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• CISPR

• PESD CISPR

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• : 30MHz- 1GHz

• : 30MHz- 1GHz

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CISPR

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EMI

300MHz- 1GHz

6.

EMI

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7.

○

: HAEFELY PESD1600

○

: 8566B

○

: EMCO 30 300MHz Biconical Antenna

300 1000MHz Log Periodic Antenna

○

: 5.7m(W) × 8.6m(L) × 6.1m(H) Anechoic Chamber

10.

SUMMARY

Electrostatic discharge (ESD) can cause direct and indirect damage to electronic devices and system. Direct damage is due to thermal effects by joule heating caused by ESD currents and dielectric breakdown failure due to induced voltages accross any capacitive element caused by the external field of the charge source. indirect damage is due to the electromagnetic pulses(EMP) produced by the transfer of charges from a source conductor to a sink conductor. In this paper we focus indirect effects of ESD. The dipole model is used to analyze the EMP caused by ESD in the time domain. We measure intensities of electric field in the frequency domain ranging from 30MHz to 1GHz. We use ESD simulator - HAFELY PESD1600 supported by human body model (HBM), as the simulation of real ESD events.

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(HBM)

HAEFELY

PESD 1600

EMI

30MHz- 1GHz

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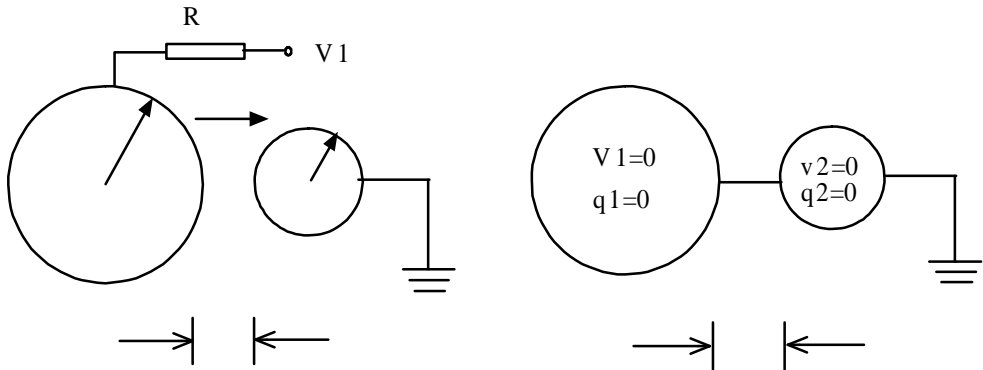
• (HBM)

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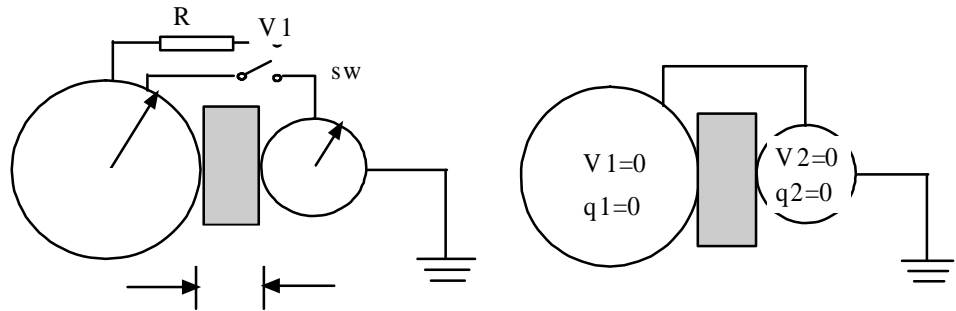
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가 (1, 2).



1) HBM : 가



2) HBM : 가
(가)

$$W_i = \frac{1}{2} c_{11} V_1^2 \quad Q_i = c_{11} V_1 \quad (1)$$

c_{11} V_1 .

2. (ESD Simulater)

[5] .

