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Computational System TechnologY (CST)

:

$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t} = -\mu \frac{\partial \mathbf{H}}{\partial t} \quad (1)$$

$$\nabla \times \mathbf{H} = \mathbf{J} + \frac{\partial \mathbf{D}}{\partial t} = \sigma \mathbf{E} + \varepsilon \frac{\partial \mathbf{E}}{\partial t} \quad (2)$$

$$\nabla \cdot \mathbf{D} = \rho_v \quad (3)$$

$$\nabla \cdot \mathbf{B} = 0 \quad (4)$$

$$d\mathbf{F} = q(\mathbf{v} \times \mathbf{B} + \mathbf{E}) \quad (5)$$

$$\nabla \cdot \mathbf{J} = -\frac{\partial \rho_v}{\partial t} \quad (6)$$

$$\mathbf{D} = \varepsilon \mathbf{E}, \quad \mathbf{B} = \mu \mathbf{H}, \quad \mathbf{J} = \sigma \mathbf{E} \quad (7)$$

- E, H, J

- σ, μ, ε

- ρ_v

- F

$$\begin{aligned}
 & \mathbf{H} \quad \mathbf{E} \\
 & \frac{\partial \mathbf{B}}{\partial t} , \frac{\partial \mathbf{E}}{\partial t} \\
 & [\nabla \times \mathbf{H} \quad \nabla \times \mathbf{E}] \\
 & (\mathbf{E}, \mathbf{H}) \\
 & (\mathbf{J}, \rho_v, \frac{\partial \mathbf{B}}{\partial t}, \frac{\partial \mathbf{E}}{\partial t})
 \end{aligned}$$

(σ, μ, ϵ)

(1)

$\mathbf{D} \quad \mathbf{B}$

\mathbf{B}

\mathbf{E}

\mathbf{E}

[1,3,9]

\mathbf{v}

\mathbf{B}

$\nabla \times \mathbf{E}$

$\frac{\partial \mathbf{B}}{\partial t}$

(2)

\mathbf{D}

\mathbf{E}_v

0.1 μm : (

$$E = E_v + E_a \quad (8)$$

$$E^2 = E_v^2 + 2E_v E_a + E_a^2 \quad (9)$$

()

(E_v^2)

(E_a^2)

($E_v E_a$)

($E_v^2 + 2E_v E_a$)

$E = fh$: f $\frac{1}{r^4}$ $\frac{1}{r^2}$

(10) - h : RF

QED

(Field particles)

.X-Rays

$$\Delta E \cdot \Delta t < \frac{\hbar}{2\pi}$$

"

"

(Virtual Photon)

-

-

[9]

:

100V/m

Momentum –

H

E

•

)

(....

[11] *H E*

RF

E

B E

B

•

•

•

()

[2,10]

$B = E$

(11)

$$\epsilon = \epsilon_0 \epsilon_r$$

$$\nabla \times \mathbf{H} = \sigma_c \mathbf{E} + j\omega(\epsilon_{b,real} - j\epsilon_{b,img})\mathbf{E}$$

:

$$\nabla \times \mathbf{H} = (\sigma_c + \omega\epsilon_{b,img})\mathbf{E} + j\omega\epsilon_{b,real}\mathbf{E}$$

(14)

$$(\mathbf{J} = \sigma\mathbf{E})$$

$$(14) \quad (\sigma_c + \omega\epsilon_{b,img})\mathbf{E}$$

$$\mu = \mu_0 \mu_r$$

B

$$\sigma_c + \omega\epsilon_{b,img}$$

:

$$\mu_r \approx 1$$

$$\sigma_c + \omega\epsilon_{b,img} = \sigma_{eff} \quad (15)$$

$$\sigma \neq 0$$

:

(2)

$$\mathbf{J}_{c,eff} = \sigma_{eff} \mathbf{E} \quad (16)$$

(1)

$$\nabla \times \mathbf{H} = \mathbf{J}_c + j\omega\epsilon_{bound}\mathbf{E} \quad (11)$$

:

\mathbf{J}_c

$$\mathbf{J}_c = \sigma_c \mathbf{E} \quad (12)$$

ϵ

σ_c

:

ϵ_{bound}

$$\nabla \times \mathbf{H} = j\omega\epsilon_{complex}\mathbf{E} \quad (17)$$

:

$$\epsilon_{bound} = \epsilon_{b,real} - j\epsilon_{b,img} \quad (13)$$

$$\epsilon_{complex} = \epsilon' - j\epsilon'' = \epsilon_0(\epsilon'_r - j\epsilon''_r)$$

(18)

$$\sigma_{eff} = \frac{1000Kg/m^3}{SAR} \quad (22)$$

E

σ_{eff}

ρ

ϵ'

ϵ''

$$\epsilon_{b,real} \quad (18)$$

$$\sigma_{eff} = \sigma_c + \omega \epsilon_{b,img} \quad \omega \epsilon'' \quad (14)$$

$$\tan \delta = \frac{\epsilon''}{\epsilon'} = \frac{\sigma_{eff}}{\omega \epsilon'} \quad (19)$$

(19)

$$\sigma_{eff} = \omega \epsilon_0 \epsilon_r \tan \delta \quad (20)$$

σ_c

$\omega \epsilon_{b,img}$

[13]

B

E

σ_c

$\omega \epsilon_{b,img}$

ΔV_{ol}

$$P = \sigma_{eff} E^2 \Delta V_{ol} \quad (21)$$

$\sigma_{eff} E^2$

[2, 6 12] ()

SAR

$$SAR = \frac{\sigma_{eff} E^2}{\rho} \quad W/Kg \quad (22)$$

-

- .[7,10]

CST

μ

ϵ

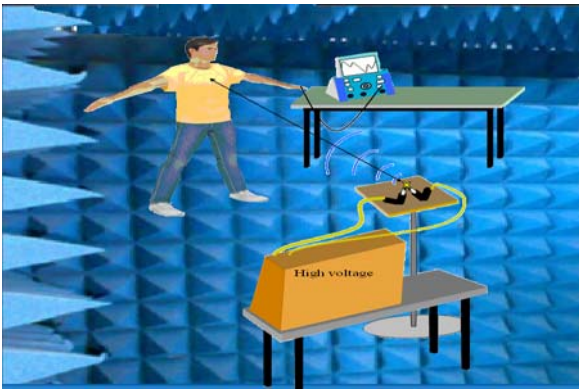
σ

)

.(

(1)

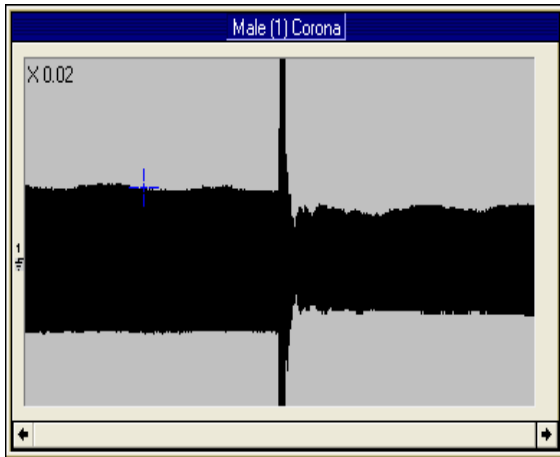
.Metrix-Mtx3352



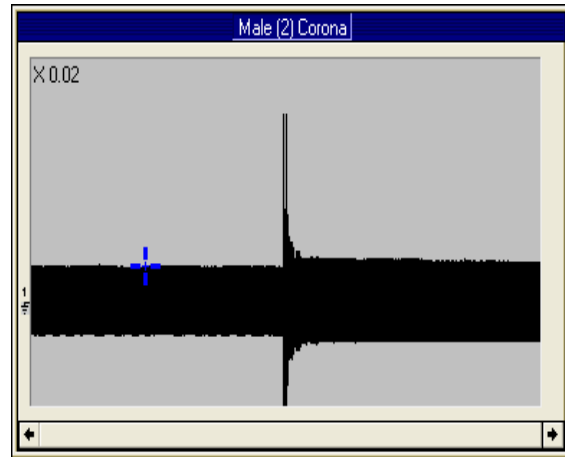
(1)

