Calculation of SAR Value from Different Handsets by Electromagnetic Detector Radiation

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Abstract: The radio wave exposure guidelines use a unit of measurement known as the Specific Absorption Rate, or SAR. The SAR limit in India for mobile phone is 1.6 W/kg. The main motive of this paper is to study about the SAR value of different phones. In this paper, we studied the definition of SAR that how it is harmful for human while using their handsets. Limit of SAR and effect on human health is also discussed in this paper. A short summary is given on equipment (Electromagnetic Detector) that is used for measuring SAR value by formula that is formulated in this paper. A well explained table is given in this paper that described the different SAR value, their EMR frequency range and observed SAR released by different phones.

Keywords: SAR, W/kg, μW/cm^2, DT-1130

I. Introduction

The limit of exposure uses a measurement unit that is known as SAR. A rate in which how much energy is absorbed by the human body that is exposed to radio and electromagnetic frequency. SAR is a power that is absorbed by the mass of body tissue and its unit in watts per kilogram. SAR is usually measured over the whole body that is10g of tissues and over a small volume that is 1 g of tissue. A regulatory threshold SAR value for the mobile phone device has accessed by every country. 1.6 W/kg units for is 1g of body tissue and 2.0 W/kg units is for 10g of body tissues are being the regulatory unit in India. In India, no mobile company can able to exceed this fix regulatory unit. [29] Although, it also refers as absorption of any type of energy by tissues that have an ultrasound. When the human body is exposed to radio waves, the SAR is a calculation of measures the rate of how much energy is absorbed. In mobile telephony system, the SAR is used to calculate the energy absorbed by a mass of human body tissue within a definite amount of time. In other words, SAR is nothing but an easy way to measure a mobile phone's radiation broadcasting potentials and helps us to make sure that a device doesn't go beyond safety limits.[1],[2],[3]

Fig 1.1 shows the exposure of radiation on the human head while talking on the phone.

SAR is calculated as under;

$$\mathrm{SAR} = \frac{1}{V}\int_{\mathrm{sample}} \frac{\sigma(\mathbf{r})|\mathbf{E}(\mathbf{r})|^2}{\rho(\mathbf{r})} d\mathbf{r}$$

Where,

σ is sample of electrical conductivity

E is RMS electric field

ρ is sample of density

V is volume of sample

Exposure between 100KHz to 10 GHz that is called as radio waves and applicate to count the cell phone absorbed power. The value will be based on exposed to the Radio Frequency in body, and on Radio Frequency source. Thus, experiment must be considered with both sources. When calculating the SAR, the mobile is placed opposite to head of human in a position of talking and then checked on the place where is the highest absorption rate in the head is found. Measurement is considered on both sides of the head and at various frequencies elected by the frequency bands.[4]

How to calculate the SAR value?

For SAR measurement, set a quantity of mass. Measurements are basically calculated on the whole body and samples of tissue. While measuring the value of SAR, the mobile phone is placed against a denotation of a human body in a position of talking. To find the SAR value, a smartphone is checked under bad condition scenario to emit the excessive radiation level and the same time, measurements are taken at different distances between the human head and phone, to imitate the way of holding phone by each user.

II. SAR Limit

After working with health and safety agencies like Food and Drug Administration and Federal Communications Commission has taken a safety exposure limit to RF energy and given a unit expressed as the SAR, that measured the summation of RF energy released by body of human when using a phone. The Federal Communications Commission demands of productioners of mobile phone to make sure that mobile is manufactured under these for safety exposure limits. The mobile under these SAR levels is a "safe" mobile. The level of SAR is 1.6 W/kg is a public exposure limit under the FCC in mobile telephones.[5] 1.6W/kg is for 1g of tissue of body. 2.0W/kg is for 10g of tissue of body.[6] In the US, 1.6 W/Kg of SAR value is taken over the 1g of tissue. In Europe, SAR limit is 2 W/kg in a sample of 10 g of bodily tissue that doesn't mean Europe have an excessive allowed limit of SAR than in the US. We cannot differentiate these two values because they have various amounts of tissue.[3]