HAEFELY PESD 16000 3

PESD 1600

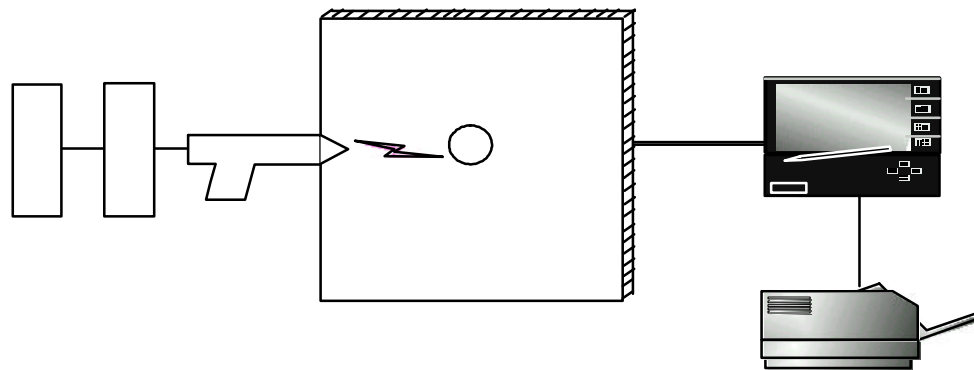
2kV, 4kV, 6kV, 8kV

4 6kV

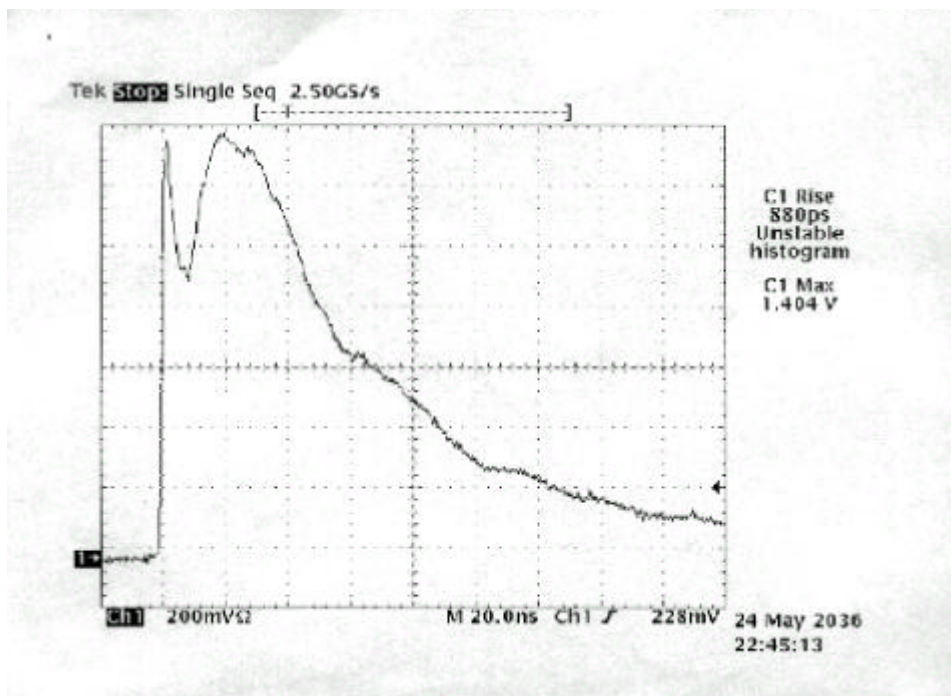
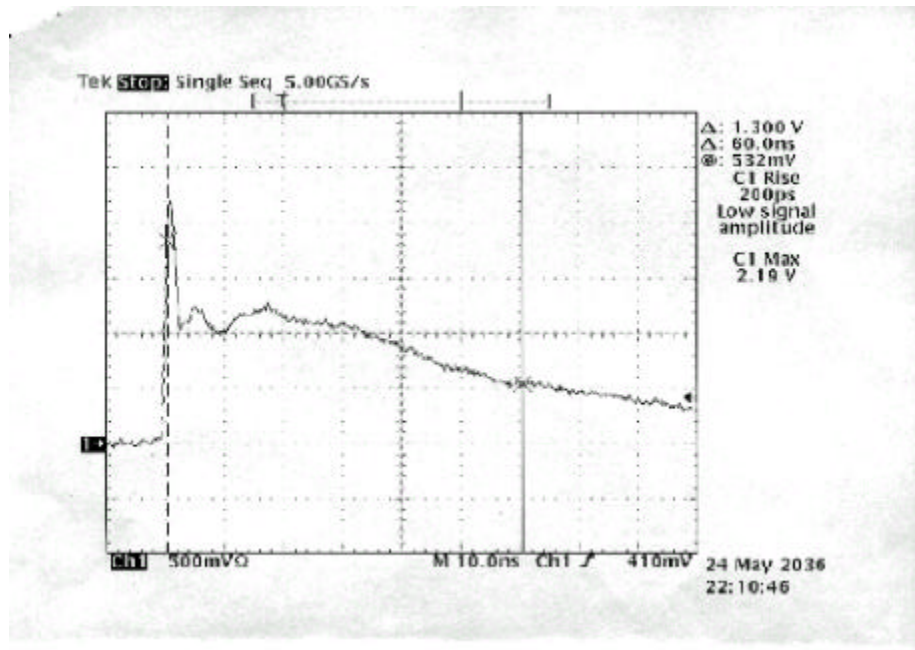
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3)



