Mobile Communication
Radio Waves & Safety

Department of Telecommunications
Ministry of Communications & IT, Government of India
# Mobile Communication - Radio Waves & Safety

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Overview

India has experienced a phenomenal growth in the number of mobile phone users. The increased use of mobile phones in India has raised public interest in possible health issues associated with exposure to electromagnetic energy. People are concerned about exposure from mobile handsets & base stations.

Radio signals are part of everyday life, emitted both by natural sources like the sun, the Earth and the ionosphere, and by artificial sources such as: mobile phone base stations, broadcast towers, radar facilities, remote controls, medical, electrical and electronic equipment. The radio frequency sources in India are the transmitting towers such as AM, FM radio towers, TV towers, Cell phone towers, etc. emit radio frequency/microwave radiation continuously. The level of EMF from sources has risen exponentially, by soaring popularity of wireless technology such as cell phones, cordless phones, Wi-Fi (Wireless Internet) Wi-max and other wireless devices. The mobile phone and its base station communicate using a two way radio communication. This radio communication produces Electro-magnetic fields.

Intensive International research has not established any adverse health effect in the short or long term of Radio Frequency radiation exposure from mobile phones and cell tower antennas.

It is important to understand what radio waves are and what their use is in our daily life. This document covers a basic introduction to radio waves, various terminologies, Do’s & Don’ts related to mobile phone usage, clarification of various myths regarding deployment, use of Radio waves/safety standards and frequently asked questions relating to Mobile phones & Human health. The document “Mobile Communication Radio waves & Safety” shall help in facilitating the right inputs and creating an environment where everyone can use the radio wave safely.

“We cannot see or feel the radio waves – all the more reason to learn more about it.”
Radio Waves in Cellular Communication System

Radio waves

Radio wave is a type of electro-magnetic field and existed in nature before man came into existence. There are electro-magnetic fields of various frequencies from outer space reaching the earth in addition to ultraviolet rays or visible light. Radio wave is not felt, but is something quite natural like the air or water. “Our relationship with radio waves for use in communication has over 100 years of history”.

Mankind began using radio waves about 100 years ago with the invention of wireless communication by Marconi and Tesla. In India the first wireless use was in 1902, and commercial radio broadcast started in 1927 and the first Television broadcast in 1959 and since then the radio waves have been contributing towards advancement of culture, security, and innumerable day to day services. It has now become part of our way of life, being used for TV, radio, mobile phone, weather satellite, GPS (Geographical Positioning System), ITS (Intelligent Traffic System), disaster management, remote sensing, security forces etc. It is important to understand the safety aspects of the use of EMF and quite obvious to have some anxieties against radio waves, as we cannot see it or feel it directly. With the new wireless technologies being introduced at a rapid pace coming out one after another our use of radio wave is poised to continue to increase.

Electric field, Magnetic field

Electric fields come from the voltage that is used to make electric current flow in a wire. The voltage is like the water pressure which makes water flow in a plumbing system, and the electric current is like the water flow. Electric fields get bigger as the voltage increases. Electric field occurs around a conductor, such as power transmission line, electric cable/wire when voltage is put in. The strength / intensity of electric field is expressed with the unit Volt per meter (V/m). When there is an electric current in a conductor, a magnetic field is generated around it. Strength of the magnetic field is expressed with the unit ampere per meter (A/M).

Electromagnetic field (EMF)

Electric field and magnetic field together are called “electro-magnetic field”. When electric and magnetic fields are alternately generated and propagated through space together, this wave is called electro-magnetic wave and the strength of EMF is expressed with the units watt per square meter(W/m²). The number of oscillations of a wave in one second is called “frequency” and it is expressed in the unit Hz (hertz). In the cellular communication system radio waves are used for transmitting information between mobile phones and antennas.
The electromagnetic field (i.e. EMF) includes electric and magnetic fields from the electricity supply, radio waves from TV, radio devices, medical devices mobile phones, radar and satellite communications.

