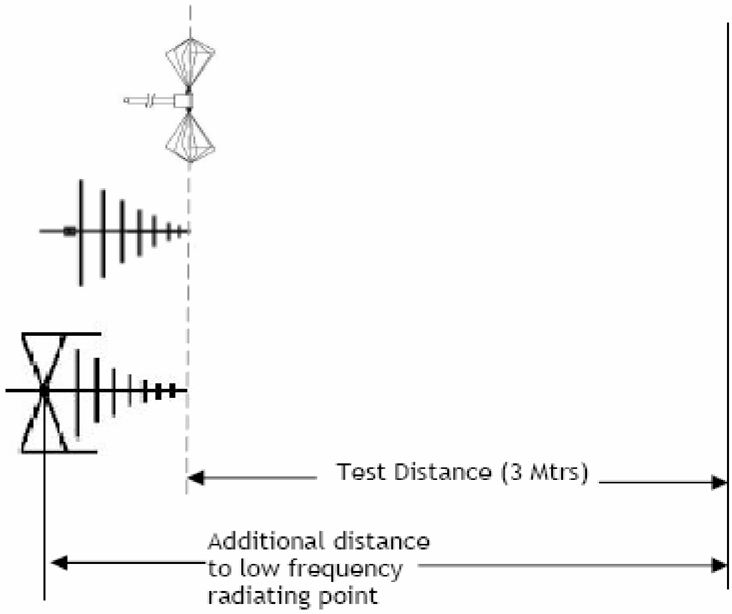

Figure 5 - Definition of antenna to EUT distance

Harmonics

All amplifiers will produce harmonics of the input signal. The level of these harmonics is dependent on the design and quality of the amplifier and will get worse as the amplifier approaches saturation. The use of broadband, combination antennae leads to a potential problem. Since the gain of these antenna typically increases rapidly between 80MHz and 200MHz, harmonics produced by the amplifier in this frequency range have a disproportionate effect in the field. (See Annex 1 for further information on the adverse effects of harmonics).

Rather than define the harmonics from the amplifier, the third edition of IEC 61000-4-3 requires the user to show that the harmonics 'in the field' are at least 6dB down on the fundamental. As most test laboratories do not have frequency selective field measuring equipment, the standard allows the user to measure the harmonics from the amplifier at each frequency and then calculate the level in the field based on the performance of the antenna. The harmonics from the amplifier must be measured at the level required to create 1.8 times the target test level as established during the field uniformity calibration. Consequently it is important here again to ensure that the amplifier is not operating near the saturation level.

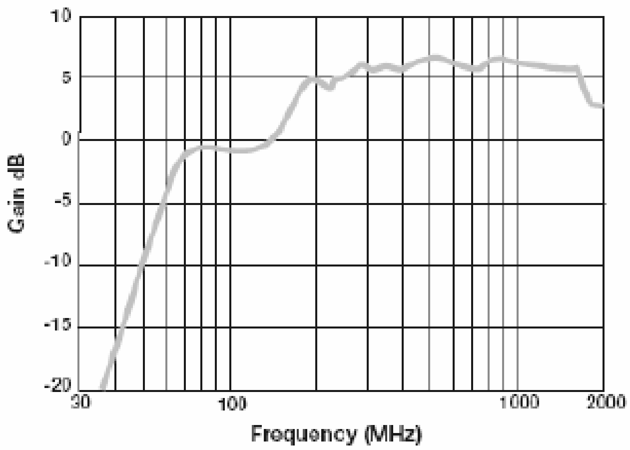

Figure 6 - Antenna gain vs. frequency

Figure 6 shows the gain versus frequency curve of a typical combination type antenna. Comparing the gain at 100MHz, 200MHz and 400MHz, it can be seen that it increases by around 6db between 100MHz and 200MHz and by around 7db between 100MHz and 400MHz. Harmonics would need to be at least 12db and 13dB respectively below the carrier frequency (100MHz) to achieve a 6dB margin in the field. Most amplifier manufacturers specify harmonics of at least 20dB down on the fundamental but only in the linear region of the amplifier. Harmonics will increase once the amplifier starts to go into saturation. (See Annex 2 for more information on the measurement of harmonics in the field).

