

Electromagnetic field probes, E-field calibration and the calibration of E-field probes

The generation of a reliable electromagnetic field is a complex matter. While most EMC laboratories are struggling with the performance of their anechoic chamber, the use of their E-field probe, including the calibration of the E-Field probe is most often underexposed. This white paper is meant to clear up a number of the most common issues and misunderstandings in this area.

What is anisotropy and how does it influence EMC measurements?

Anisotropy is the error that the probe has, when it is rotated in a three dimensional field. This sounds clear but in the real world it is found that this is not the case at all. First of all 100% isotropic probes do not exist. There are two basic types of field probes.

- 1) Cube probes that are connected to the monitoring unit via Fibre optic cable. They are mostly used in stationary mode.
- 2) Stalk probes that have fixed connection to the monitoring unit, in many cases through a 30 cm long stalk or cable. These probes are often used as handhelds for mobile applications.

Cube probes have better characteristics concerning the isotropy than the stalk probes, but also cube probes are not fully isotropic. In practice probes for higher frequencies, e.g. above 8 GHz, are stalk probes. Stalk probes have an anisotropy (error in the isotropy) that can be as high as 20 dB! Question that rises: How can it be that much better isotropy figures are presented? This is because during calibration some laboratories either keep the box out of the field, or rotate the probe in a very specific way so that in fact only the two dimensional isotropy is measured. As a matter of fact in this case the rotational symmetry is measured instead of the anisotropy.

How to compare results from a RadiSense with other probes?

This is a very complicated task, as in fact the RadiSense is a cube probe while often stalk probes are used as a reference. It is therefore very important to take into account the exact method that was used, and the exact orientation (relative to the direction of the field and direction of propagation) in which the probe was placed during calibration and the differences in design and operation.

If an EMC test laboratory tries to compare these values, it has to take into account all aspects of the calibration. So this means that the obtained correction values are put into the software, the probes should be placed exactly in the same orientation and the anisotropy of the probes as well as the total measurement uncertainty should be taken into account. It has happened that customers have seen huge differences in result, which were all due to not taking into account one or more of the previous factors in the correct way.

In the end it turned out the RadiSense was giving correct readings and the stalk probe was not used in the correct orientation.

What happens beyond the specified band of an E-field probe?

Every E-field probe has a maximum frequency. The maximum frequency of an E-field probe is defined as the frequency where one or more of the parameters are no longer acceptable for proper measurements. Most often the main parameter is the frequency response of the probe. Beyond this maximum frequency there are three possibilities for the frequency response of the probe:

- 1) the probe curve falls off;
- 2) the probe curve goes on straight;
- 3) the probe curve goes up.

To start with number two: if this would be the case, the probe would be specified to a higher frequency! So for this discussion we can leave out this point. This means that a probe curve above the specified frequency will either go up or down. In **both cases** the measurements are wrong for harmonics of the fundamental frequency, as soon as these fall outside the frequency range of the probe. In case the frequency response falls off, signals above the specified frequency are not taken into account while they are present. In case it goes up, signals above the specified frequency are taken into account heavier than they are in reality.

As a matter of fact it all comes down to basic EMC measurement technology. If the probe is specified to a certain frequency, either the amplifier or the antenna should be limited to the same or lower frequency. If this is not the case, a low pass filter should be applied. In many cases the real problem is the harmonics that are generated by the amplifier.

Certainly TWT (Travelling Wave Tube) amplifiers have low harmonics suppression (generally around -5 dBc). In fact these types of amplifiers are not suitable for EMC tests without low pass filters, however it is still common practice in EMC laboratories to use them without filters.

Should the linearity of an E-field probe be measured at all frequencies?