4)



5) PESD :

6kV (), 6kV ()

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[6] 50pF 250pF
2kV 15kV
60nsec 가 (1)

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	50pF	100pF	150pF	200pF	250pF
2kV	1.7A 10^{-4}J	3.4A $2 \times 10^{-4}\text{J}$	5.1A $3 \times 10^{-4}\text{J}$	6.8A $4 \times 10^{-4}\text{J}$	8.5A $5 \times 10^{-4}\text{J}$
4kV	3.4A $4 \times 10^{-4}\text{J}$	6.8A $8 \times 10^{-4}\text{J}$	10.2A $12 \times 10^{-4}\text{J}$	13.6A $16 \times 10^{-4}\text{J}$	17.0A $20 \times 10^{-4}\text{J}$
6kV	5.1A $9 \times 10^{-4}\text{J}$	10.2A $18 \times 10^{-4}\text{J}$	15.3A $27 \times 10^{-4}\text{J}$	20.4A $36 \times 10^{-4}\text{J}$	25.5A $45 \times 10^{-4}\text{J}$
8kV	6.8A $16 \times 10^{-4}\text{J}$	13.6A $32 \times 10^{-4}\text{J}$	20.4A $48 \times 10^{-4}\text{J}$	27.2A $64 \times 10^{-4}\text{J}$	34.0A $80 \times 10^{-4}\text{J}$
15kV	12.5A $56 \times 10^{-4}\text{J}$	25.0A $112 \times 10^{-4}\text{J}$	37.5A $168 \times 10^{-4}\text{J}$	60.0A $224 \times 10^{-4}\text{J}$	72.5A $280 \times 10^{-4}\text{J}$

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(HP 8566B)

msec

nsec

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$f_0(t)$

$F_0(\omega)$

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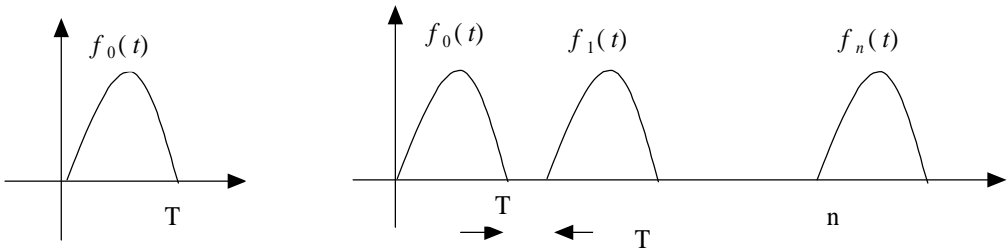
$$F_0(\omega) = \int_{-\infty}^{\infty} f_0(t) e^{j\omega t} dt = \int_0^T f_0(t) e^{j\omega t} dt$$