CST

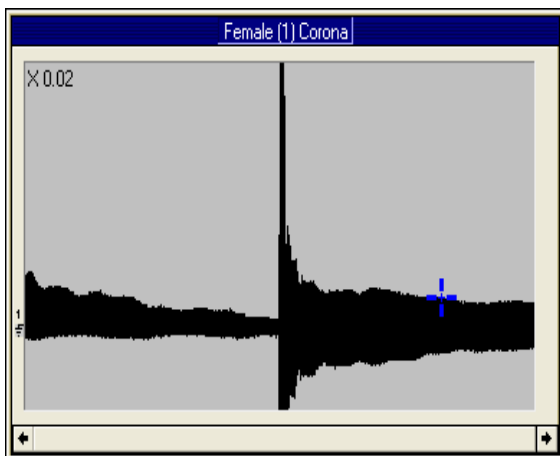
(2)



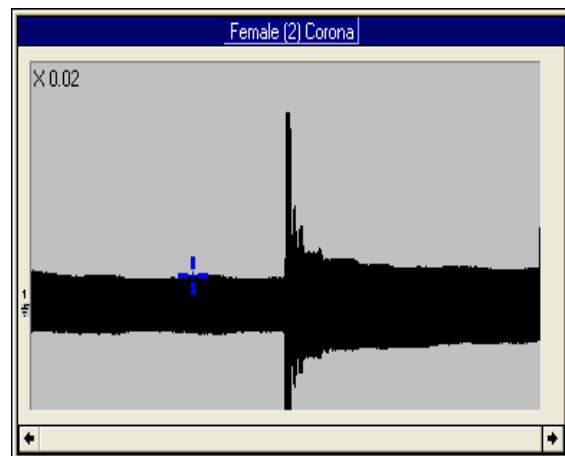
1



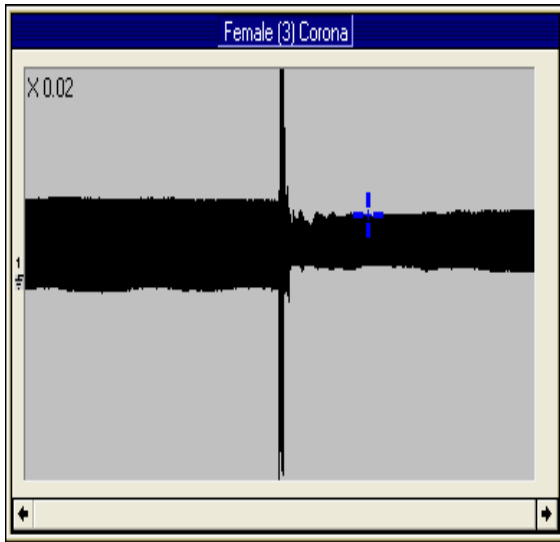
2



1

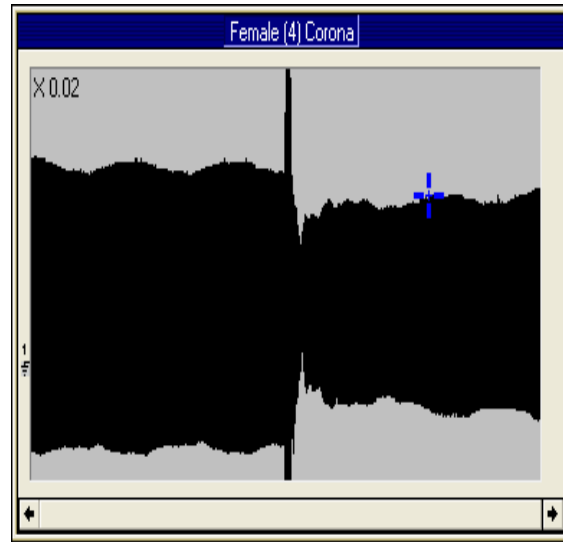


2



3

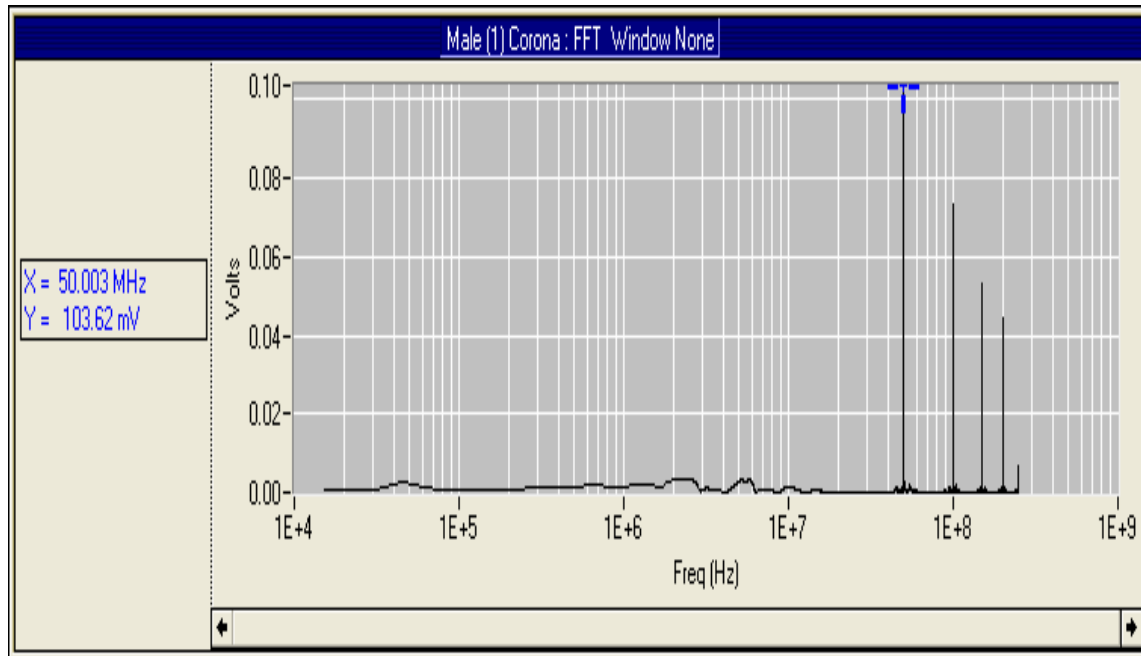
(3)



