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Section: RF- and Microwaves, Radars

85577 Neubiberg, 20th of August 2003
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EXPERT REPORT

Ordered by: marburg TECHNIC
J.B. Schaefer GmbH & Co. KG
Bertram-Schaefer-Straße 11
D-35274 Kirchhain
Germany

Device under Test : (DUT) ***EMC-reinforcement fabric***

Subject: Shielding-measurements of electromagnetic waves from 200 MHz to 10 GHz; including separate measurements between two rectangular waveguides from 900 MHz to 1800 MHz

Regulations: According to MIL-Standard 285, respectively IEEE 299 –1997 and VG-Standard 95 370-15, KS03

Date of Measurements: 18th and 19th of August 2003

Contents: 4 pages of text, 3 pages with 6 measured diagrams, 1 page explanation of frequency distribution across the diagrams in appendix # 3

Results: This ***EMC-reinforcement fabric*** has been measured with vertically and horizontally polarised electromagnetic waves at frequencies between 200 MHz and 10 GHz. The results proved equal shielding-effectiveness against the two linear polarisations.
At 900 MHz (Cellphone D-Net) the shielding effectiveness is 25 dB, which means, that 99.7% of the power-flux density of the wave is shielded, only 0.3% of the incident power penetrates the DUT.
At 1800 MHz (Cellphone frequencies of the E-Network) the ***EMC-reinforcement fabric*** presents a shielding of 20 dB. Here only 1 % of the power passes the tissue, 99 % are shielded (appendix #1 + #2).
All these shielding values were confirmed by a second measurement between two rectangulare waveguides in the L-Band from 900 MHz to 1800 MHz (appendix #4).

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1. Introduction

To explain the measured diagrams, it is helpful to use the table at the bottom. You can easily calculate the relation between shielding in "dB" and transmission in "%".

The network analyzer presents the results of the shielding measurements in "Decibel" (dB). The mode of measurement is a typical transmission measurement (S_{21}-measurement).
This dB value describes, how much the level of an incident power or power-flux density has decreased, passing the device under test.

It describes values of field-strengths as well. But the calculation of the percent-values in the table at the right refers to the power-relationships.
So it tells – for example - that 20 dB shielding reduces the penetrating power to 1 %.

Conversion of Decibel to Percent of transmitted Power

dB	Power Transmission in %	dB	Power Transmission in %
0	100,00		
1	81,00	21	0,78
2	62,80	22	0,63
3	50,00	23	0,50
4	40,00	24	0,39
5	31,60	25	0,31
6	25,00	26	0,25
7	20,00	27	0,20
8	16,00	28	0,18
9	12,50	29	0,12
10	10,00	30	0,10
11	7,90	31	0,08
12	6,25	32	0,06
13	5,00	33	0,05
14	4,00	34	0,04
15	3,13	35	0,03
16	2,50	36	0,02
17	2,00	37	0,02
18	1,56	38	0,02
19	1,20	39	0,02
20	1,00	40	0,01

To calculate the dB-value from the incident power P_1 or electric fieldstrength E_1 and the transmitted power P_2 respectively E_2 , one has to use the following equation:

$$a_{Shield} = 10 \cdot \log \frac{P_2}{P_1} = 20 \log \frac{E_2}{E_1}$$

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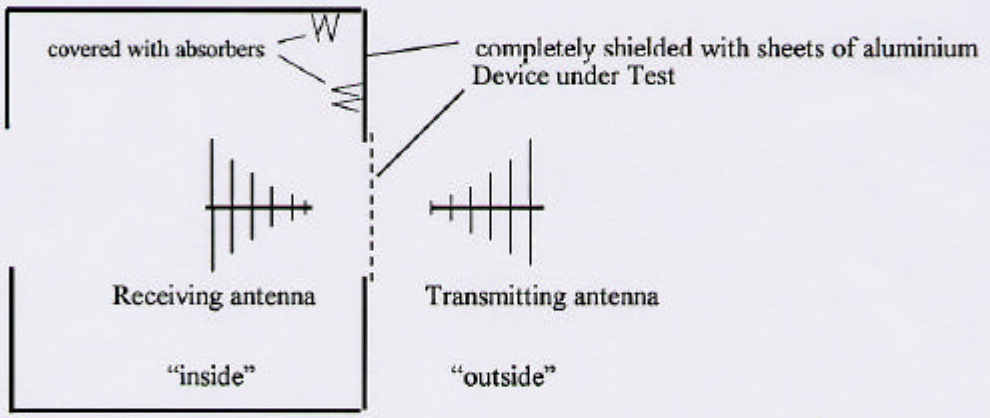
2.Measurement Set-up