T n 6()

. n

$F(\omega)$

$F_0(\omega)$ (2) 가 .



$$F(\omega) = F_0(\omega) \frac{1 - e^{jn\omega(T + \Delta T)}}{1 - e^{j\omega(T + \Delta T)}} \tag{2}$$

dB

$$A = 20\log |F(\omega)|/F_r \tag{3}$$

ω A

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$$A = 20\log |F_0(\omega)|/F_r = A - 10\log \frac{1 - \cos n\omega(T + \Delta T)}{1 - \cos \omega(T + \Delta T)} \tag{3}$$

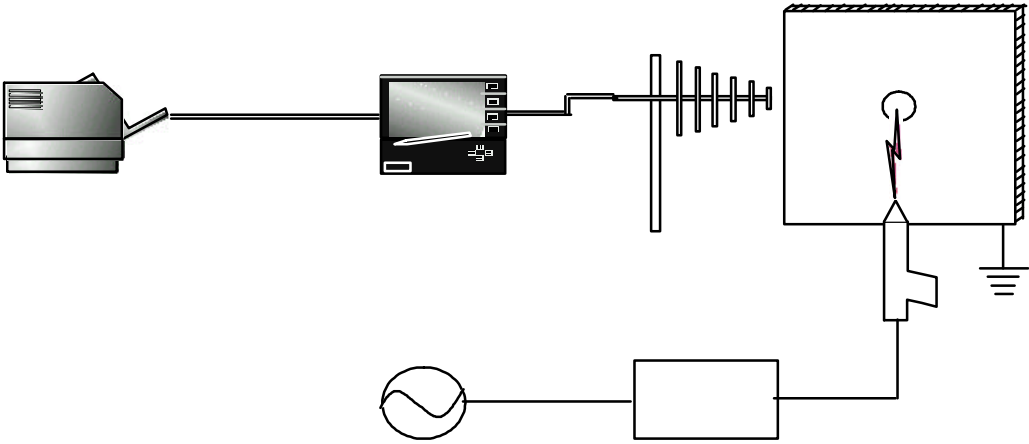
F_r

T T

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7:

5.7m (W) × 8.6m (L) × 6.1m (H)
HP 8566B

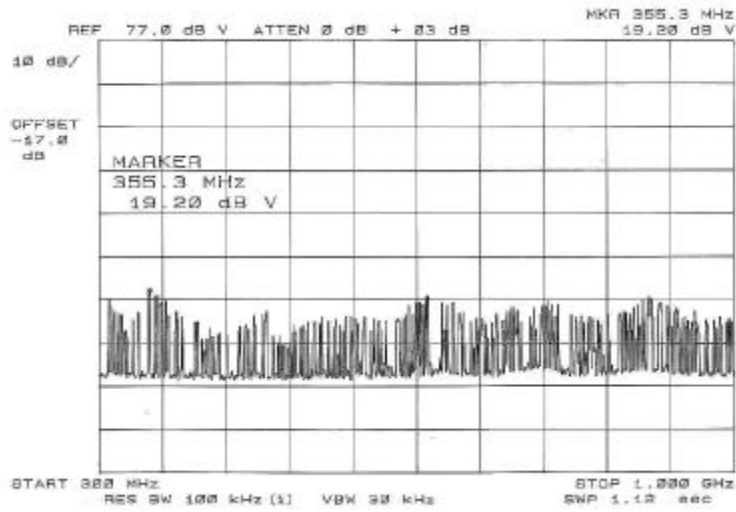
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EMCO 300- 1000MHz