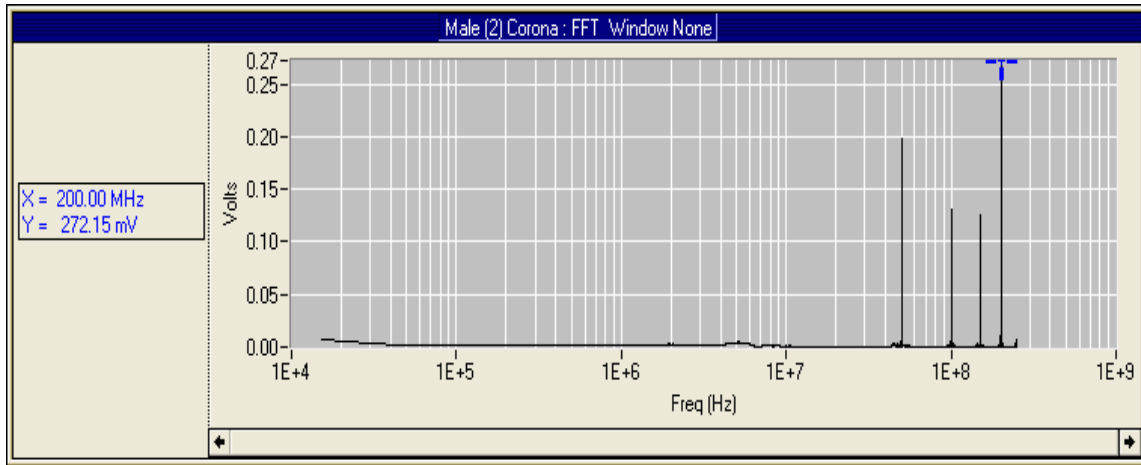
4

(2)

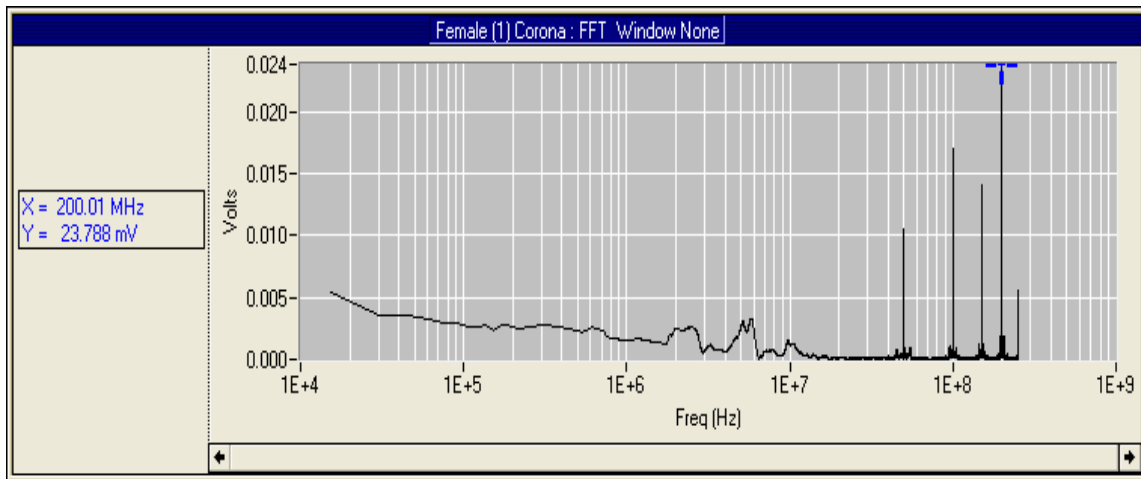
(2)



