CHARACTERISTICS OF THE EUROTEM FAMILY

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Abstract: The new four stripline TEM cell is a patented, compact, symmetrical TEM device with a fully absorber lined enclosure. Due to the broadband nature, this device family can be used for radiated immunity and emission measurements. The family is scaleable in size and can take test objects (DUT) as big as 2 m high industrial cabinets. The four stripline antenna arrangement of the new TEM cell can also be fitted into fully absorber lined chambers (e.g. 7 m x 4 m x 3m), replacing the antennas, the mast and the need for high power amplifiers. In contrast to the 10 years old GTEM technology, polarization can be switched from horizontal to vertical. The DUT is positioned on a turn table as on OATS and in semi-anechoic chambers. There is no need for rotating the DUT through an upside down position like in the GTEM. The four stripline TEM device offers very high field quality and major space and cost savings for a given DUT size over other TEM devices and absorber chambers.

INTRODUCTION

The European EMC directive prompted an exponential increase in all different kinds of test cells and boxes, of which manufacturers claim precompliance or full compliance characteristics with the standards. In most of these cases a detailed description of the real field quality is not presented. The argument "precompliance only requires a repeatable but relative measurement quantity and some correlation to full compliance facilities" is highly doubtful, because of a high risk of over or under testing.

Some relevant IEC and CISPR standards are more and more recognized to be inconsistent and need to be adapted to the rapid change in modern electronics and communications technology [1].

The prime interest for EMC test facilities of radiated nature today lies in the frequency range 26 MHz to 2 GHz. This was the design target of the new TEM cell. Additionally investment and operating cost should be minimized. Consequently there is the need for minimal driving power from the amplifiers, good impedance match and broadband characteristics to avoid rearranging of antenna setups during the sweep and between emission and immunity tests.

In previous publications we presented the data from a small variant of the new four stripline TEM cell (EUROTEM 2) [2]. This is now extended by expanding the size to the large four stripline antenna, fitted into our fully absorber lined chamber [3].

THE NEW TEM FAMILY

The principle of polarization switching, including the four electrodes in the traverse cross section of the cell and the associated E field pattern is shown in Fig. 1.

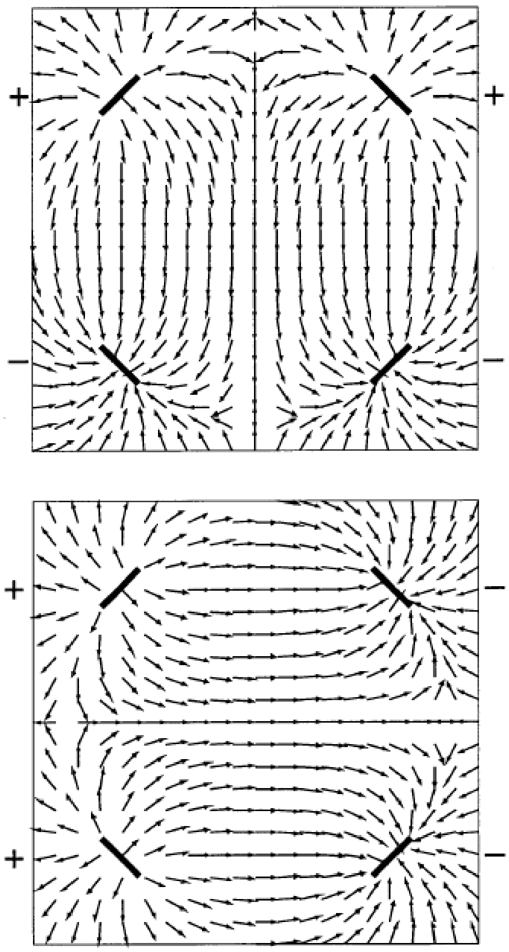

Fig. 1: Vertical and Horizontal Polarization Mode in the Four Stripline TEM Arrangement

The longitudinal cross section of the Four Stripline TEM arrangement is shown in Fig. 2. The arrangement in b) can also be removed from the end wall of the fully anechoic chamber and represents a stand alone antenna system.

