Report

Specific Absorption Ratio Measurement

Panasonic / Matsushita Communication Industrial CO,. LTD.

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1 Subject of Investigation

The Panasonic company manufacture mobile phones for US-TDMA. A new device are the ***„EB-TX210A"*** and ***„EB-TX220A"*** these are dual-band dual-mode TDMA phone (AMPS mode at 800Mhz band , TDMA mode at 800MHz band , TDMA mode at 1900MHz band).The mobile was investigated with respect to guidelines referring to limits for electromagnetic field exposure in order to avoid adverse health effects to human beings. The examinations have been carried out by the use of a dosimetric assessment system „DASY" described below.

2 Radio frequency Field Exposure Standards

2.1 SAR Limits for Mobile Phones

In this examination the comparison between the existing standards with the measured data should be made using basic limits for the specific absorption rate SAR.

Having in mind a consideration of safety that proceeds under all circumstances from an unfavorable operation, all following listed limits count for the uncontrolled environment, for exposure times longer than 6 minutes and for SAR-values which may appear in the head. At the same time local SAR-values have to be averaged concerning an interval of 6 minutes and a volume given in Tab. 1. Corresponding to the different mass for the averaging procedure there will be distinguished between SAR values for 10 g ***mass*** (SAR_{10g}) and for 1 g mass (SAR1g)

Norm	Status	Averaging	SAR limit	Reference
DIN VDE 0848 Teil 2, 1991	draft	10 g mass, shape: arbitrary	2.0	[DIN 0848/1991]
CENELEC ENV 50166-2, 1995	draft	10 g mass, shape: cube	2.0	[ENV 50166 1995]
ANSI C95.1-1991	in force	1 g mass, shape: cube	1.6	[ANSI 1991]

Tab 1: Relevant basic limits for the specific absorption rate (SAR), valid for mobile phone's in the frequency range from 30 MHz to 6 GHz

2.2 Instructions for the Measurement Procedure to Determine SAR-Values

For a long time there have been exact instructions about how and which antennas under what distances and under what conditions the electrical field strength, which is produced by devices like mixers, heatable blankets etc., has to be measured [EN 55014]. Very recently there has been a draft for a measurement instruction for SAR-values for mobile communication systems: " Safety considerations for human exposure to EMF from mobile telecommunication equipment (MTE) in the frequency range 30 MHz to 6 GHz't approved by the CENELEC SC1 l1B Task Group [CENELEC 96]. This standard will surely obtain the status of a product standard and contains therefore, an exact instruction for the product, measurement procedure and what kind of specification for the used measurement equipment has to be realized. For the useful application the following three points are important:

- **The Dosimetric Assessment System (DASY) meets the CENELEC requirements for an appropriate SAR measurement systems.**

- Different positions of the mobile phone to the head have to be considered and The phone must operate at maximum RF output power during the measurement

3. The Dosimetric Assessment System

DASY stands for „Dosimetric Assessment System'' and describes a system which is able to determine the SAR distribution inside a phantom of a human being. It consists of a robot controlling a newly *E*-field probe with outstanding features and calibrated for use in liquids, an anatomically correct shell phantom, tissue simulating liquids and software. The software controls the robot and processes the measured data to compare them with the limits of the several guidelines [ANSI 1991, ENV 50166 or DIN 0848 91]. Fig. 1 - Fig. 3 show our equipment, similar to other items installed in the laboratories of several large companies [DASY 1995]. It was delivered by the Swiss company *Schmid & Partner Engineering AG*, and has been developed by Professor Kuster from the Swiss Federal Institute of Technology in Zürich.

Fig1: The robot controlled probe during SAR measurement.

3.1 SAR Measuring Procedure

A MTE acting on maximum power level is placed in four well-defined positions at a shell phantom of a human being as described in the CENELEC instruction [CENELEC 96] and depicted below. The electric field strength distribution E is measured within the head model in a tissue simulating liquid. The corresponding SAR values are calculated using the relation

$$SAR = \sigma \frac{E^2}{\rho}$$

where •is the electrical conductivity of the tissue and •is the mass density. The software controlling the robot is able to determine the averaged SAR-values (averaging region 1g applying the ANSI guidelines or 10g using the European prestandard) for the compliance test.