"The electro-magnetic field weakens very quickly as it moves away from the antenna. It is reduced to ¼ when the distance from antenna doubles and 1/9 when distance is tripled and so on."

Electromagnetic Radiation (EMR)

Electromagnetic Radiation consists of electric and magnetic energy waves moving together through space at the speed of light. We are exposed to both natural and man-made radiation. The electromagnetic radiation may occur naturally such as ultraviolet light from the sun and as made by lightning. The EMR, generated artificially/man-made, are for fixed and mobile radio communication, radio and television broadcasting, radar and other innumerable applications. The radio waves carry signal for television, cellular phone etc.

Types of Radiation

There are two types of radiation: Non-Ionizing radiation & Ionizing radiation

Non Ionizing radiation

The electromagnetic fields emission from mobile handsets and antenna are at relatively low end of electromagnetic spectrum and the energy carried by them are unable to break chemical bonds in molecules i.e. the energy level associated with Radio Frequency and microwave radiation, are not great enough to cause the ionization of atoms and molecules. The Radio Frequency (RF) energy is, therefore, a non ionizing radiation like radiation from visible light, infra-red radiation, and other forms of electromagnetic radiation with relatively low frequencies.

Cell phone is a very, very low level of radio frequency energy – too low to cause damage. The type of energy emitted is non-ionizing – means it does not cause damage to chemical bonds or DNA.

Ionizing radiation

"Ionization" is a process by which electrons are stripped from atoms and molecules. Those types of electromagnetic radiation with enough energy to ionize biological material include X-ray radiation and gamma ray radiations are examples of ionizing radiation. The ionizing radiation like from a medical X-ray, can present a health risk
at certain doses. However, small prescribed doses that are safe are often used in medical applications.

**Mobile handsets & Radio waves**

A mobile handset or a cellular phone is a low-power, two way radio. It contains a transmitter and a receiver. It emits electromagnetic / RF radiation to transmit information to the base station and it also acts like a receiver of information. Radio signals in a mobile phone are generated in the transmitter and emitted through its antenna. The radiation emitted by the antenna is not sufficient to cause any significant heating of tissues in the ear or head, although a rise in skin temperature may occur as a result of placing the mobile phone too close against the ear or head for a long time. This is due to insulation of the phone, contact with the screen, lack of ventilation between the ear and the phone, and the energy generated by electronic components.

**Cellular phone tower & Radio waves**

Mobile phone base stations are radio transmitter with antennas mounted on either transmission towers or roof tops on buildings. The antennas need to be located at optimum locations and heights so they can adequately cover the area. Antenna position usually range in height from 50-200 feet. When a person makes a cell phone call, a signal is sent from the mobile phone’s antenna to the nearest base station antenna. The base station responds to this signal by assigning it an available radiofrequency channel. RF waves transfer the information to the base station. The voice/data signals are then sent to a switching center, which transfers the call to its destination. The voice signals are then relayed back and forth during the call. In India mobile phones operate in the frequency range of:

- 869 - 890 MHz (CDMA)
- 935 - 960 MHz (GSM900)
- 1805 – 1880 MHz (GSM1800)
- 2110 – 2170 MHz (3G)

Cell phones connect with the base station as frequently as every minute so as to relay information about your location which generates a near-field by the cell phone even when you are not making a call. When you make a call on a mobile phone, the phone transmits radio waves to the antenna of a nearby base station. The base station then transmits the call using the mobile telecommunications network to the phone of the person you are calling.

In town and cities where there are many phone users, more base stations are needed than in rural areas. The antenna of the base stations are mounted on mast, buildings or towers. The intensity of the radio waves emitted from base stations in places where the public have access are generally found to be hundreds of times below the health and safety guidelines.