The measurements were performed according to MIL-Standard 285 in a shielded room of the Radar Laboratories at the German Armed Forces University Munich in Neubiberg at frequencies from 200 MHz to 10 GHz. Linear polarisation was radiated by logperiodic antennas. The device under test, the ***EMC-reinforcement fabric***, was attached to a specific window as shown in the picture below (height 80 cm, width 60 cm).
During the measurements neither interferences from external signals nor any creeping waves between DUT and cabin wall could be detected. To test the device in the different planes of linear polarisation (vertically and horizontally), the sample was rotated in 90 degrees.



Setup for Shielding Measurements

The test range was calibrated
1. without any object between the two antennas, to calibrate the zero-dB-transmission-value,
2. with a solid sheet of aluminium, to test the optimum shielding possible.

Due to the antenna specifications, measurements were performed in two frequency bands:
Range I: 200 MHz to 2200 MHz
Range II: 1 GHz to 10 GHz
According to MIL-STD 285, both antennas were positioned at a distance of 12 inches in front of the tested fabric and behind it.

Measurement equipment:
Vector Networkanalyzer Type 360, (40 MHz to 18,6 GHz), Wiltron/Anritsu
Vector Networkanlayzer Type 8753D (30 kHz – 6 GHz), Hewlett & Packard
2 Antennas (MHz): Bilog-Antennas , Type CBL 6112A (30 MHz to 2000 MHz), CHASE
2 Antennas (GHz): LogPer-Antennas Type HL 025 (1 GHz to 18 GHz) Rohde & Schwarz
Printer: Laserjet 4, Hewlett & Packard

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3. Results of the measurements and comments

All diagrams present the transmission values in decibels as a function of frequency.
Scale: 10dB/DIV. The 0 dB-Reference line is indicated by this marker ►.
The upper trace shows the results of the measurements between 200 MHz and 2200 MHz, the trace below was measured between 1 GHz and 10 GHz.
Thus the important frequencies between 1000 MHz and 2200 MHz have been measured twice with different antennas and individual calibration. The good matching between the two results indicate the validity of the measurements.
To find out, how many percent of the incident power is shielded, the table on page 2 presents the conversion between **dB** and **%** (of power).

To read the exact frequencies at the horizontal axis, the diagrams of *appendix #3* may be helpful.

The ***EMC-reinforcement fabric*** has been measured with vertically and horizontally polarised electromagnetic waves at frequencies between 200 MHz and 10 GHz. The results proved almost no difference in shielding effectiveness against the two polarisations.

At 900 MHz the device presents values of 25 dB which means, that 99.7% of the power-flux density of the wave is shielded, only 0.3% is penetrating the DUT.

At 1800 MHz (Cellphone frequencies of the E-Network) the ***EMC-reinforcement fabric*** presents a shielding of 20 dB. Here only 1 % of the power passes the DUT, 99 % are shielded.

The waveguide measurements between 900 MHz and 1800 MHz (presented in appendix #4) proved the results, measured between the logper Antennas.