Because the electric parameters of human tissue (and the synthetic liquid also) are frequency dependent, it becomes necessary to report these parameters in order to support comparison with other measurements. We use parameters given in the most recent issue of the ANSI measurement instruction

Fig2: The measurement set-up with a phantom containing tissue simulating liquid .

3.2 Near Field Characterization

The DASY system is also an important tool for the development and the design of new antennas and handsets for mobiles. The six-axis robot includes an extreme accurate mechanism and the probes are highly isotropic, small and without metallic feeding. Due to these

Fig3: The measurement set-up MTE under test.

skillful combination it is possible to measure reliable electric and magnetic field strengths in the near field region very close to the telephone surface. In order to get information about the source of the radiation causing high SAR values in a human head it becomes helpful to analyze the electric and especially the magnetic field strength distribution. DASY measurements can be done in a plane close to the surface as well as along a line in order to get distance dependencies.

3.3 Handheld Mobile Phone Positions

As it cannot be expected that the user will hold the phone exactly in only one well defined position, different reasonable operational conditions shall be tested. The intended position that is the most popular position. For an exact definition helpful geometric constructions are introduced and shown in Fig. 4. A reference line describing the phone is defined as a line (on the surface of the phone facing the phantom) which connects the center of the ear piece with the center of the bottom of the case (typically near the microphone). The human head position is given by means of a reference plane defined by the following three points: auditory canal opening of both ears and the center of the closed mouth.

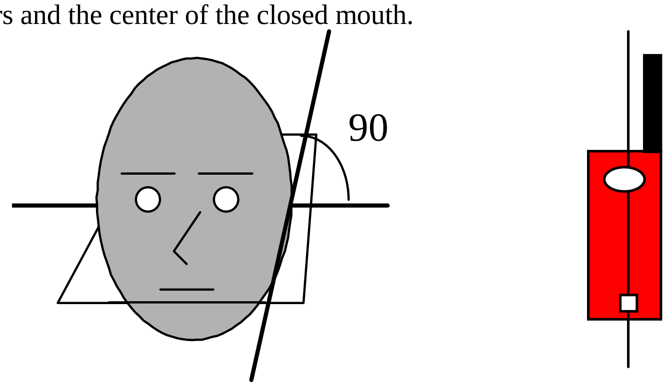
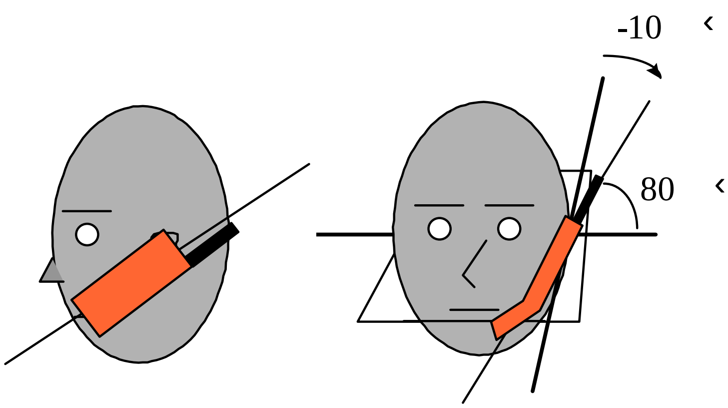


Fig4: Geometric constructions supporting the definition of different positions for a mobile phone at a human head. The phone is described by a line and the head by means of a plane.



The center of the ear piece shall be placed directly at the entrance of the auditory canal. The telephone line shall lie in the head plane and shall be situated in an angle of 80• to the line connecting the both auditory canal openings.

Fig 5: The “intended use” position describes the normal operating condition.

