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A new method for high-frequency field sensor calibration

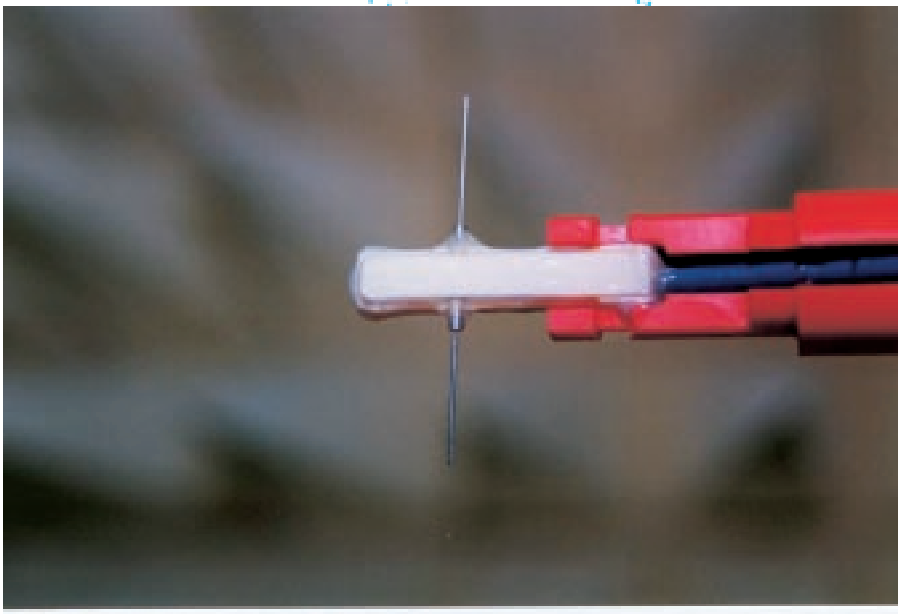

Fig. 1: Electromagnetic sensor with extended dipole arms

The Institute of Research into Electromagnetic Compatibility at the Technical University Braunschweig at present develops a basically new method for calibration of HF field sensors. This method will provide higher accuracy of measurement data regarding mobile radio frequencies.

As a waveguide the new method uses an open two-wire conductor calculating field strengths similar to established methods applied in closed transverse electromagnetic cells (TEM) (see illustration) on the basis of HF power input and waveguide geometry. The use of the open two-wire structure offers the following crucial advantages:

- It is possible to overlap at first unidentified irridiated and waveguided fields. Thus, a bridge wiring for measuring high-frequency fields is created facilitating the determination of field sensor and waveguide coupling – a source for errors until now insufficiently quantifiable.
- Closed TEM waveguides show hollow space resonances already at relatively low frequencies. The two-wire line allows the production of a pure TEM mode for sensor calibration also above 2 GHz.
- Irridiated fields can be absolutely calibrated in the frequency range up to 3,5 GHz, if necessary also across bigger planes or volumes. This is made possible through change of location of the two-wire line.

Fig. 2 illustrates the new method: The two-wire transmission line as a field source is feeded via a symmetry network L with a symmetrical outlet at the end of the conductor. The sensor is located at reference level. The double port between the coaxial inlet of the symmetry network L and the reference level is marked as L'. Dispersion parameters of this double port L' can be determined by means of a vectorial network analyser; they are required for calculating the preceding wave a1 at the ref-