Conclusion

The third edition of IEC61000-4-3 better defines the test conditions and clarifies some previous anomalies. The test distance for combination antennae is now better defined and the quality of the test field in terms of modulation shape and harmonic content is now specified. The purpose is to create more consistency and repeatability in testing but may result in some test facilities failing to meet the new requirements. Some improvements can be achieved by better antennae or cables but in some cases there will be no alternative but to increase the power available for the amplifier.

Software

As with all aspects of RF EMC immunity testing, the amount of data required to confirm the field uniformity, amplifier linearity and harmonic performance, makes the use of automated test software essential. Teseq has just released version 4.00 of its Compliance 3 RF Immunity test software which now includes all the necessary tools to allow a test laboratory to perform the field uniformity calibration at 1.8 times the nominal test level and then to determine and record the linearity and harmonics at the test level.

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Annex 1

Why are harmonics in the field a problem?
This is explained in detail in Annex D of the standard and falls into three main areas

1 Inaccuracy of measurement of the test level

Virtually all field measuring devices in common use in EMC test laboratories are broadband measuring devices, i.e. they have no frequency selectivity and therefore measure the total field present at all frequencies. If there is a significant harmonic content in the field, the measurement of the fundamental field strength will be incorrect. As there is no way of predicting if the various signals present will be added or subtracted (due to phase differences) there is no way to make any corrections for this error. It is therefore vital that the harmonic content of the field is kept to a minimum.

2 False failures in the EUT

It is possible that, when testing at a particular fundamental frequency, an EUT could have a susceptibility not at the fundamental but at the harmonic frequency. This would generate false failures at the fundamental frequency which could result in wasted time trying to design out the problem from the EUT.

3 When testing intentional receiver devices

Commonly when receiver devices are tested the test software is configured to skip the intended operating frequencies of the receiver. If however there are significant harmonics in the test field, high levels of the receiver's operating frequency will be generated during the testing of the lower frequency range which could adversely affect the EUT.

Annex 2

Implications of the requirement to measure the harmonic content in the field

1 Test equipment

The vast majority of EMC test labs use only broadband measuring equipment for immunity testing (Isotropic field probes and power meters). In order to measure the harmonics, access to a frequency selective device such as a spectrum analyzer or measuring receiver will be required. The standard is not clear on how many harmonics should be measured but from a practical standpoint it is clear that the lower order harmonics will dominate and that broadband amplifiers do not generate significant harmonics beyond their defined operating frequency range. Therefore it would be required that the laboratory have access to a device capable of measuring to at least the highest achievable test frequency. This device would only be required occasionally in order to verify the harmonics and would not be needed in order to run tests on a daily basis.

2 Antenna calibration

In the past it was not necessary to have the antenna used for immunity testing calibrated. So long as the antenna was efficient at the required frequency there was no need to know its actual performance as the system is calibrated as a whole as part of the test.

Since frequency selective field measuring devices are not commonly available and are prohibitively expensive, the standard defines a method of determining the harmonic field strength by measuring the harmonic power from the amplifier and calculating the field strength based on the performance of the antenna at that frequency. Therefore there is now a requirement to know the performance of the antenna, this can either be the gain or antenna factor (gain can be calculated from the antenna factor by the formula [Gain{dB} = 20 x Log(Frequency {MHz})– 30 - Antenna Factor {db/m}]

3 Software

The process of measuring and calculating the field strength of the harmonics can be enhanced with the use of appropriate test software such as the Teseq Compliance 3 immunity test software which can automate the process and produce both a simple go/no go indication and a table of the harmonic field strengths at each frequency.

Biography

John Dearing is product manager for the Teseq range of RF broadband power amplifiers and Compliance 3 test software. Educated to degree level in Electronic and Electrical Engineering he went on to further study RF and microwave electronics while working on the deign and development of a range of rugged TWTs for the defense industry.
John Later specialized in RF EMC test systems and has more than ten years experience in the supply and design of RF EMC test facilities.

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