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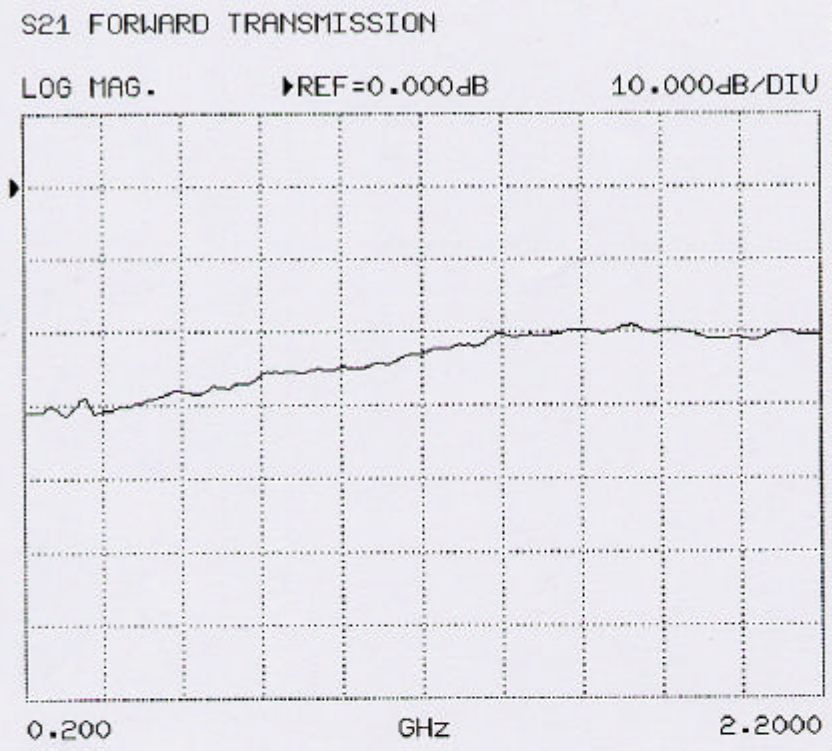
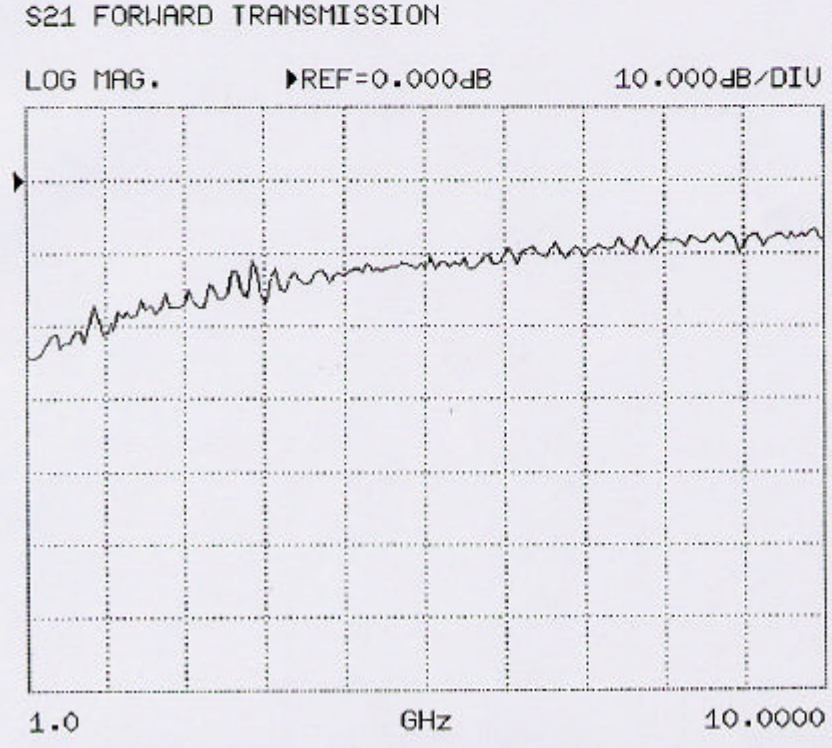
Appendix 1, 20th of August 2003
Polarisation vertical

Device under test: EMC-reinforcement fabric
(upper trace: 200 MHz – 2200 MHz, lower trace: 1 GHz – 10 GHz)