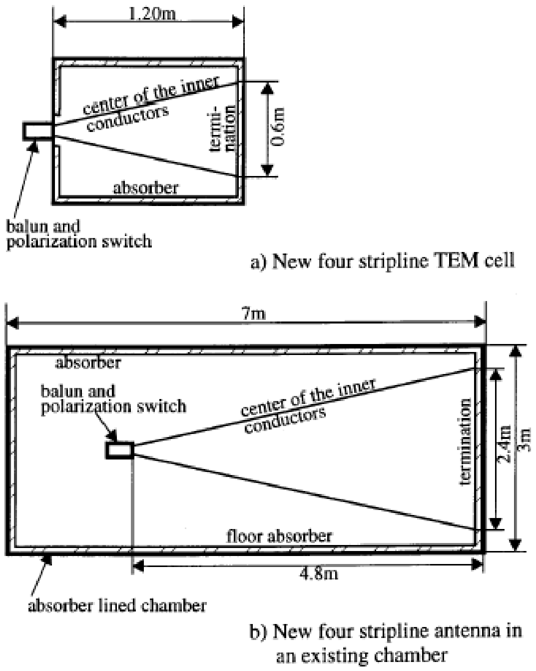

Fig. 2: Longitudinal Cross Section of the Small Four Stripline TEM Cell (a) and the New Four Stripline Antenna (b)

A real design example of a cell is shown in Fig. 3 and the antenna is shown in Fig. 4. The new four stripline antenna is retrofitted into our 3m test distance absorber lined chamber. The large DUT in this chamber is positioned on a ferrite coated R&S low heigth turn table.

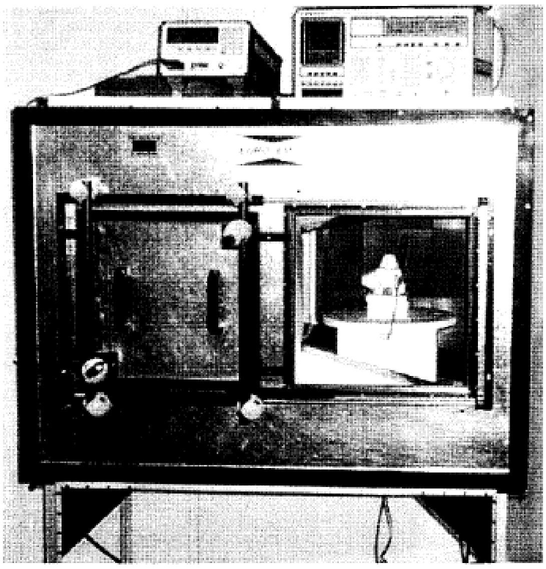

Fig. 3: Small Four Stripline TEM Cell for Radiated Immunity and Emission Tests

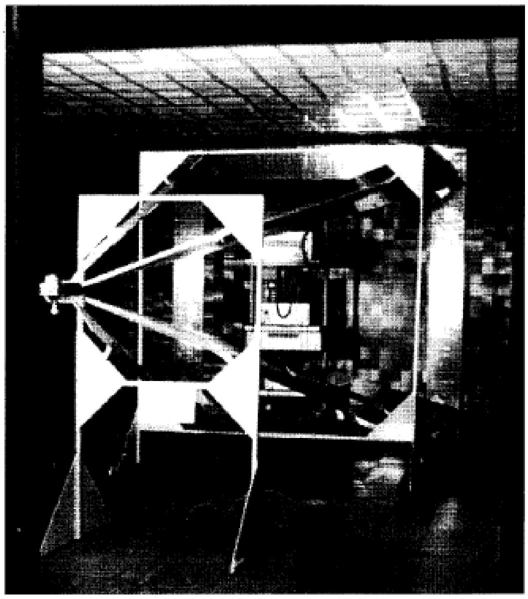

Fig 4: Early Prototype of the Four Stripline Antenna, Fitted into our 7m x 4m x 3m Fully Ferrite Lined Chamber

