narda Safety Test Solutions

Technical Note 012

Measuring RMS Field Strength

Demonstrating adherence to limit values using the NBM wideband measuring sets

Numerous national and international safety standards and directives have been published for protection from non-ionizing radiation. These define permissible limit values. Measuring the frequency-dependent reference values specified in the standards provides proof that the limits are not exceeded. These reference values are given as RMS (root mean square) values, so they represent the equivalent average value of the signal power level. The RMS value for a sine wave signal is equal to the peak value divided by √2 (figure 1). The RMS value is used because it represents the relevant influence quantity for the thermal effects of electromagnetic radiation. IEC 60050-101 also uses the terms “effective value” or “quadratic value” instead of RMS; all these terms have the same meaning.

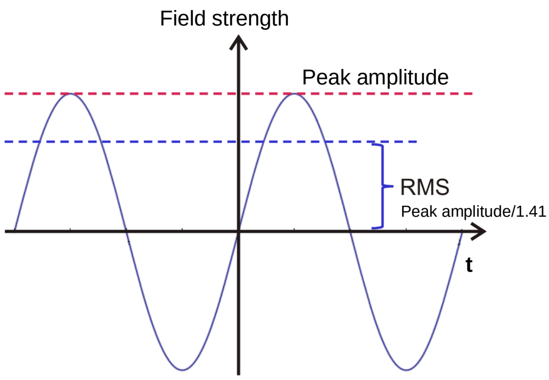

Figure 1: RMS value of a sine wave field strength signal versus time

RMS result display

Measured field strengths should always be taken as being RMS values unless otherwise stated. This is comparable to any multi-meter that displays the RMS value of an AC voltage, without specifically displaying “RMS” (figure 2). The NBM field meter, too, always registers the RMS values with its wideband probes, regardless of the result type setting (Actual, Maximum, Minimum, Average or Maximum Average). The probe and basic unit are therefore calibrated for RMS values.

Figure 2: Results are always displayed on the NRM as RMS values just like a multi-meter regardless of the result type setting

How this works in the NBM

The RMS detector in the NBM is formed by the probe, which in conjunction with the basic unit produces an overall integration time of about 300 ms. The probe itself delivers a DC voltage proportional to the square of the field strength, but which also still contains some residual ripple. This residual ripple is smoothed by integration in the basic unit; the signal is then digitized and displayed as the RMS value. This method applies both to diode-based probes and to thermocouple probes. The nonlinearities that inherently occur in diode probes at increasing amplitudes are compensated by the basic unit for each probe individually. To do this, the basic unit reads the linearity data out from the memory module integrated into the probe (figure 3). This method ensures that the highest possible accuracy is achieved for large and small signal levels alike.

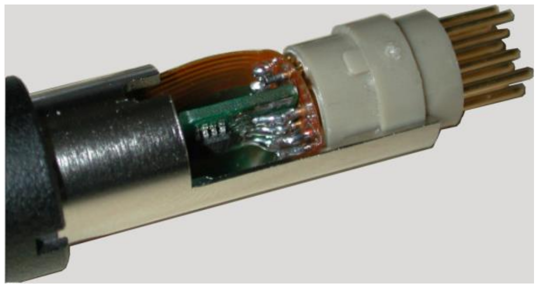

Figure 3: A small memory chip in the NBM probe stores all the major probe data

Multi tone signals

If the measured field comprises several different frequency components at high levels (multi tone signal), the true RMS value is always measured using a thermocouple probe. If a diode-based probe is used, the signal level should be within the “True RMS” range specified in the data sheet. Extremely high result accuracy is achieved even with multi tone signals within this specified range.

Averaging the RMS values

In most of the standards, demonstrating compliance with exposure limit values for frequencies above 100 kHz generally involves an average measurement over a 6 minute period. The RMS field strength values recorded during the measurement interval have to be averaged quadratically. The 6 minute interval is based on the absorption characteristics of human tissue, which shows a similar time constant. However, other averaging times are specified in some standards. The NBM allows you to set the averaging time in the range 4 seconds to 30 minutes. The NBM uses a floating average to enable standard-compliant measurements to be performed over longer time periods. This uses a continuous memory (figure 4), in which the oldest measurement result is always replaced by the latest value. The highest average value occurring during a long term measurement can be conveniently displayed on the NBM using the “Maximum Average” result type. This important function is not provided by any other wideband device.

$$RMS = \sqrt{\frac{x_1^2 + x_2^2 + \cdots + x_n^2}{n}}$$

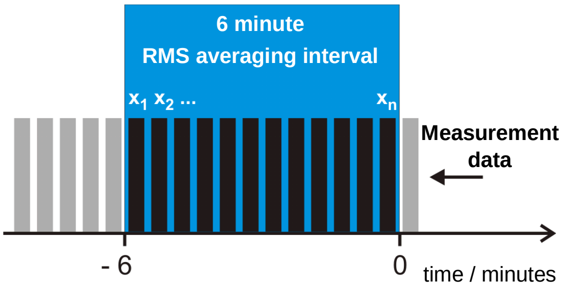

Figure 4: Formation of the floating average field strength value using a continuous result memory

Summary:

RMS detectors (as used in the NBM) are predominantly used for wideband measurement of high frequency electric or magnetic fields in order to demonstrate compliance with the exposure limit values in the standards. Quadratic averaging should also be applied to long term measurement of RMS values, preferentially in the form of a floating average value. The display of the measurement results is calibrated for RMS values.

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