Some good habits that help to keep yourself from the radiation. They are:

- Avoid the cell in a pocket or close to the body when not in the use.
- When receiving signal is quite low, then try not to make or receive a call for a long time because of low signal phone increases their transmission power that can be harmful to human health.
- Do short calls and use headphones for long calls.
- It is better to do texting over calls.
- When you call or dial, don’t put the phone close the ear till you hear the ring sound
- It is better to choose the mobile with low SAR.[7]

III. Table of SAR

Table 3.1 shows Harmful Impact of SAR on Human

Sr. No.	SAR	Reported Biological Effects	Year	References
1.	0.000021 to 0.0021 W/Kg	It can change in system of human cell.	1997	Kwee, (Sage)
2.	0.0004 W/Kg	It can cause a change in the Blood-Brain Barrier at 915 MHz of frequency in GSM cell phone.	1997	Salford, (Sage)
3.	0.0008 W/Kg	It can increase the DNA Strand Breaks.	2009	Kesari and Behari, (Levitt/Lai)
4.	0.0004-0.008 W/Kg	It can cause leakage BBB.	1997	Persson, (Sage)
5.	0.001 W/Kg	It affects the cell growth rate and damages the DNA.	2000	de Pomerai, (Sage)
6.	0.0027 W/Kg	It can cause a behavioral change in human after 5 hours of mobile exposure	1994	Navakatikian, (Sage)
7.	0.0037 W/Kg	It may change the repair mechanisms of DNA.	2009	Belyaev et al, (Levitt/Lai)
8.	0.005 W/kg	It can increase calcium flux in cells.	1989	Dutta (Levitt/Lai)
9.	0.0024 W/Kg - 0.024 W/Kg	It can damage the DNA and DNA repair mechanisms. Also, the low intensities digital cell phone can cause DNA effect in the Human cell.	1989	Phillips, (Sage)
10.	0.0317 W/kg	It can cause abdominal stomach problems.	1990	Ray & Behari, (Sage)
11.	0.3-0.44 W/Kg	Using more cell phone may change the thinking and mental task related to memory retrieval.	2000	Preece, Koivisto et al, (Sage)
12.	0.3-0.44 W/Kg	Within this range, user experience changes in thinking and mental tasking of brain.	2000	Krause et al, (Sage)
13.	0.037 W/Kg	The ultra-wide band pulses of 600/Sec can cause hyperactivity.	1999	Seamans, (Sage)

14.	0.005-0.05 W/Kg	It can increase the calcium flux.	1989	Dutta (Sage)
15.	0.121 W/kg	It can cause hypertension.	1999	Lu et al, (Sage)
16.	0.14 W/kg	It may affect the immune system response at range of 100 μW/cm2.	1996	Elekes (Sage)
17.	0.26 W/Kg	It can cause dangerous effects to the eye.	1992	Kues (Sage)
18.	0.15-0.4 W/Kg	At 480 μW/cm2, it can cause the risk of malignancy. Tumors statically	1992	Chou, (Sage)
19.	0.58 - 0.75 W/Kg	With 836 MHz of frequency in TDMA Digital cell phone, it can cause tumors in the brain.	1996	Adey, (Sage)
20.	to 1.0 W/Kg (max)	It can change the patterns of sleep and EEG	1999	Borbely et al, (Sage)
21.	0.6 to 1.2 W/Kg	It may increase the DNA with RF exposure (2450 MHz)	1996	Lai & Singh, (Sage)
22.	2 to 3 W/Kg	It can cause cancer in skin or breast cancer.	1982	Szmigielski, (Sage)

IV. Equipment used for Measuring SAR Value

To calculate EMI radiation, we use Electromagnetic Radiation Detector (DT-1130) device.