3.4 Technical Parameters of the Measurement System

Parameter	DASY	CENELEC requirements
spatial resolution	5 mm	5 mm
repeatability of probe position	+/-0.2 mm	+/-0.5 mm
dynamic range	5mW/kg ~ 100W/kg	100mW/kg ~ 100W/kg

Table 2: System specification in comparison to requirements stated by CENELEC.

Parameter	Accuracy
frequency linearity	< 0.2 dB
deviation from isotropy (in air)	< 0.8 dB
surface detection	0.1 mm

Table 3: Probe specification.

Parameter	Noise Floor
SAR values (see chapter 3.1)	< 0.002 W/kg
field strength E_{eff} electric field	< 1.5 V/m
field strength H_{eff} magnetic field	< 0.006 A/m

Table 4: Sensitivity of DASY (normal non shielded environment).

Accuracy Influencing Conditions	Accuracy of SAR Values
Isotropy, calibration, noise floor	< 13%@1W/kg
Extrapolation of SAR values	< 7%
Dielectric parameters	< 5%

Table 5: Influences on accuracy of the SAR_{1g} and SAR_{10g} values determined by measurements.

4 Measurements

4.1 Record

4.1.1 Administrative Data

record - indent : Yuichi Kimura
record file: Polaris.doc
record author(s): Mitsuharu Nakasato
date of measurement: 18.04.2000-28.04.2000
data stored at: disk:

4.1.2 Subject and Requirements for Operation

MTE: Panasonic EB-TX210A / EB-TX220A(Dual-mode Dual band phone)

Mode	channel	EB-TX210A power	EB-TX220A power
AMPS	991	25.0dBm	25.0dBm
	380	25.0dBm	25.0dBm
	799	25.0dBm	25.0dBm
800MHz TDMA	991	26.8dBm	26.8dBm
	380	26.8dBm	26.8dBm
	799	26.8dBm	26.8dBm
1900MHz TDMA	2	26.0dBm	26.0dBm
	1000	26.0dBm	26.0dBm
	1998	26.0dBm	26.0dBm

MS power was measured at cable adapter.

4.13 DASY Options

software version: DASY3 V1.0
probe: ET3DV5 SN: 1303 (dosimetric probe)
calibration: 18.04.2000 using a dipole validation kit: D900V2 (900 MHz)
25.04.2000 using a dipole validation kit: D1800V2 (1800MHz)
phantom: original “Kuster” twin head phantom (Fa. Schmid & Partner)
material parameters:

	Target	Measured
permitivity at 900MHz •r	42.5 +/-5%	40.9 41.6
permitivity at 1800MHz •r	41.0 +/-5%	39.58
Conductivity at 900MHz •	0.85 +/-10% S/m	0.835 S/m 0.820 S/m
Conductivity at 1800MHz •	1.65 +/-10% S/m	1.678 S/m
permitivity at OET65 Supplement C 900MHz •r	56.1	53.97
Conductivity at OET65 Supplement C 900MHz •	0.945 S/m	12.4 S/m
permitivity at OET65 Supplement C 1900MHz •r	54.3	52.47
Conductivity at OET65 Supplement C 1900MHz •	1.44S/m	1.666 S/m
mass density •	1.0 g/cm^3	

Tab. 6: Parameters of the tissue simulating liquid.

4.2 Measurement Results

The tables below contain measured values for the SAR_{1g} values. According to different rules for the region used for averaging two SAR values are supported: SAR_{1g} corresponding to the ANSI guideline and SAR_{10g} for a comparison with the European and German limit. Note that in all copies and publications of these results the material parameters must be enclosed because the SAR values depend on it. Due to inhomogeneous SAR distribution within the phantom, in all cases all SAR_{1g} values exceeds the SAR_{10g} values because for the determination of a SAR_{1g} value a smaller averaging volume with a more distinct focus on the high SAR region is used.