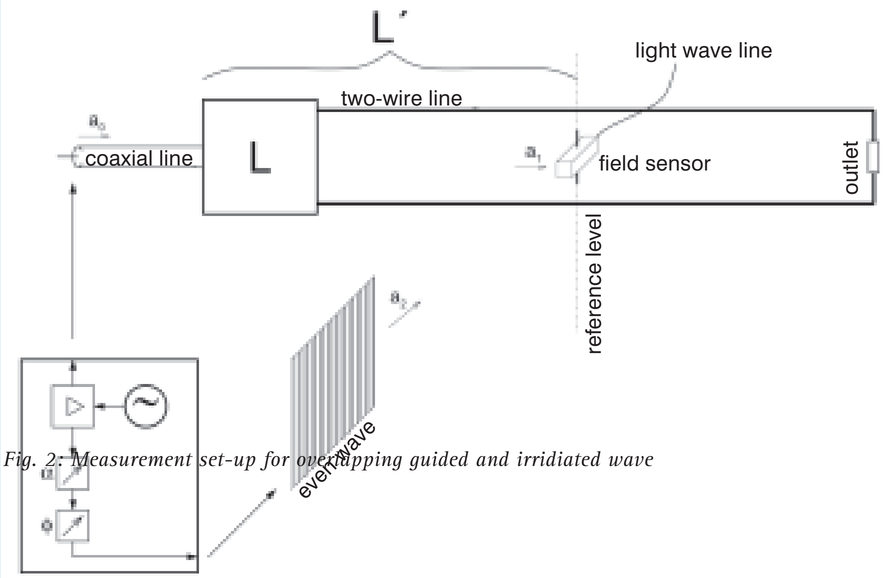

Fig. 2: Measurement set-up for overlapping guided and irridiated wave

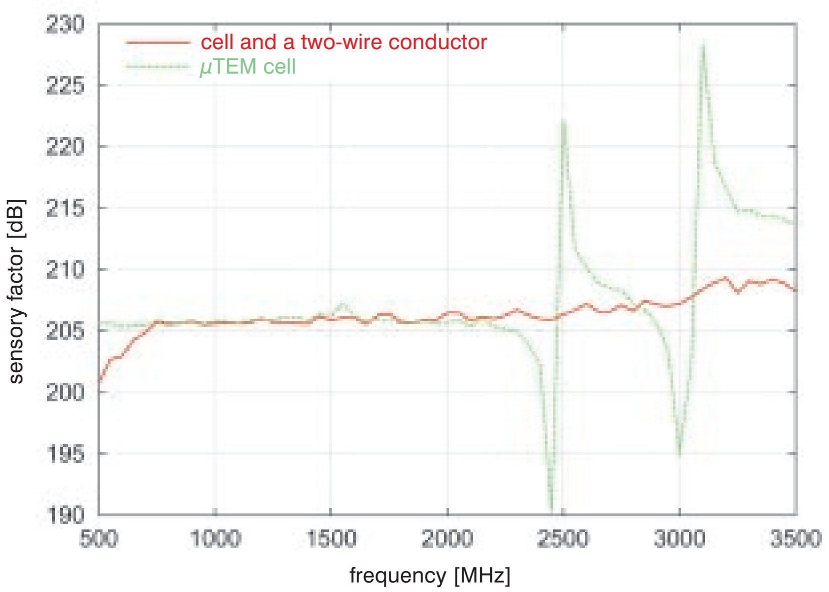

Fig. 2: Comparative measurement in a μTEM

erence level of the two-wire line from the coaxially feeded power of a wave a0. An analytically exact determination of these dispersion parameters is made possible through the use of modern calibration methods. Last, on the basis of reference level power and conductor geometry we can calculate the electric field strength.

For the detection of field sensor and waveguide coupling the irridiated even wave field a2 is applied which is produced phase-synchronically with the conducted wave. Here, the electric field vector is perpendicularly polarised towards the conductor and parallel to the sensor. Amplitude and phase position of the radiated field are adjusted to extinguish guided and irradiated wave at the site of the sensor. At switching off the input from the two-wire conductor and maintaining the irridiated field the field sensor at first detects the same power level as previously was the case with the conducted wave, but without the irridiated field. At this point, the two-wire conductor is completely removed, whereas the irridiated field remains unaltered. An alteration of the detector power level at the field sensor's outlet now is an immediate measurement quantity for the coupling between field sensor and field source. Thus, this method for the first time enables us to connect irridiated field quantity measurement technically with conducted field quantities. Simultaneously, the radiated field is calibrated by the depicted method.

At the Institue for the Research into Electromagnetic Compatibility an electrovisual sensorial system is used that can carry out measurements of size and phase at high sensitivity. Fig. 2 shows a single sensor head; here, the only 8 mm long dipole arms were extended for increasing sensitivity. The sensor is covered with a gel substance, thus also being appliable during measurements via physiological chloride solutions.

The shown sensor was measured without dipole arm extensions once in a so-called µTEM cell as is used as a primary field strength standard by the Federal Office for Physics and Technology (Phyikalisch-Technische Bundesanstalt) as well as in a two-wire line. At both sites, the sensory factor was the logarithmic relation of theoretical field strength and measured detector power level:

For both field sources the theoretical field strength was calculated on the basis of the input power and the waveguide geometry.

Fig. 3 shows the comparison of both measurements in the frequency range of 0.5 to 3.5 GHz. In the range of 750 MHz to 2200 MHz both curves show a distinctive correspondence. The deviation below 750 MHz results from bandwidth characteristics of the used symmetry network L. At 1550 MHz the µTEM cell shows the first clear resonance; further resonances are clearly recognisable at 2.5 GHz and 3 GHz. In contrast, the measurement in the two-wire line shows an even frequency course of the electrovisual sensor only slightly increasing above 3 GHz, as the frequency approaches to the 3dB-bandwidth of the sensorial system.

The conducted measurements confirm the appliability of this method. Future research will concentrate on improvements of magnetic field probe calibration and on the analysis of a possible refinement of system exactness.

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Fig. 4: Inserted TEM cell (450 MHz) in biological in vitro experiments (TU Braunschweig)

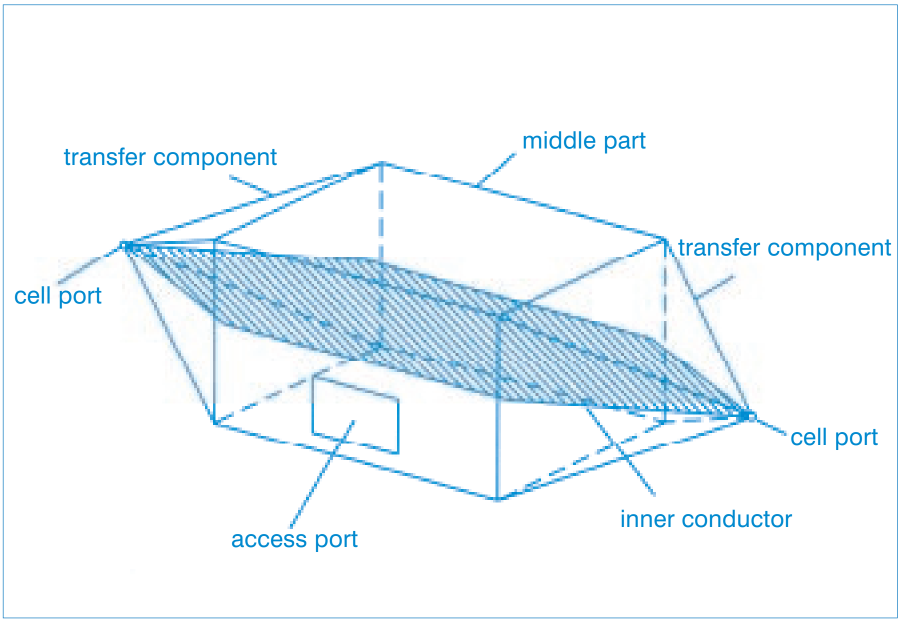

Fig. 5: Sketch of a TEM cell