CHARACTERISTICS OF THE NEW TEM FAMILY MEMBERS

Impedance Match and Input Power for 10 V/m

In the following the technical relevant data for two family members, namely the smallest and the largest, is presented. Starting with the return loss (impedance matching) in 50 Ohms of the feeding balun data is shown up to 1 GHz, demonstrating excellent matching of almost 20 dB (fig. 5), about 1% return power and VSWR 1.3.

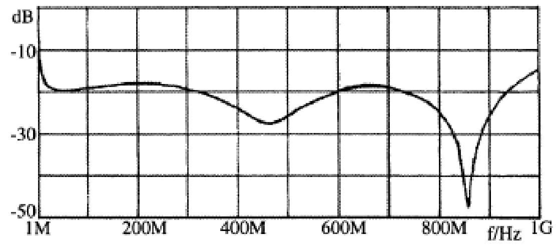

Fig. 5: Return Loss of Balun Used for the new TEM cell

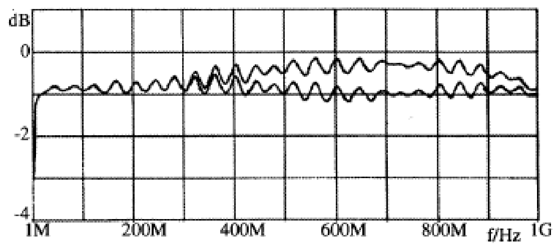

Fig. 6: Insertion Losses of the Balun for the Positive and Negative Output

The quality of symmetry and insertion losses can be depicted from fig. 6. These are exceptionally low values for a power balun.

The time domain reflectometry technology used, reveals the overall impedance matching situation of the small cell (fig. 7) and the four stripline antenna (fig. 8). Both figures prove low reflections, however, the striplines are still not perfectly trimmed. This would result in flat line. Furthermore, we used different instruments and techniques in this case (Tektronix and HP). In the first case we used the full bandwidth of more than 10 GHz directly in time domain, while the second case was measured in frequency domain with a bandwidth filter of 2 GHz and time domain transposition.

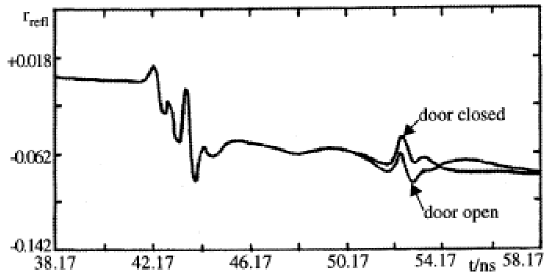

Fig. 7: TDR of the New Four Stripline TEM Cell Including Balun and Final Termination

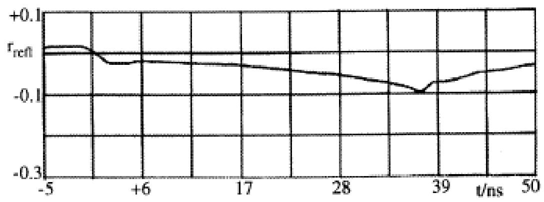

Fig. 8: TDR of the New Four Stripline Antenna

A demonstration of the effectiveness in terms of unmodulated power needed for generating 10 V/m in the center of the test volume, which is at about two third of the length of the cell axis, is given in fig. 9 and 10. For the small cell (fig. 9) this is about 30 dBm (1W) and for the new four stripline antenna (fig. 10) 43 dBm (20 W). In the antenna case the matching of the boards was not as good as in the small cell. This deficiency can be corrected by improved profiling of the termination, as was the case in the small cell. The new TEM device family can also be designed to generate higher field strength. To increase the field strength by a factor of 10 the drive power is 100 times higher. In order to take the modulation issue of 80 % into account (EN 61000-4-3) an additional power factor of 3.24 is needed.

