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Technical Note - TN20

Calibration of pulse field sensors

Bertrand Daout, montena technology, 1728 Rossens, Switzerland

1. Introduction

The calibration of pulsed electric field sensors is harder than for CW signals. The devices used for the calibration must be very broadband and have to preserve the phase integrity. Therefore some CW calibration methods are not valid for the time domain.

This note compares the different test methods and the motivation of the selection of the most adapted ones. See also [1] and [2].

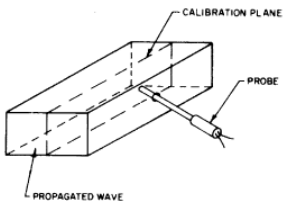
2. Calibration method comparison

2.1 Calibration with antennas

An antenna can be used to calibrate electric or magnetic field sensors. But some difficulties quickly appear: the antenna must be able to correctly radiate pulses without waveform and phase distortions and the radiated field must be precisely known in the calibration volume. Horn antennas cannot be used for the first reason. IRA or HIRA antennas (see picture) could be used but the field is not known with enough precision.

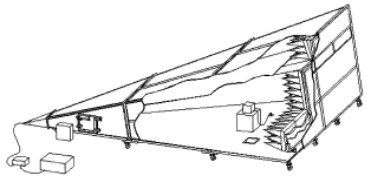
2.2 Waveguides and cavities

A resonant cavity or a microwave waveguide could be used for the calibration of CW field sensor. The field inside these devices can be determined with a good precision, for instance by calculation. But due to the narrowband properties of both elements, this method is not adapted to pulses.



2.3 GTEM cell

The GTEM has no transition except the load at the end of the internal line and the broad operation frequency range of the GTEM cell are main advantages. As counterpart the homogeneity and field precision are not high enough. Therefore the GTEM can be used for probe calibration but only with the substitution method: 1) calibration of the transfer probe in a precise device (TEM cell for instance), 2) calibration of the GTEM cell by the transfer probe and 3) calibration of the probe to test. But this method is too complicated for the pulsed field calibration.



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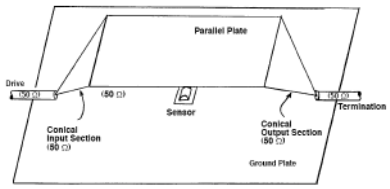
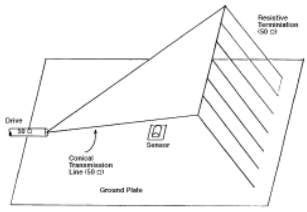
2.4 Parallel plate transmission line (stripline)

The advantage of the structure is that the field under the plate is precisely known because it is easy to calculate. Due to the transitions between the slope and the flat parts, high order parasitic modes are produced which distort the waveform of the pulse. For this reason, the frequency range of the line is limited. It is inversely proportional to the height under the plate. In addition, the environment can influence the propagation around the line. For this last reason, the TEM cell is preferred.



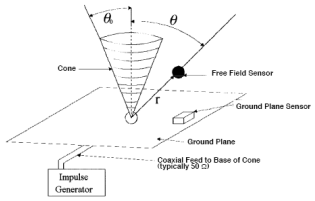
2.5 Transmission line

This type of structure is also named bounded wave or guided wave line. This method is similar to the stripline but without transition, except for the load at the end of the line and is similar to the GTEM cell but is open. The field is not homogeneous under the line and the reflection at the end of the line is not easy to avoid. Therefore this method has no real advantage.



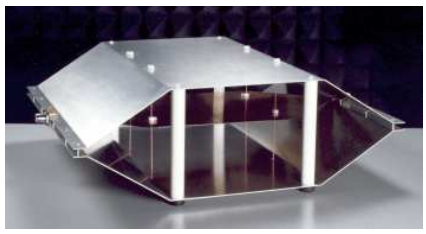
2.6 Monocone antenna

The monocone antenna produces a spherical wave around it. The minimum frequency is limited by the length of the antenna. The maximum frequency is theoretically infinite but is actually limited by the quality of the construction and of the connexion. The field is not homogeneous and the environment could interfere with the antenna.



2.7 TEM cell

The field inside the TEM cell is easy to calculate and therefore can de determined with high precision. As for the striplines and for the parallel plate line, due to the transitions between the slope and the flat parts, high order parasitic modes are produced which limit the maximum frequency of the cell. But the advantage is that the environment has no influence on the field inside the cell. The TEM cell is the most precise device for sensors calibration.



3. Conclusions

The TEM cell is the preferred calibration method with limitation of the maximum frequency and of the size of the sensor. It is also mentioned in the British standard DEF STAN 59-411 part 3 issue 1 (par. 6.22.1). The precision of this method is the best one. For sensors with large dimensions and high frequency range, the monocone antenna can be preferred but is less precise.

References:

[1]: IEC 61000-4-33 (chap. 6).
[2]: IEEE Std 1309-1996 (annex B).

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