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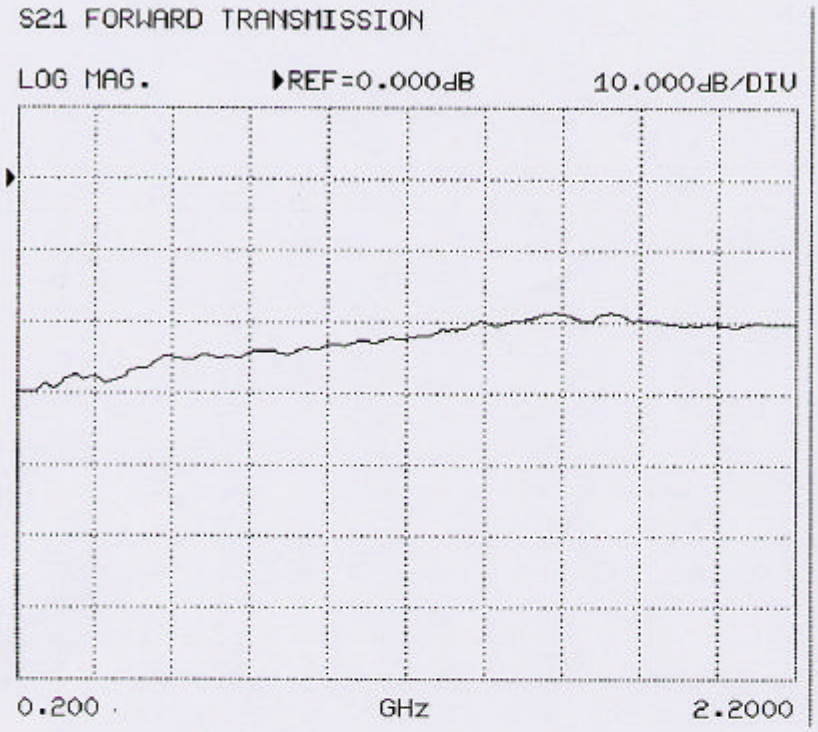
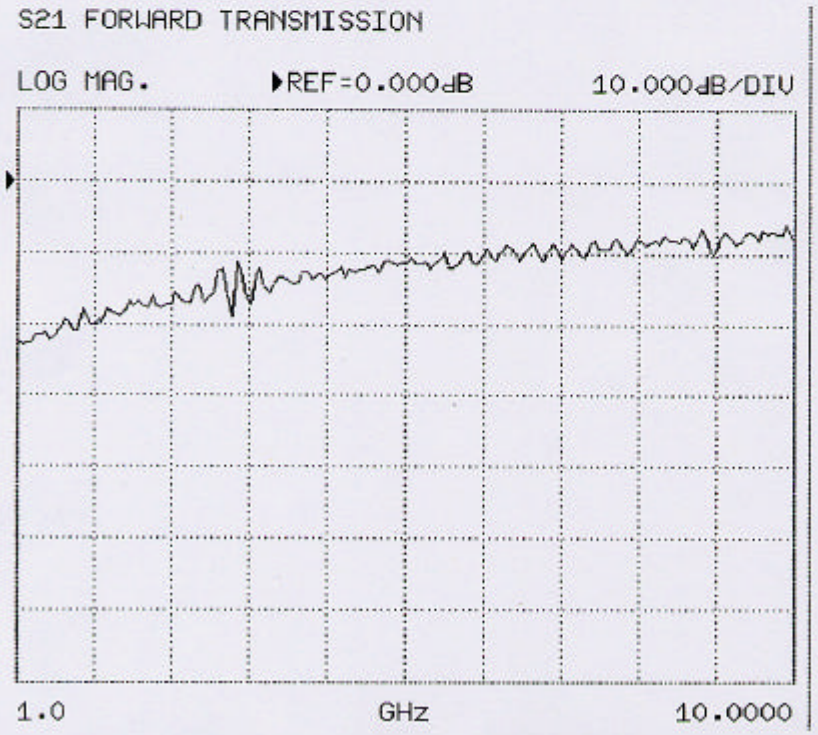
Appendix 2, 20th of August 2003
Polarisation horizontal

Device under test: EMC-reinforcement fabric
(upper trace: 200 MHz – 2200 MHz, lower trace: 1 GHz – 10 GHz)