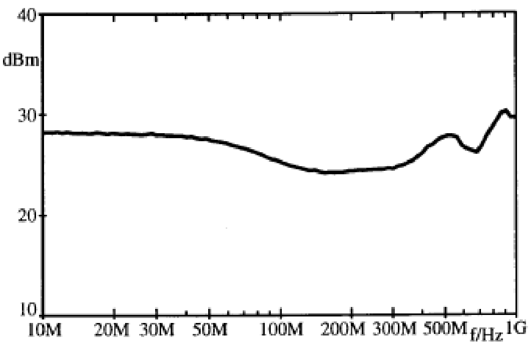

Fig. 9: Power to Generate 10 V/m in the New Small TEM Cell

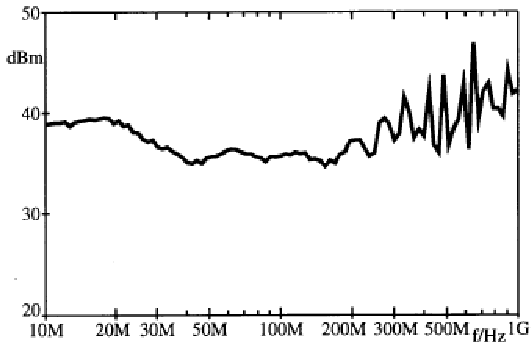

Fig. 10: Power to Generate 10 V/m in the New Four Stripline Antenna

Radiated Emission Data and OATS Correlation

Following the procedure with a special self contained small test radiator, which was a battery driven comb generator [4], the evaluation was performed. Fig. 11 displays the excellent side component suppression, almost approaching an ideal TEM device. It needs to be considered, that the test radiator broad band dipole (VSQ) is about 40 cm long. This is very big for the new small four stripline TEM cell. The originally existing metallic case resonance of the self contained electronics could be 20 dB reduced by absorber lining of the box. Therefor the resonance at about 200 MHz disappeared. The dipole was oriented in all three orthogonal directions, positioned in the center of the test volume. Moving it around did not show major changes.

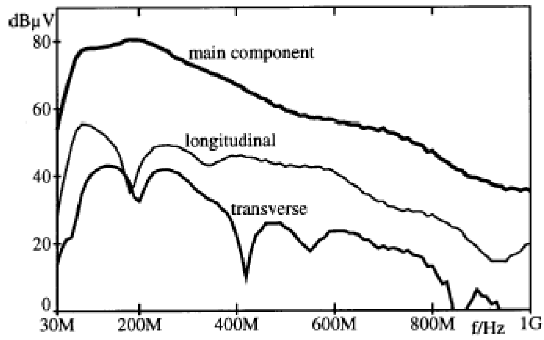

Fig. 11: Emission Data for the Small Test Radiator in the New Four Stripline TEM Cell

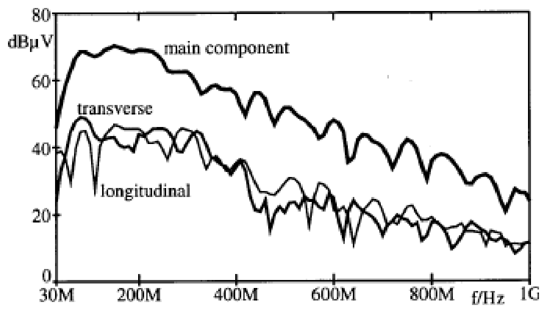

Fig. 12: Emission Data for the Small Test Radiator in the Four Stripline Antenna (termination not yet optimal)

The same procedure was executed for the four stripline antenna, which is documented in fig. 12. In principle excellent scalability is demonstrated. The side component suppression is remarkably good. This is surprising, because the final termination arrangement of the early prototype was not as good, as for the optimized small cell. The ripple on the main component demonstrates the yet non optimal profile of the termination.