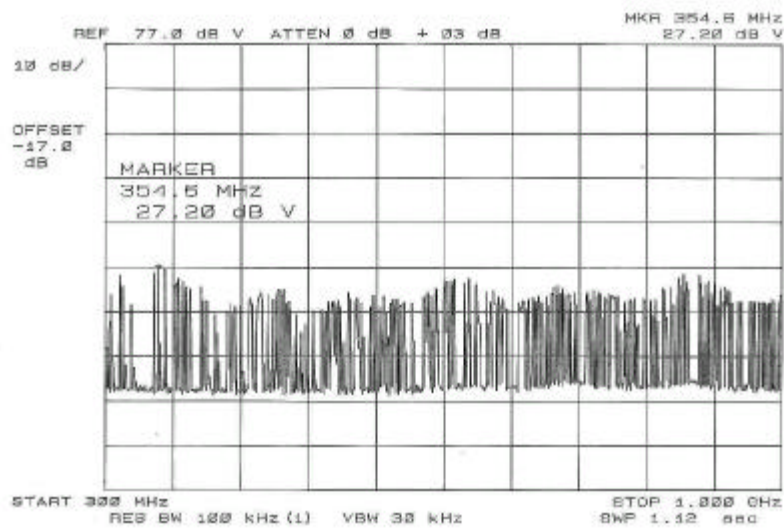
2.

0.5 2 240
300MHz- 1000MHz , ,
2 2 , 2kV 6
kV 8 15 .

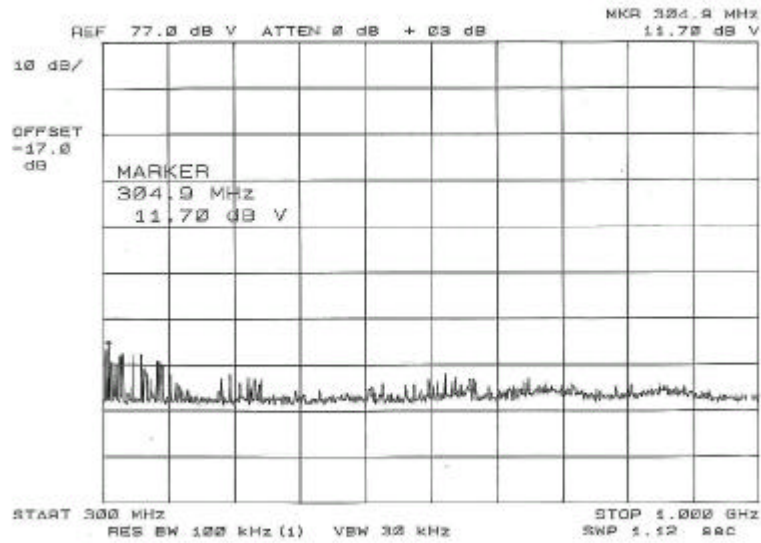
(MHz)	30 300, 300 1000
(kV)	2, 4, 6, 8, 15
	,
(cm)	20, 100
	○.5 (2)
	240



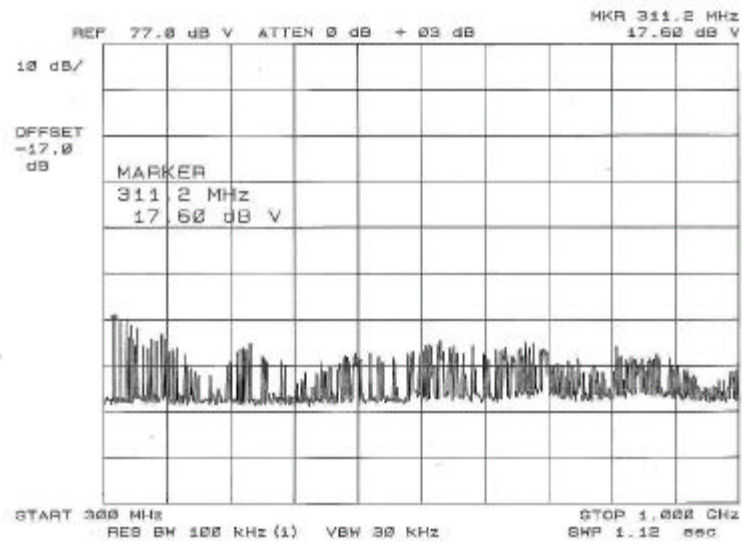
8 20cm 2kV (300MHz- 1GHz)