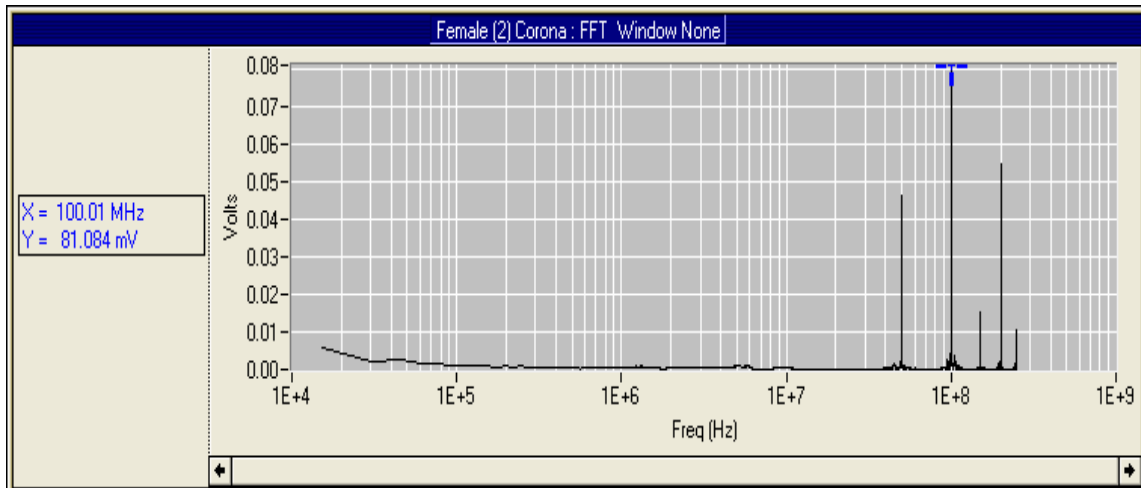
1



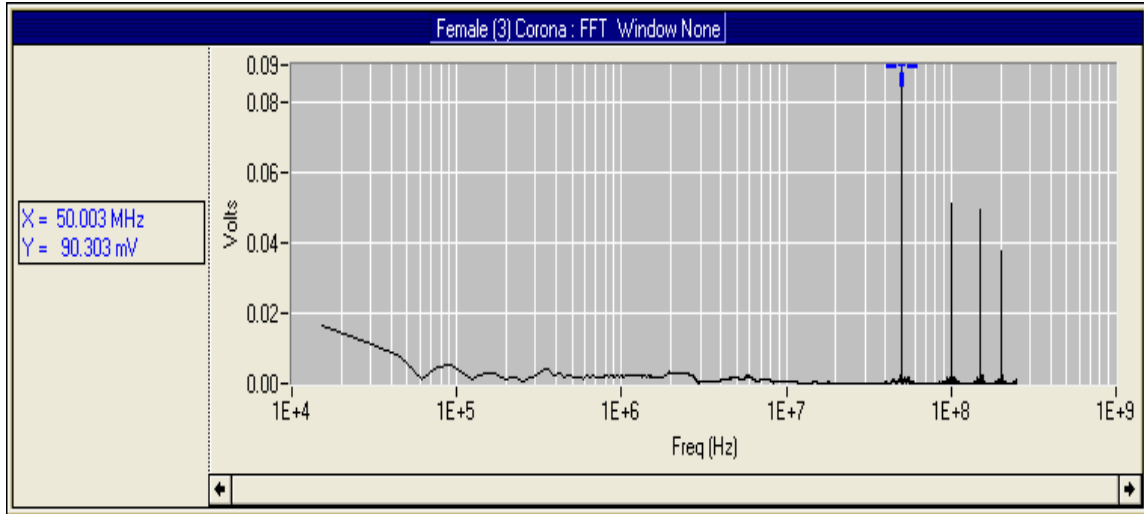
2



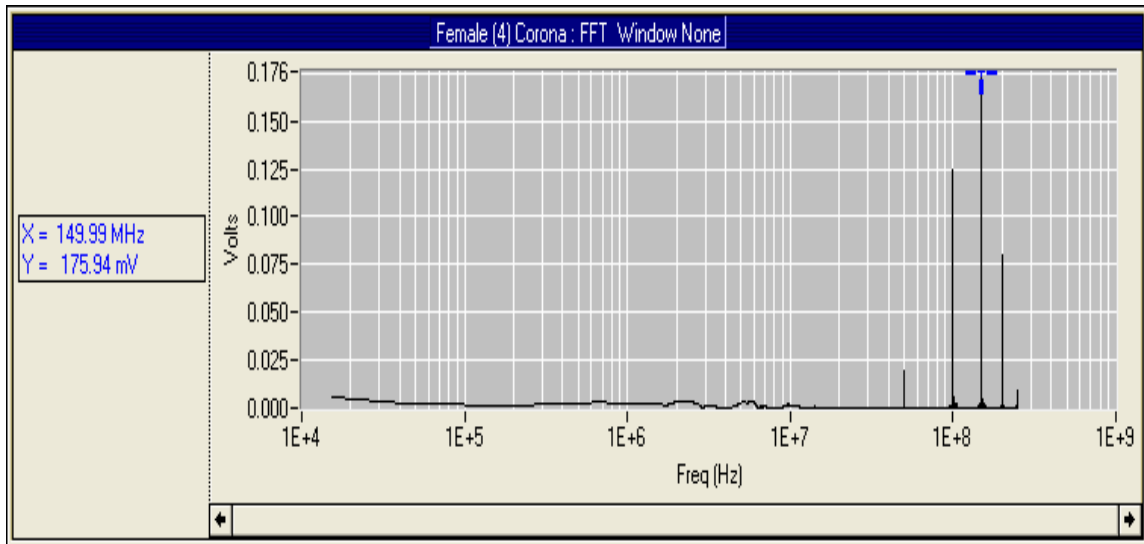
1



2



3



4

(3)

100

250 MHz

50 MHz

3 m

MHz

1.5 m

(3)

(2)

.50 MHz

(1).

(1)

(250 MHz) [mV]	(200 MHz) [mV]	(150 MHz) [mV]	(100 MHz) [mV]	(50 MHz) [mV]	
7.009	44.087	53.229	73.500	103.620	(1)
7.043	272.150	124.910	131.350	197.990	(2)
5.598	23.788	14.042	16.926	10.452	(1)
10.331	54.498	15.305	81.084	46.207	(2)
1.035	37.634	49.248	51.191	90.303	(3)
9.230	80.033	175.940	125.070	19.542	(4)

(50-250 MHz)

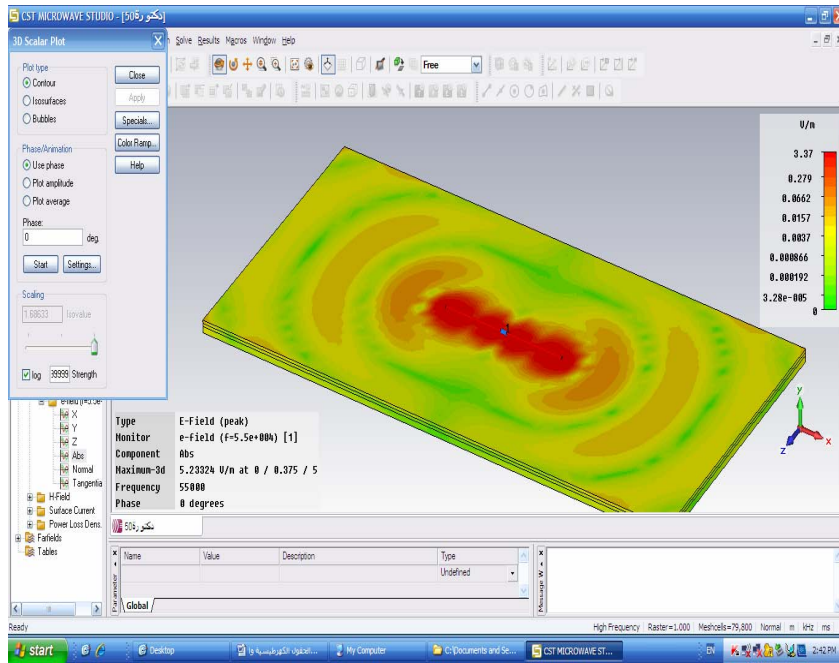
(FDTD) Finite Difference Time Domain

CST

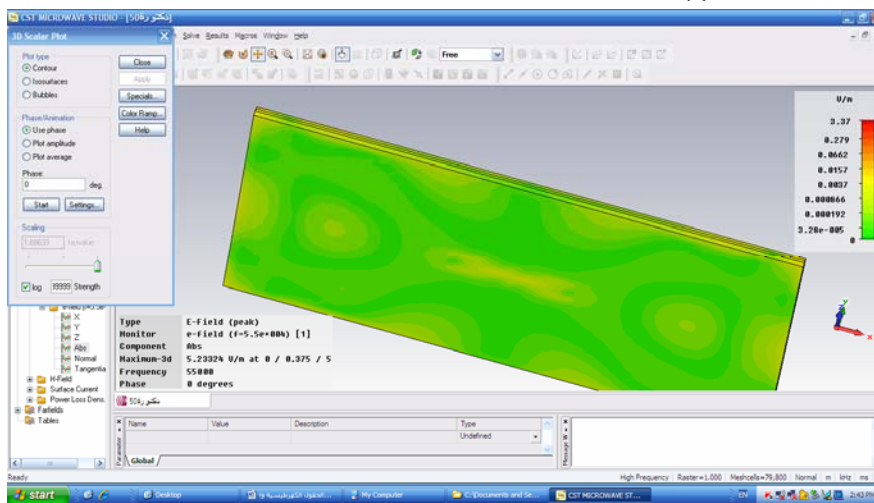
.FDTD

[(3)]

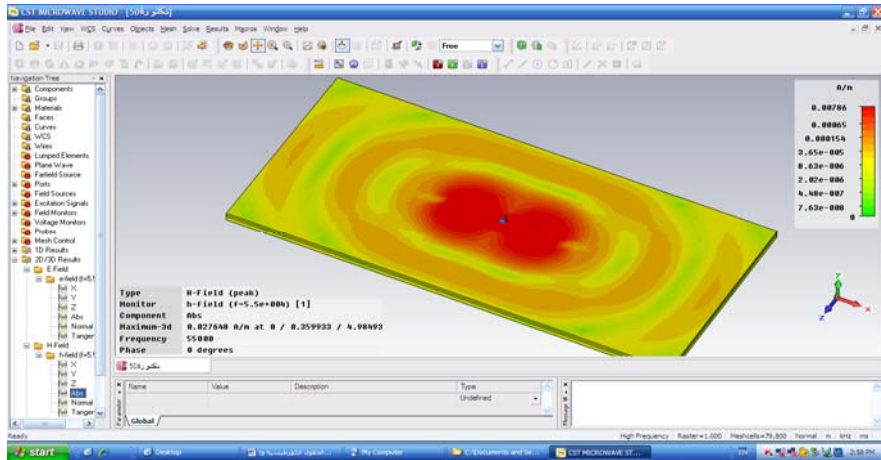
(50-100-150-200-250) MHz



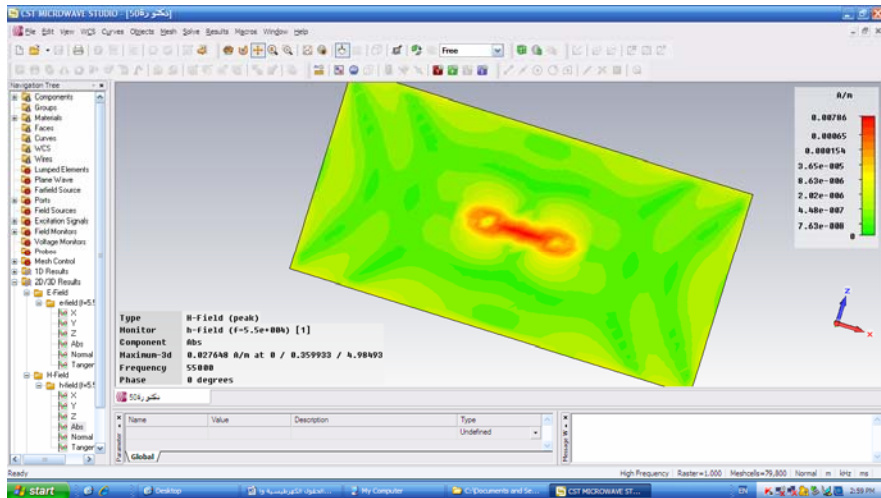
50 MHz 2 : (1)