Phantom Position		right head		left head	
Position	Channel/model	EB-TX210A	EB-TX220A	EB-TX210A	EB-TX220A
intended	991ch	0.948	0.934	0.938	0.841
	380ch	1.340	1.380	1.120	1.290
	799ch	0.886	0.934	0.953	0.911

Tab. 7: Measurement SAR_{1g} results at AMPS mode
(900 MHz, $\bullet_r$ = 40.8, • = 0.82 S/m and • = 1.0 g/cm^3).

Phantom Position		right head		left head	
Position	Channel/model	EB-TX210A	EB-TX220A	EB-TX210A	EB-TX220A
intended	991ch	0.559	0.471	0.530	0.472
	380ch	0.746	0.757	0.736	0.710
	799ch	0.650	0.620	0.600	0.616

Tab. 8: Measurement SAR_{1g} results at 800MHz TDMA mode
(900 MHz, $\bullet_r$ = 41.6, • = 0.83 S/m and • = 1.0 g/cm^3).

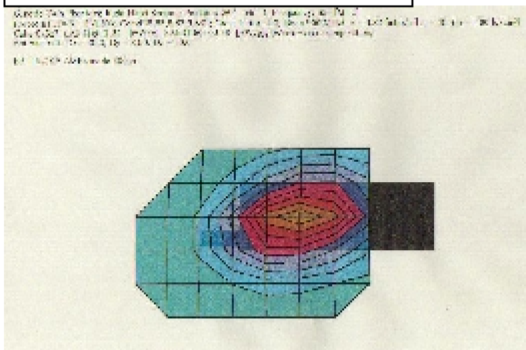
Phantom Position		right head		left head	
Position	Channel/model	EB-TX210A	EB-TX220A	EB-TX210A	EB-TX220A
intended	2ch	1.300	1.360	1.110	1.210
	1000ch	1.110	1.160	0.958	1.270
	1998ch	1.140	0.975	1.040	1.080

Tab. 9: Measurement SAR_{1g} results at 1900MHz TDMA mode
(1800 MHz, $\bullet_r$ = 39.58, • = 1.678 S/m and • = 1.0 g/cm^3).

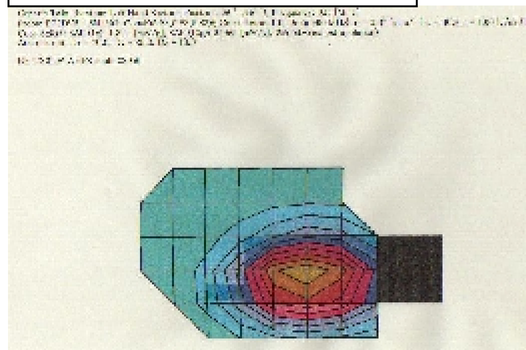
Tab 7 Tab 8 and 9 are summarized and compared to the limits.