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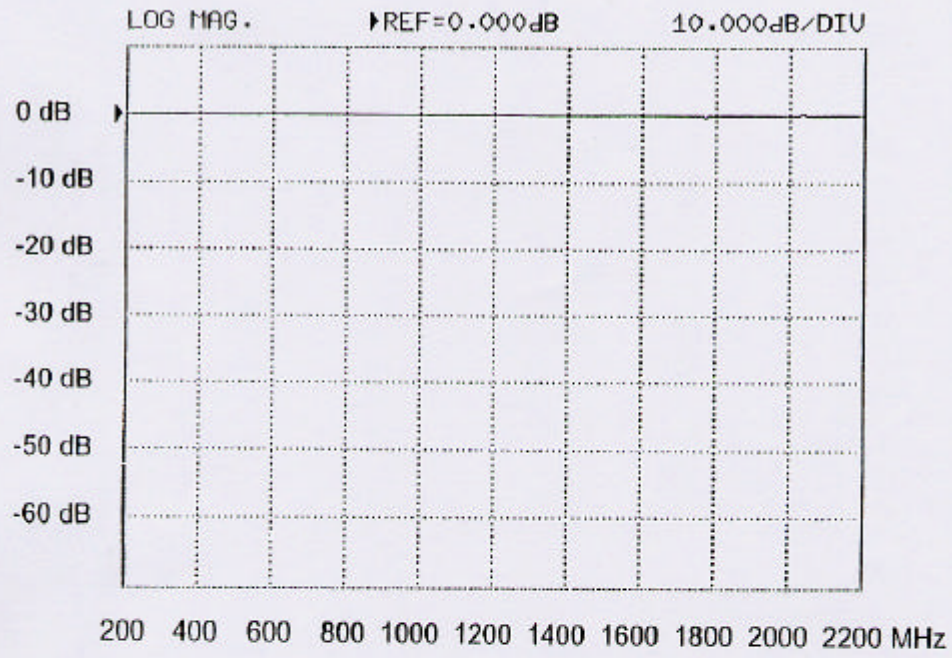
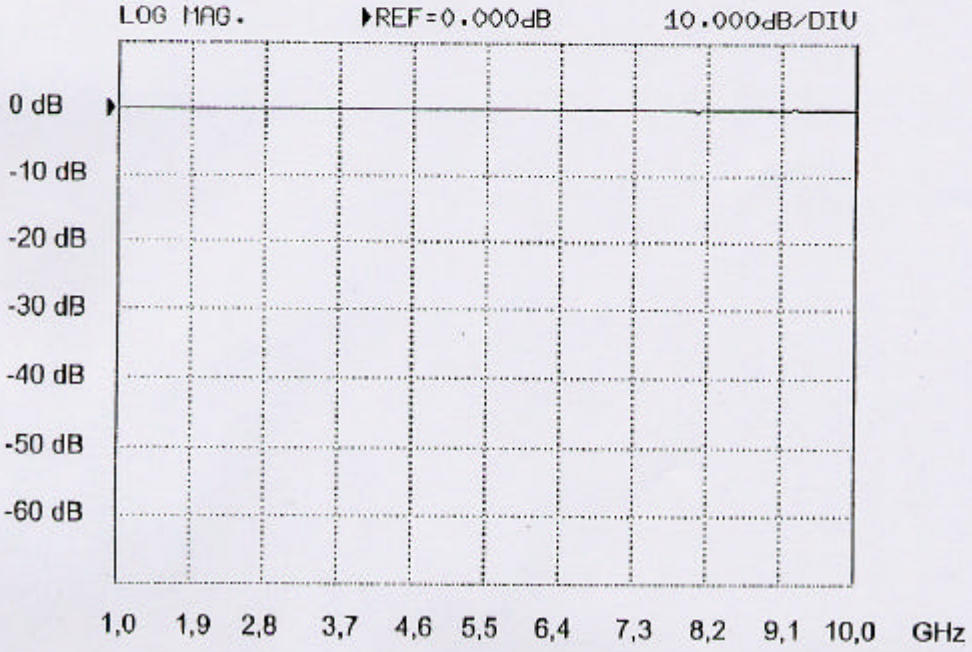
Appendix 3, 20th of August 2003
Diagrams with frequency-values at the horizontal axis (MHz in upper and GHz in lower diagram)





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Appendix 4, 20th of August 2003
Measurement between two waveguides

Device under Test: EMC-reinforcement fabric
(upper trace: vertical polarized, below: horizontal polarized)