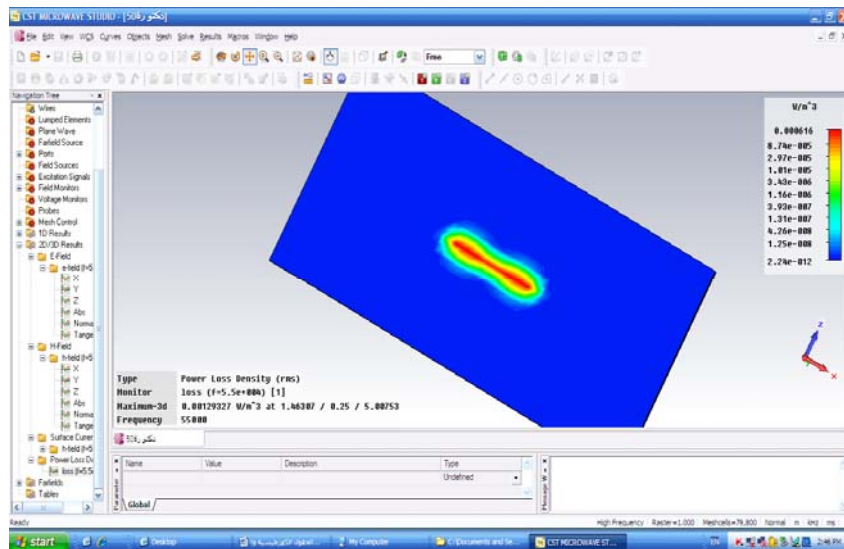
50 MHz 2 : (2)



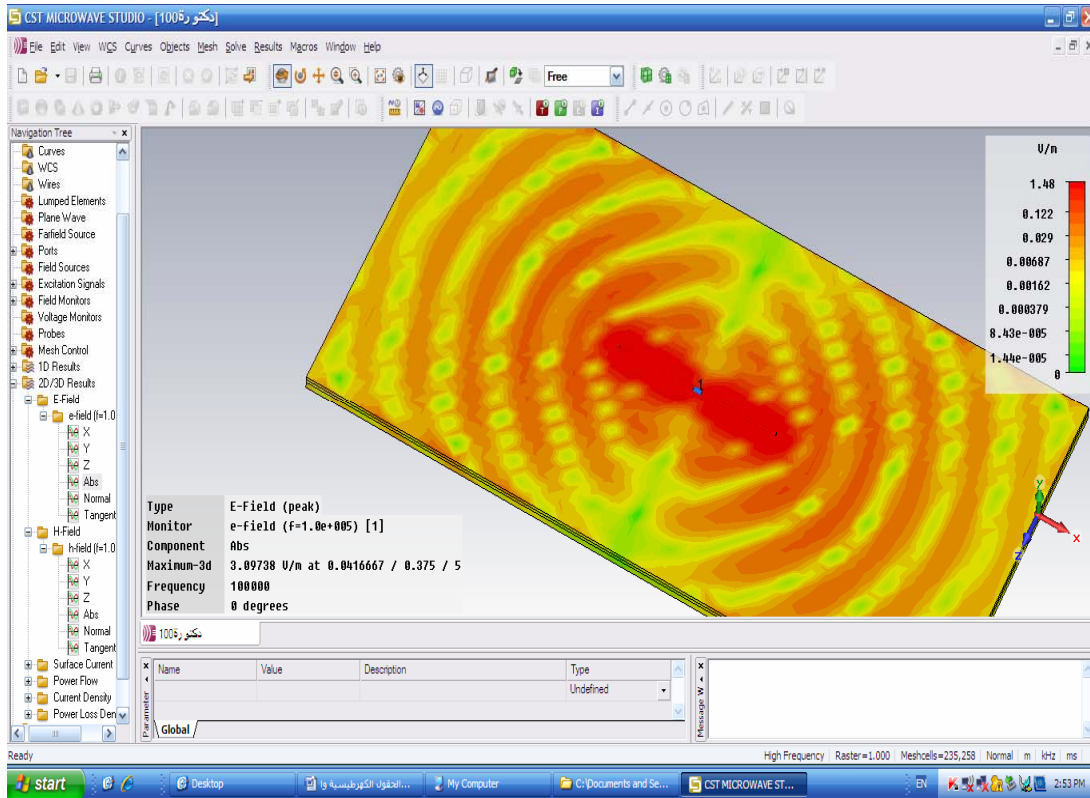
50 MH 2 :(3)



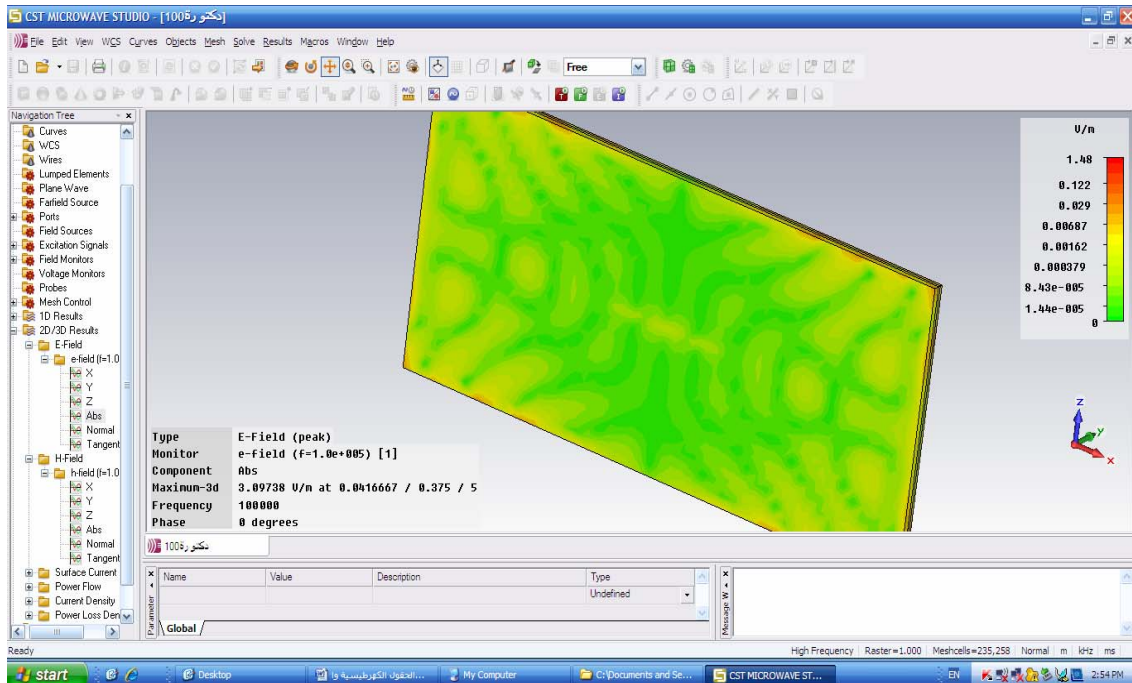
50 MHz 2 :(4)