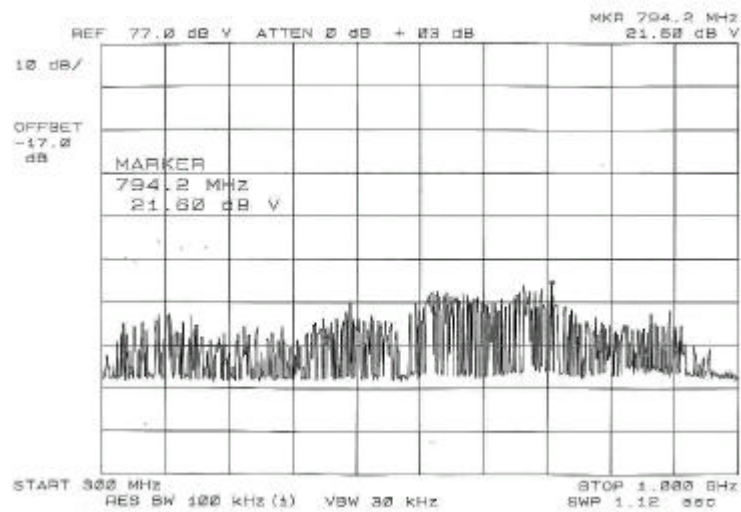
9 20cm 6kV (300MHz- 1GHz)



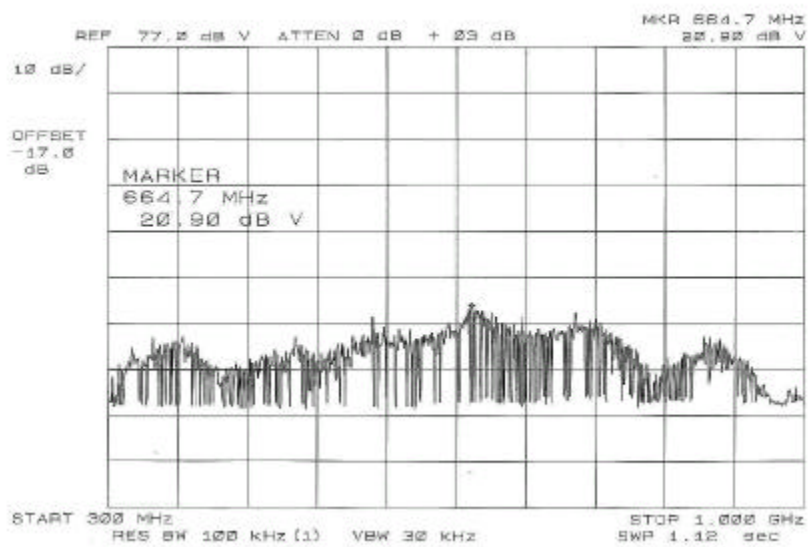
10 1m 2kV (300MHz- 1GHz)