Most of the time three items of an E-field probe are calibrated: the frequency response, the linearity and the isotropy. The isotropy is explained at point one. The frequency response is the frequency dependent deviation (error) over the complete operating range of the E-field probe. For example at 100 MHz the field is 10 V/m and the reading of the probe is 11 V/m, while at 500 MHz the reading of the probe is 8 V/m. For every frequency the probe will have a (small) deviation to the real value. This is called the frequency response of the E-field probe. During calibration of an E-field probe these frequency dependent deviations are registered and stored in a so called correction factor table. The frequency response calibration of an isotropic E-field probe should be performed in all three probe orientations. The correction factor table for every probe orientation should be entered in the measurement software to ensure valid readings with no larger deviations than the measurement uncertainty (as specified in de calibration report). D.A.R.E!! Calibrations performs the calibration under accreditation and provides the correction table to the customer.

The linearity of an E-field probe is the response of the probe at different field levels. As the reading of an E-field probe is based on a diode curve, the linearity is intrinsically the same on all frequencies. Therefore the linearity of an E-field probe is calibrated at several field levels but only at one single frequency only. It is recommended to calibrate the E-field probe as close as possible to the field strength where it is actually used.

Should an E-field probe be calibrated at every field level it is used?

Another question is the level at which an E-field probe should be calibrated. As already explained in the previous answer, the linearity of an E-field probe is frequency independent. As such there is no direct need to calibrate the probe at exactly the same level as it is used in daily practice. Of course there is some benefit to calibrate it close to the used field level. However it is more important to take into account the range switches. If for example an E-field probe switches between ranges at a level of 10 V/m, it is not wise to calibrate it at exactly 10 V/m as this will lead to significant deviations. In such case it may be wise to select a range where the probe will not switch ranges, e.g. 30 V/m. However in that case it is very important to use the same range during the EMC measurements.

So there is no direct need to calibrate at multiple E-field levels. However, some standards, (like the EN61000-4-3) prescribe the probe must be calibrated at a field level of 2 times the test level of the EMC test.

It should be noted the RadiSense does not have any ranges and therefore does not suffer ranging problems.

Is it necessary to measure the characteristics of an E-Field probe in modulated fields?

During measurements in the area of technical safety at work it is often necessary to measure modulated fields (e.g. radio transmitters). The correction factor of a probe can depend strongly on the field strength and the modulation depth. In this context particular attention should be paid to pulsed fields.

What is a RVA accreditation?

Accreditation is the most efficient way to ensure reliable and traceable calibrations. Europe has several accreditation bodies, at least one per country. Well known accreditation bodies are UKAS (UK), COFRAC (FR), DKD (D) and RVA (NL). These national accreditation bodies are member of the European Accreditation (<http://www.european-accreditation.org>) the European Co-operation for Accreditation. As such all accreditation bodies recognize each other as well as the test-, calibration or certification results of the laboratories and institutes they have accredited. As D.A.R.E!! Calibration is accredited by the Dutch Council for Accreditation (RVA, www.rva.nl) calibration results from calibrations performed under accreditation by D.A.R.E!! Calibrations are accepted by all other European accreditation bodies.

Conclusion

As follows from the above questions and answers section it is very difficult to obtain proper results when generating electromagnetic fields. It is important to use an E-field probe that is suitable for the application and that is calibrated under accreditation in a way that matches its use in real life.

The following questions should be discussed with the calibration laboratory:

- For which field generating facility will the probe be used? (anechoic chamber, wave guide, Antenna, etc.)
- In which frequency range will the probe be used normally?
- How large is the dynamic range?
- Are measurements in modulated fields necessary?
- Will any additional accessories be used such as stands?
- Which date format is needed for the documentation of the calibration values?

Once the E-field probe is calibrated the calibration results should be applied during the EMC measurements.

Different models of E-Field probes can not be compared easily, in general cube probes are better than stalk probes and small probes are better than large probes.

D.A.R.E!! Development

As a product leader company D.A.R.E!! Development works hard to develop and deliver accurate field probes and open new technologies, which can be used for EMC measurements achieving reliable measurement results.

D.A.R.E!! Calibrations

D.A.R.E!! Calibrations is an accredited calibration laboratory specialized in RF calibrations and more specific in EMC calibrations.

More information on both companies can be found at www.dare.nl