AMPS mode SAR

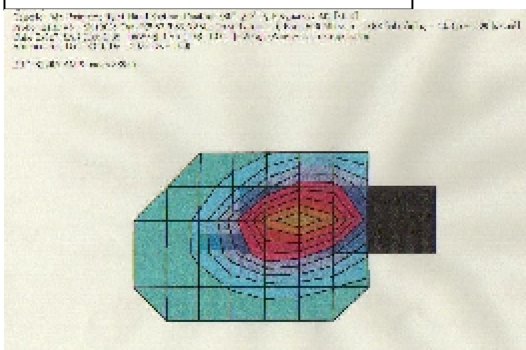
EB-TX210A 380ch Right



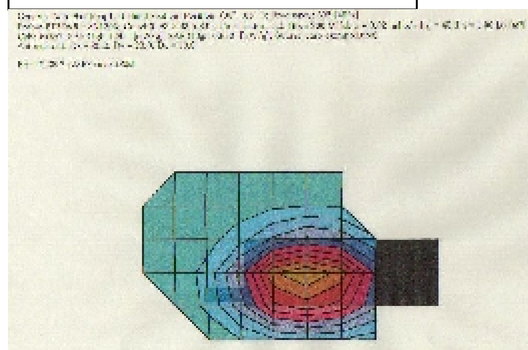
EB-TX210A 380ch Left



EB-TX220A 380ch Right

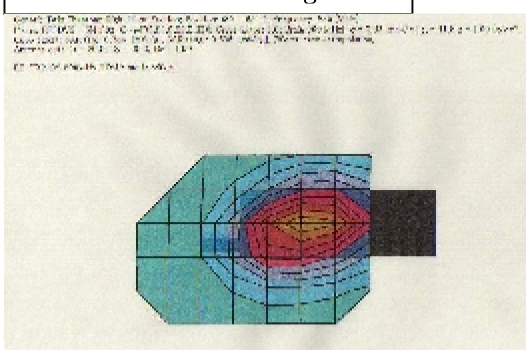


EB-TX220A 380ch Left

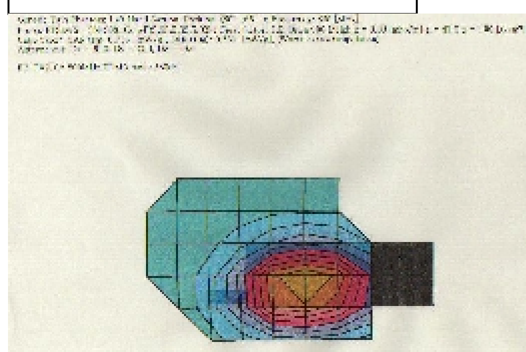


800MHz TDMA mode SAR

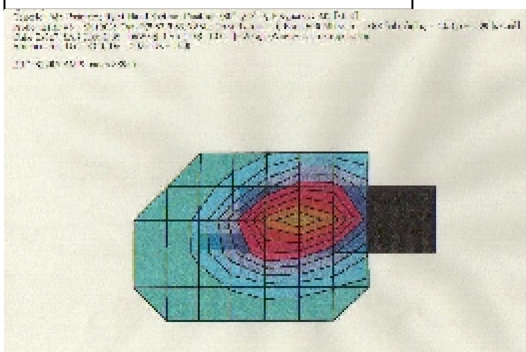
EB-TX210A 380ch Right



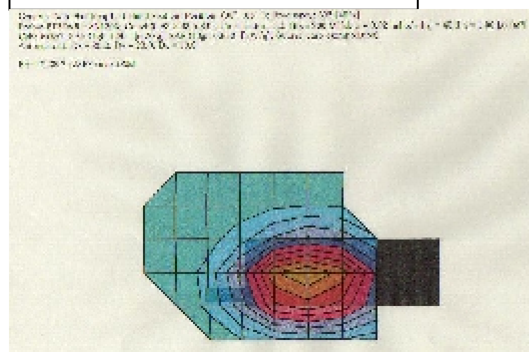
EB-TX210A 380ch Left



EB-TX220A 380ch Right

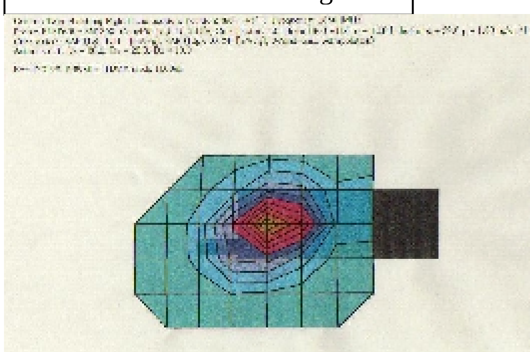


EB-TX220A 380ch Left

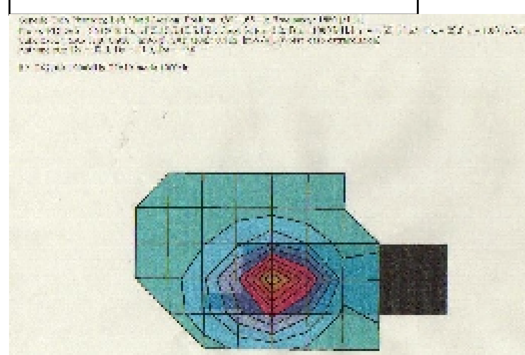


1900MHz TDMA SAR

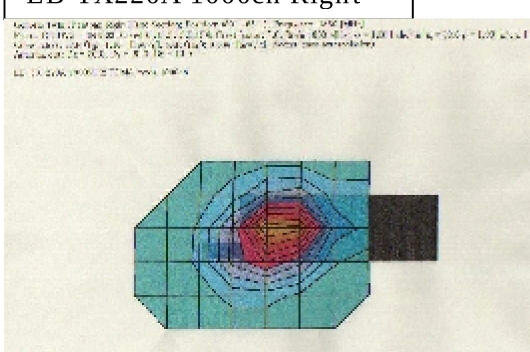
EB-TX210A 1000ch Right



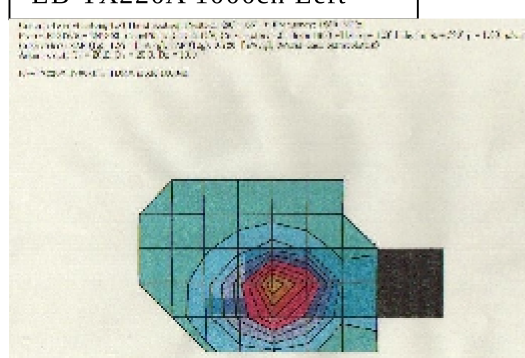
EB-TX210A 1000ch Left



EB-TX220A 1000ch Right



EB-TX220A 1000ch Left



4.3 Judge

Panasonic cellular phones(EB-TX210A/EB-TX220A) are compliance with FCC guideline.

5 References

[ANSI 1991]

ANSI C95.1:IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields,3kHz to 300GHz,Inst.of Electronics Engineers,Inc.,1991.

[DASY 95]

Referenzliste der Herstellers, der Fa. Smhid & Partner Engineering AG,uber instllierte DASY-System mit RX90 robrten

[Kuster 1997]