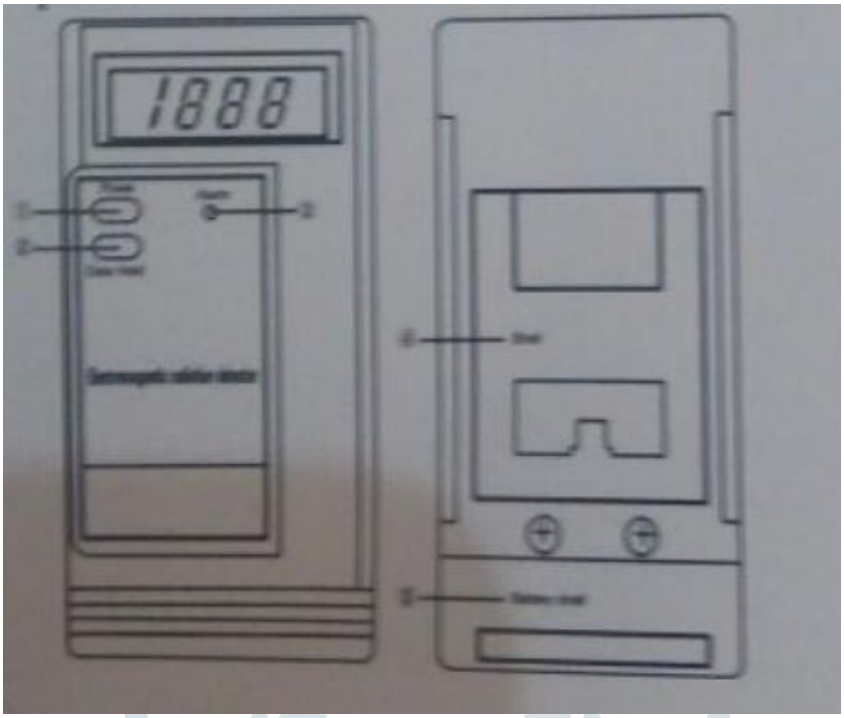


Fig 4.1 diagrammatic representations of Electromagnetic Radiation Detector (DT-1130) device.

This device is latest electromagnetic radiation product.

4.1 Advantages

i. The device has low cost.
ii. It has a wide frequency range.
iii. It is more stable, especially for mobile.
iv. It is more reliable.

4.2 Functional Component of device are:

i. Switch
ii. Data hold
iii. Alarm
iv. Battery shell
v. Display Screen

Fig 4.2 Electromagnetic radiation detector DT-1130

a) **Specifications**

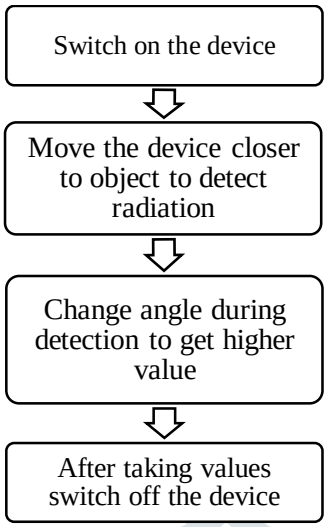
i. Size: 132mm(L)x69mm(W)x29mm(H)
ii. Weight: 190g
iii. Screen: LCD
iv. Frequency range: 50Hz to 2000MHz
v. Reacting time: 0.4s
vi. Voltage: 9V
vii. Battery model: 6F22 9V
viii. Accessory: User manual, warranty card, battery.

4.3 About battery

Fig 4.3 9V Battery

i. The detector uses 9 volts of battery.
ii. If readings are too low and alarm start to ring that means device has low power and has to be changed.
iii. Remove the battery after the reading has noted.