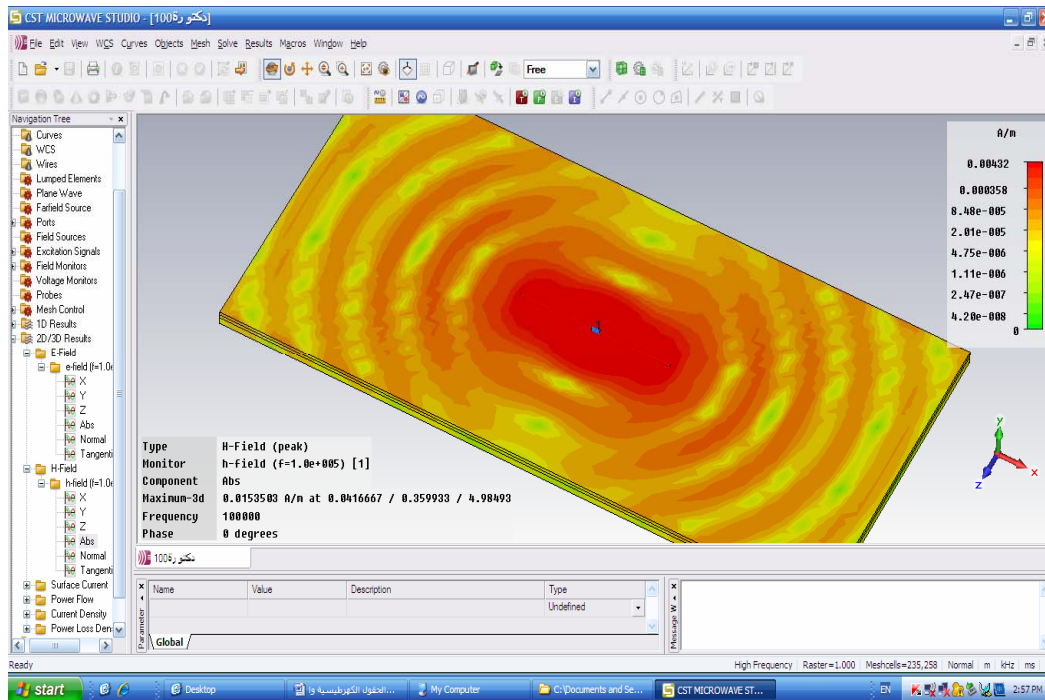
50 MHz 2 SAR :(5)



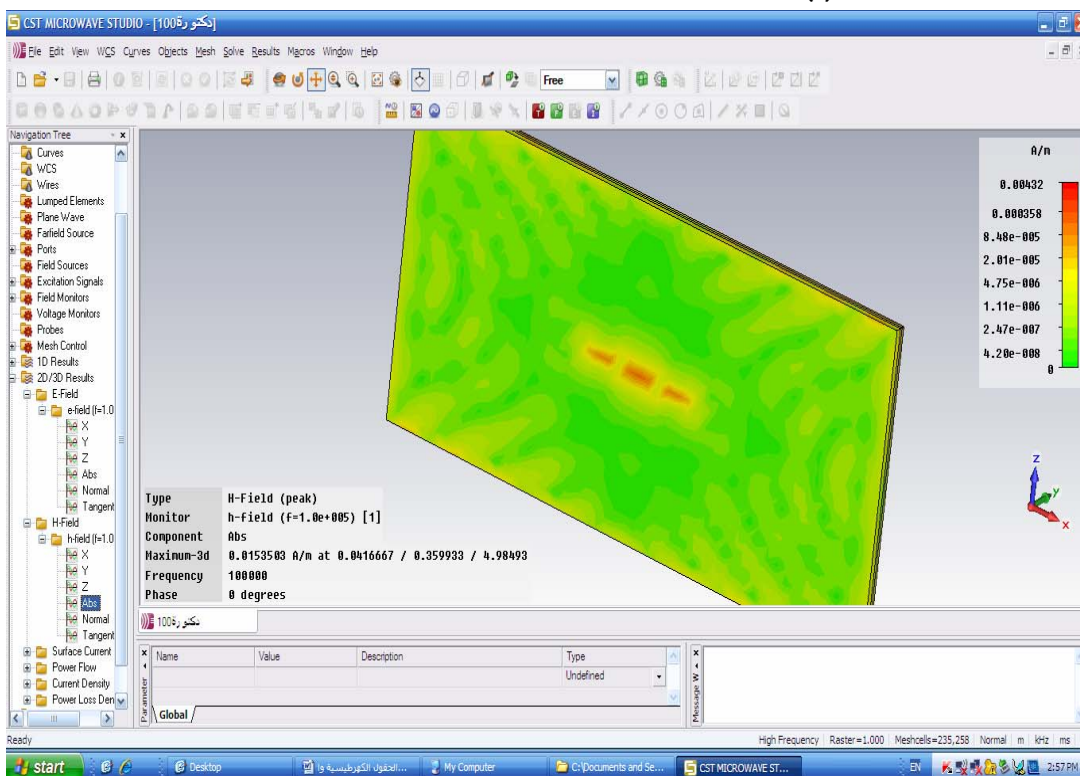
100 MHz 2 :(6)



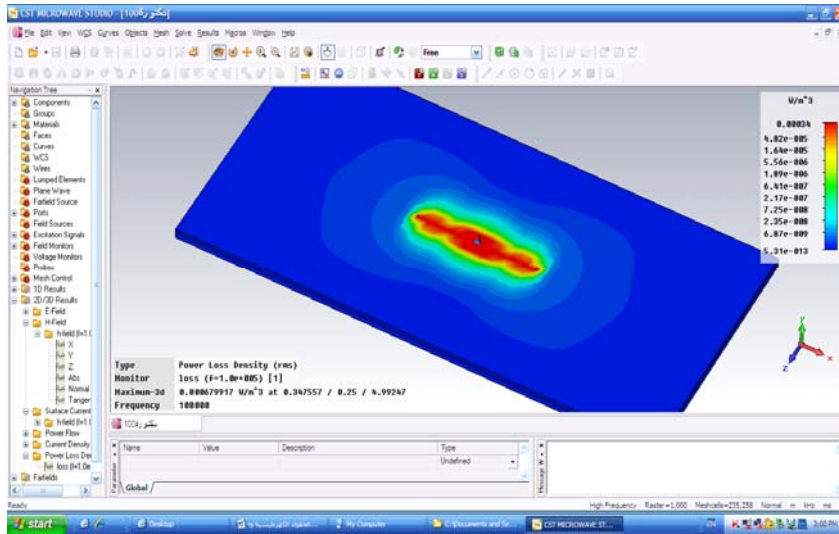
100 MHz 2 :(7)