N.Kuster, R. Kastel and T. Schmid:Domestic evaluation of handheld mobile communications equipment with known precision,In:IEICE Trans. Commun.,Bd.E80-B,No.5,S.645-652,1997

[WHO 1993]

WHO/IRPA task group on electromagnetic fields: ,,Environmental Health Criteria 37, Electromagnetic Fields (300 Hz to 3006Hz)", WHO, Geneva, 1992.

6.List of test equipment

	Equipment	Manufactured	Model
SAR measurement DASY3V1.0	E field probe(isotropic)	S&P EAG	ET3DV5(SN:1303)
	Data acquisition system	S&P EAG	DAEV1(SN:223)
	Software	S&P EAG	DASY3
	Personal computer	S&P EAG	Gateway 2000
	Generic twin phantom	S&P EAG	V3.0
	Sample holder	S&P EAG	V2.0
	Robot	S&P EAG	RX90L
	Robot arm extension	S&P EAG	V2.1
Liquid measurement	Network analyzer	HP	HP8752C
	Software	HP	HP85071B
	Materials measurement probe	HP 3rd party	CSH2-APC7
	Brain simulating liquid 900MHz	S&P EAG	900MHz sample
	Brain simulating liquid 1800MHz	S&P EAG	1800MHz sample
System calibration	Vector signal analyzer	HP	E4432A
	Power amplifier	R&K	A1000-15-R
	Power amplifier	R&K	
	Power meter	HP	HP437B
	Power sensor	HP	HP8482B
	Dipole validation kit(900MHz)	S&P EAG	D900V2(SN:010)
	Dipole validatin kit(1800MHz)	S&P EAG	D1800V2(SN:205)

Manufactured

S&P EAG: Schmid & Partner Engineering AG
HP: Hewlett Packard
R&K: R&K inc
HP 3rd party: Kantou Denshi Ouyou Kaihatsu