4.4 Step to Radiation Detection



The flow chart shows the steps of radiation detection. The first step is to switch on the device. By switching on the device, the led in detector is blown up and ready to use. Then the second step is to move the device (that is used for measuring the SAR and Radiation) closer to the detector for testing. Change the angle during detection of device to get the highest value. By tilting the angle while detection, more accurate value will be obtained and we get the value of the device. After all these steps or taking values, switch off the device and removed the battery from the detector.[1], [2]

V. Formula Formulation

The mobile phone exposure limits use SAR (Specific Absorption Rate) as a unit of measurement. The SAR limit is 1.6 W/Kg for mobile phones. The detector, we used to measure the rate of radiation is Electromagnetic Radiation Detector DT-1130. The unit of measurement of this device is microwatt per square centimeter ($\mu W/cm^2$). For calculating the SAR value, we have to convert $\mu W/cm^2$ to W/Kg.

So formula formation is as follows

$\mu W/cm^2$= W/Kg

Firstly, convert microwatt to watt i.e. 1mw is equal to 10^{-6} which is equal to 1/1000000

Then convert Kg to cm

1 Kg is equal to 415.54cm^3

From this we can find 1 Kg to cm^2

So 1 Kg is equal to 55.6855cm^2

By this formulation we can convert $\mu W/cm^2$ to W/Kg and easily calculate the SAR value from Electromagnetic Radiation Detector DT-1130.[1],12]

VI. Table of SAR Calculation

Table 1.6 shows the SAR value in Branded/ Non-Branded:[1],[2],[3],[8],[9],[10]

Sr. No.	Mobile Phone	Model Number	Given SAR (W/Kg)	Frequency $\mu W/cm^2$	Observed SAR (W/Kg)
1.	Samsung J2 Pro 16	SM-J2-10 F	0.780	1620	0.0902
2.	I Phone 5	MF 35 2HNA	1.18	1622	0.0903
3.	Motorola	Moto E (2G)	0.16	1161	0.0646
4.	Samsung J7	SM A710 F	0.296	1509	0.0840
5.	I-Pad	MP2F2HNA	1.19	1412	0.0786
6.	Samsung Galaxy Tab 2	GT-P3100	0.831	1228	0.0683
7	Intex	Yuvi+	0.902	874	0.0486
8	Motorola Moto G5 Plus	XT1684	0.38	1450	0.807
9	Motorola Moto G6 Plus	XT1926	0.44	1347	0.750
10	Motorola Moto G7 Plus	moto g(7) plus	0.45	1220	0.679
11	Nokia 8.1	TA-1119	1.49	1500	0.835
12	Nokia 3.1	TA-1049	1.63	1580	0.879
13	Nokia 5.1	TA-1105	1.8	1709	0.951
14	Iphone XS Max	A1921	1.52	1660	0.924
15	Iphone XS	A1920	1.53	1612	0.89
16	LG V40	V404TAB	1.59	1665	0.927
17	Sony Xperia XZ3	H8416	1.08	1200	0.668
18	Nokia Lumia 925	RM-893	1.40	1101	0.613
19	Samsung Galaxy S3	GT-i9300	0.87	1480	0.824
20	LG V30	H930DS	1.20	1567	0.872
21	Xiaomi Redmi Note 5	5 SD625	1.29	1574	0.876
22	Samsung Galaxy J7 Prime	SM-J727T1	0.64	1309	0.728
23	Redmi Note 4	4 SD625	0.375	1107	0.616

24	Nokia 6.1	TA- 1103	0.944	1209	0.673
25	Nokia lumia 735	RM-1038	0.8	1010	0.562

VII. Conclusion

Sar take an important role in mobile communication system. There is a public exposure limit of SAR value given by FCC that is 1.6 W/kg for head SAR and 2.0 W/kg for whole body SAR. No mobile company are able to exceed this limit of exposure, and if they do so, the FCC banned their handsets. In this paper we discussed the harmful effect of high-level SAR and concluded the original and observed SAR released by different handsets.

Reference

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