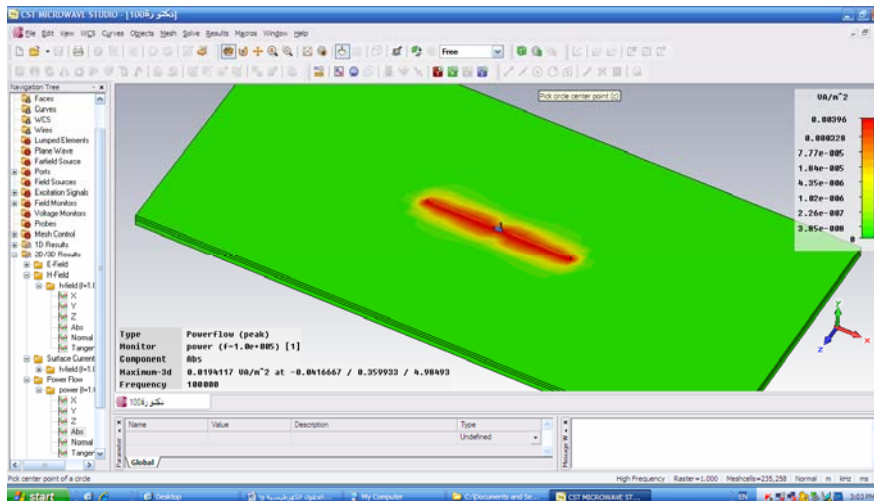
100 MHz 2 : (8)



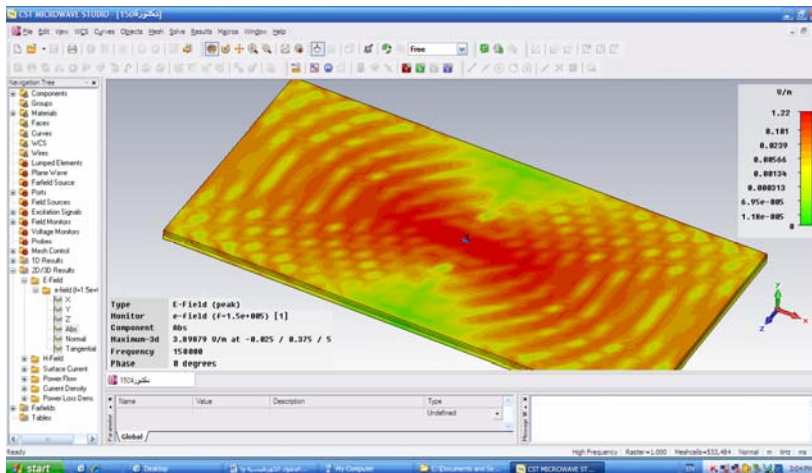
100 MHz 2 : (9)



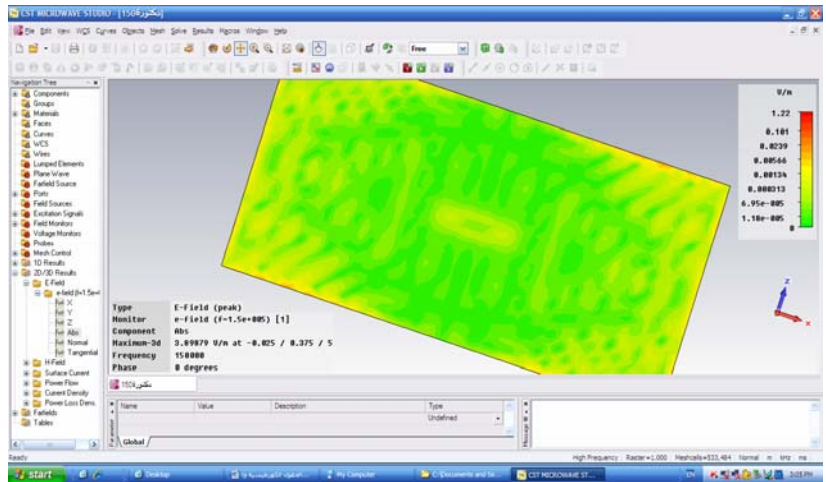
100 MHz 2 SAR : (10)



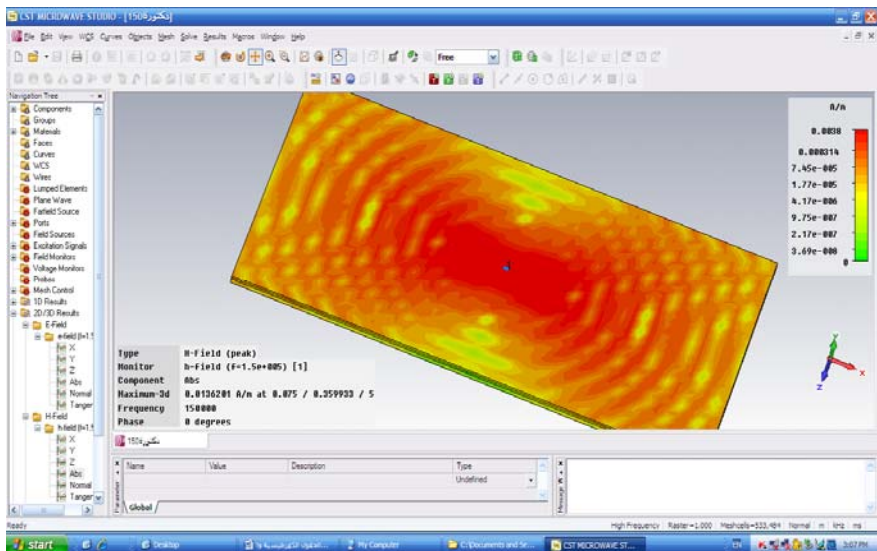
100 MHz 2 : (11)



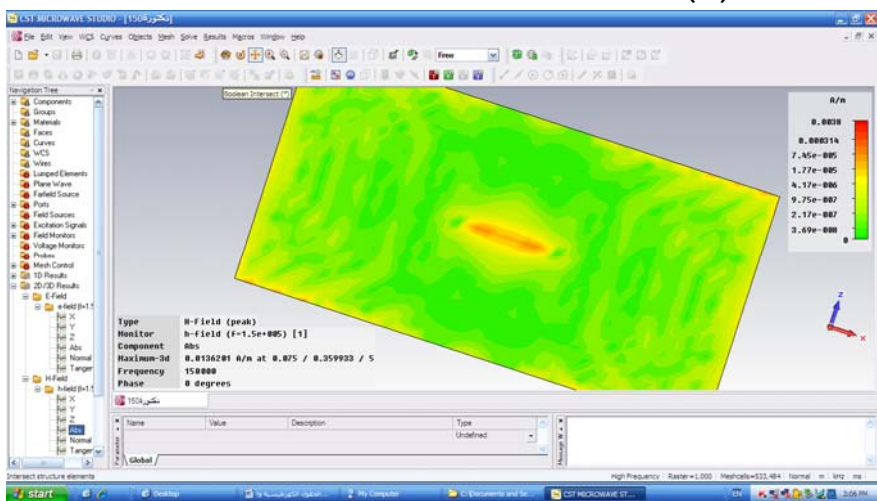
150 MHz 2 : (12)