Regarding the correlation issue, it is known from literature [5], that even accredited 10m OATS differ for small EUT (VSQ) by ± 6 dB and for objects including cables by ± 12 dB. This is interesting, because the ± 4 dB NSA was always achieved on all accredited OATS used. Naturally a 10 m site in a semi-anechoic chamber would not be any better. To do the correlation from the four stripline TEM cell to OATS and for our fully absorber lined chamber, we took the average of the OATS data (Ø) for comparison. This chamber is the same, as we used with the four stripline antenna. The correlation results are listed in Fig. 13.

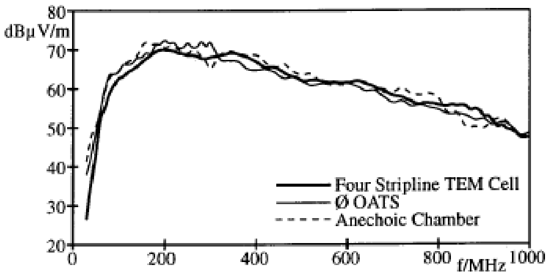

Fig. 13: Four Stripline TEM Cell to 10 m OATS Correlation

THE NEW FOUR STRIPLINE ANTENNA VERSUS CONVENTIONAL ANTENNAS

Commercially available combinations of biconical and logarithmic periodic antennas are known to be used in EMC down to frequencies of about 20 MHz. The problem however is there efficiency in the frequency range below 100 MHz. In this range the antenna is simply to short compared to the wave length with the consequence of extremely bad impedance matching conditions. In order to generate fields of e.g. 10 V/m in 3 m distance almost 500 W have to be supplied by the amplifier. Top loading the ends of the bicon antenna is somehow helping the efficiency in the low frequency range, however, this may lead to critical resonances and impair the broadband nature of the antenna. The logarithmic periodic part offers a reasonable antenna gain. The disadvantage is the existence of side lobes,

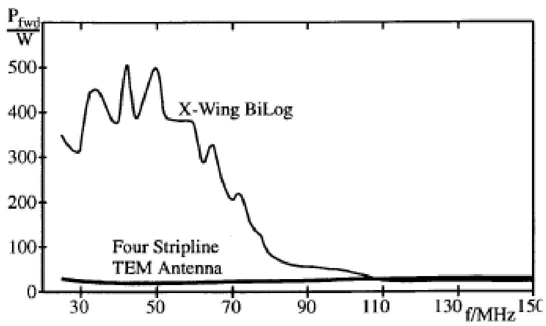

Fig. 14: Power Required to Drive 10 V/m 80% AM in 3 m Distance for the CBL 6140 and the New TEM Antenna

which could lead to unwanted coupling and reflections. The four stripline arrangement does not have this kind of problem as demonstrated in fig. 14. Only a fraction of the power of the biggest Schaffner Chase X-Wing Bilog is needed to drive 10 V/m in 3 m distance. The cost savings for the reduced amplifier power is about 80 %. Additionally there is no need for any antenna mast. The four stripline arrangement can principally be used from very low frequencies far into the GHz range. In the R&D lab we have already tested baluns down to 10 kHz and up to 2 GHz. Presently work continues to expand the new four stripline technology up to 18 GHz.

CONCLUSION

A novel TEM device for immunity and emissions has been presented. It is space, weight and cost saving over the conventional technology like the GTEM cell. The new four stripline device proves superior field quality. It may also be used to retrofit existing fully absorber lined chambers. This procedure increases the efficiency in particular in the frequency range below 100 MHz. Polarization switching can be automated and consequently we only need two runs for the hole procedure from 26 MHz to 1 GHz.

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