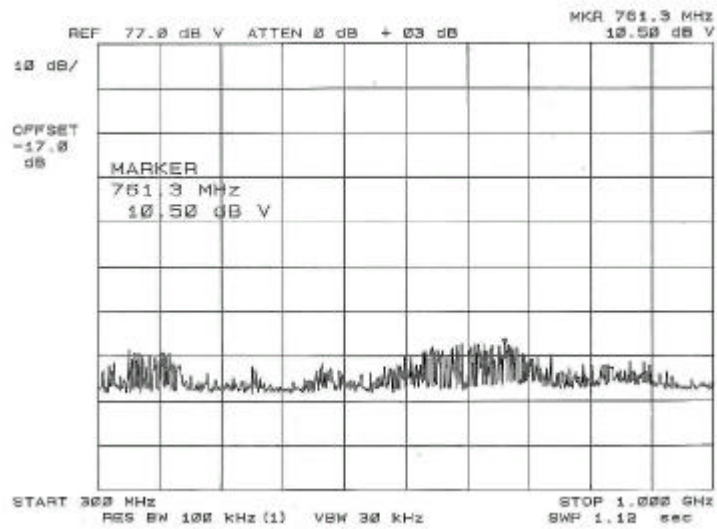
11 1m 6kV (300MHz- 1GHz)



12 20cm 2kV (300MHz- 1GHz)



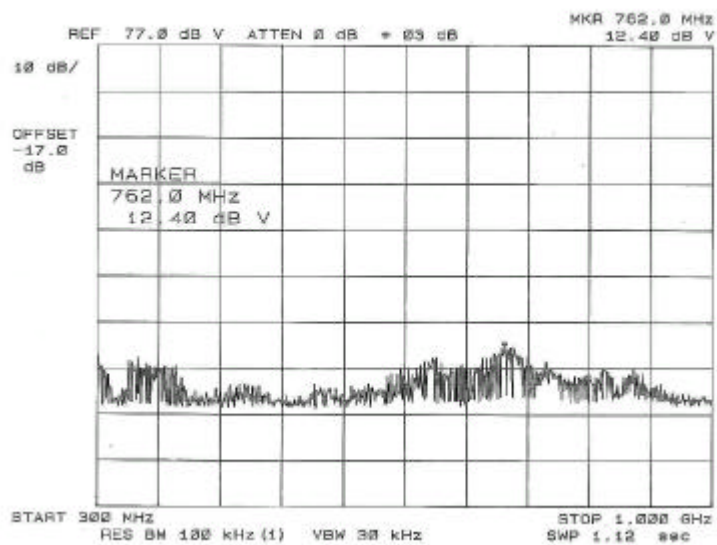
13 20cm 6kV (300MHz- 1GHz)



14

1m 2kV

(300MHz- 1GHz)



15

1m 6kV

(300MHz- 1GHz)

3.

8 15 300MHz- 1GHz

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2kV 가 8kV 1m

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	20cm	1m	20cm	1m
2k V	353.3MHz 19.20dB μ V	304.9MHz 11.79dB μ V	794.2MHz 21.60dB μ V	761.3MHz 10.50dB μ V
4k V	359.5MHz 28.10dB μ V	300.7MHz 14.8dB μ V	773.2MHz 18.60dB μ V	358.8MHz 11.80dB μ V
6k V	354.6MHz 27.20dB μ V	311.2MHz 17.60dB μ V	664.7MHz 20.90dB μ V	762.0MHz 12.40dB μ V
8k V	343.4MHz 32.60dB μ V	315.4MHz 20.30dB μ V	767.6MHz 18.20dB μ V	763.4MHz 12.50dB μ V

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300MHz- 1GHz

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- [1] Perry F. Wilson "Field Radiated by Electrostatic Discharges" IEEE Trans. on Electromagnetic Compatibility. Vol. 33, NO.1 pp. 10-24, Feb. 1991
- [2] William D. Greason "Indirect Effect of ESD: Modeling and Measurement" Proc. 11th Int. Zurich Symp. Tech&Exh, 114R1 pp. 613-618, 1995
- [3] Technical Staff of KeyTeck Instrument Corp "The Pulsed EMI HANDBOOK" KeyTek, pp. 3-35, 1994
- [4] William D. Greason, "Constant Charge and Constant Potential Models for Electrostatic Discharge and the Human Body", IEEE Tran. on Industry Application, Vol.35, NO.1, January/February 1999, pp. 259-271
- [5] IEC Specification 61000-4-2, 1999
- [6] , () (ESD), 1994, pp. 27-30, pp.77-84