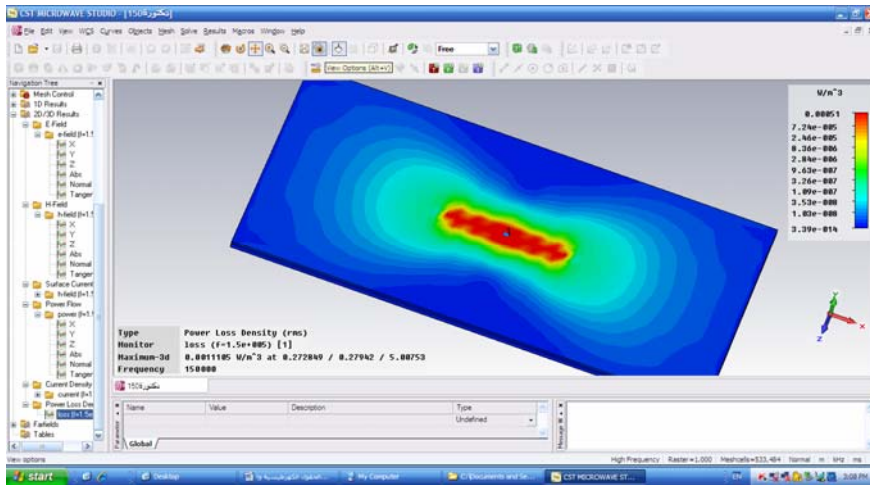
150 MHz 2 : (13)



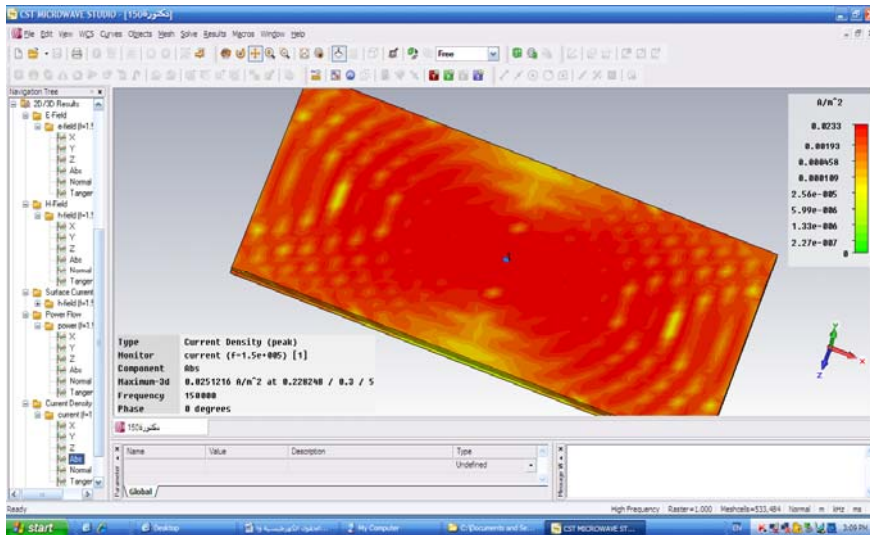
150 MHz 2 : (14)



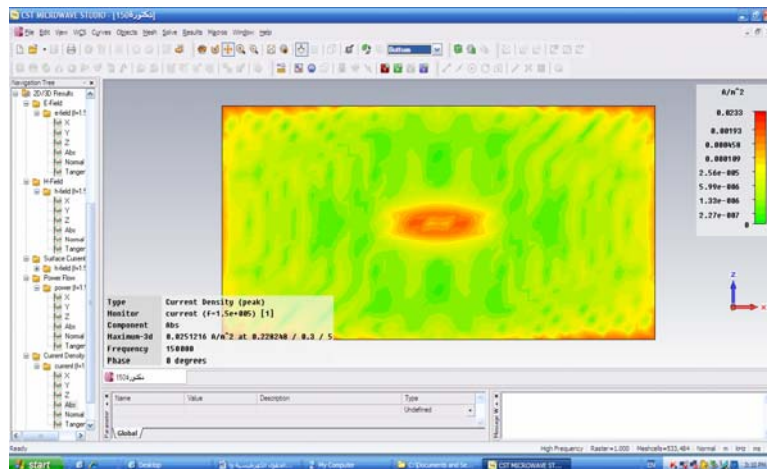
150 MHz 2 : (15)



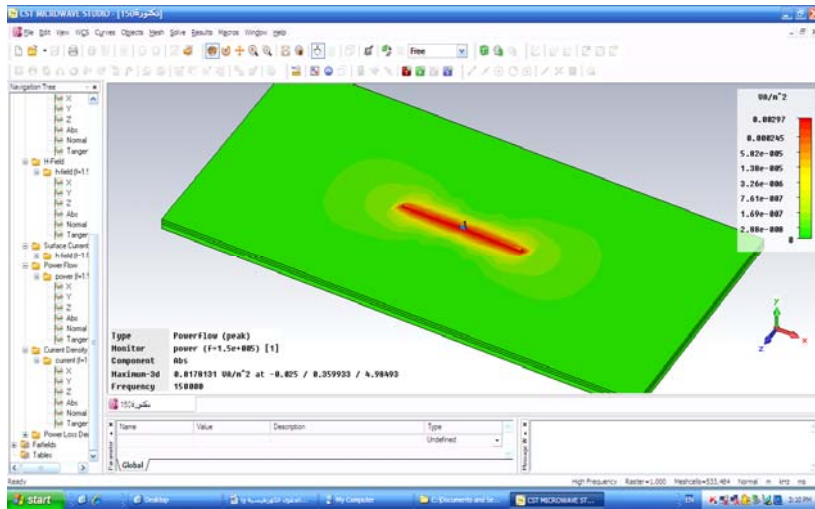
150 MHz 2 SAR : (16)



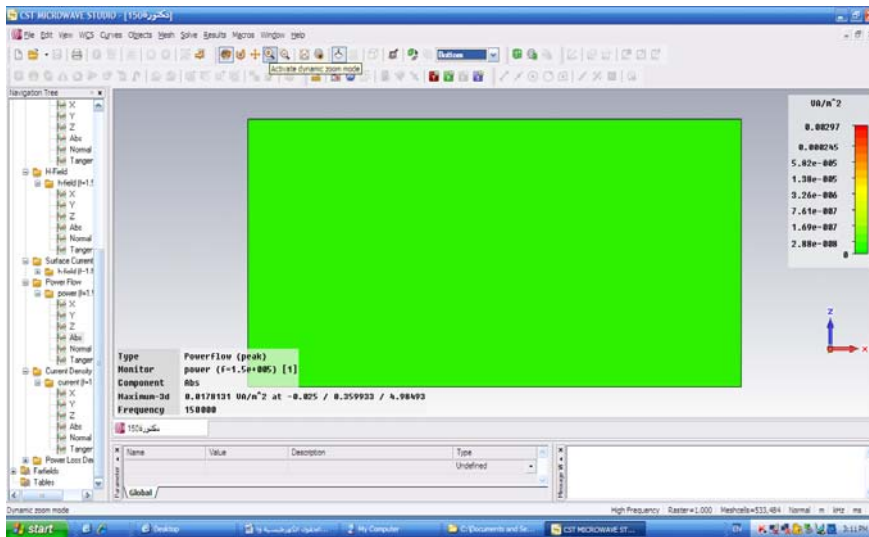
150 MHz 2 : (17)



150 MHz 2 : (18)



150 MHz 2 : (19)



150 MHz 2 : (20)

CST

] [10 5]
 . [18 17
 :

. [1 , 2, 3, 4, 5, 6, 7, 8, 9]

[20 19] ()

50 –250 MHz

[6,5]
(1 ~~μ s~~ = 1ms)
20 ms 50 Hz

100 MHz

Reference*

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