The intensity of electro-magnetic wave (power density) weakens very quickly as it moves away from the antenna. It is reduced to ¼ when the distance from the antenna doubles and to 1/9 when the distance is three times.
Power
The analog phones are being phased out. The major difference is that analog phones use more power than digital. Analog mobile phone uses up to 2 watt, while a digital mobile phone has an average power level of 0.25 watt. Phones typically operate at much lower levels during normal use as the phone power is automatically adjusted to the minimum radio signal level needed for call quality. This extends battery life.

Effects of radio wave exposure on human health
The Radio Frequency Radiation (RFR) exposure from both mobile phones and mobile towers may have possible thermal/non-thermal effects caused by holding Mobile phones close to the body. More the use of mobile phone, higher will be the temperature increase of ear lobes.

Research focusing on mobile telephony over the last 2 decades has shown no conclusive / convincing evidence that the radio signals from mobile phones cause adverse health effects. The cause and the effect have not yet been established. Hence we may have to adopt precautionary principles.
Radio Waves and Human Body

A strong EMF may be due to a weak radiation source nearby or a powerful source far away. A human body is exposed to more EMF radiation in case of a call from mobile phone in comparison to the one from a mobile tower. The mobile phone is a weak source of RF signal, but it is very close to human body, whereas the more powerful mobile tower is at far end.

Specific Absorption Rate (SAR)

SAR (Specific Absorption Rate) is the rate at which Radio Frequency energy is absorbed in the human body over a given time and expressed as the power absorbed per unit mass. SAR values are usually expressed in the units of watts per kilogram (W/kg) of tissue. This measurement is used to determine whether a mobile phone complies with safety norms/guidelines. Every model of mobile handset has specific SAR value.

SAR value is an important tool in judging the maximum possible exposure to RF energy from a particular model of cell phone. The SAR rating of mobile handset is a specified value which indicates that the device will never exceed the maximum level of consumer radio frequency exposure permitted but it does not indicate the amount of RF exposure the consumers experience during the normal use of the device. The actual SAR level of an operating device can be below the maximum value depending on number of factors such as how close the cell phones to a network base station i.e. distance from a transmission mast, phone is used indoor or outdoor, signal strength, how close the phone is held to the ear and other operating factors. Cell phone handsets constantly vary their power to operate at a minimum power necessary to communicate. A Cell phone is considered more efficient which operates at lower power.

SAR value of a mobile handset

In India, the SAR limit for cell phones prescribed is 1.6 W/Kg averaged over one gram of human tissue.

Mobile phone manufacturers ensure that their products supplied in the country comply with the prescribed SAR values. There is a range of SAR values for the mobile handsets sold all over the world. SAR value information of the mobile handsets is normally available on the manufacturer’s web site & in the handset’s manual. In India the information on SAR values shall be made available to the consumer at the point of sale and displayed on the handset itself.

Radiation level by a mobile tower

Every antenna on cell phone tower radiates electro-magnetic power. Cell phone tower is being used by a number of operators, more the number of antennas; more is the power intensity in the nearby area. The power level near towers is higher & as we move away, it reduces with distance. It is reduced to ¼ when the distance from antenna doubles, and 1/9 when distance is tripled and so on.
Risks and Safety Measures

Electromagnetic Radiation Risks
There are many types of radiation, both natural and man-made, to which we are exposed in our daily life. Everyone is exposed to small amount of radiation everyday from naturally occurring radio waves. This radiation is called background radiation.

International research has not yet established any adverse health effect in the short or long term of Radio Frequency radiation exposure from mobile phones/towers. As there is no scientific evidence to prove that the mobile telephony system can lead to adverse health effects, we should take precautionary steps to minimize our body exposure to Electromagnetic radiation.

Safety Measures -Reduce the Exposure

Electromagnetic radiation from a source spreads in a surrounding area and creates Electro-magnetic Field (EMF). The intensity of EMF is strongest at the source and becomes weaker and weaker as distance increases. Thus the distance plays a vital role. Time is also a key factor towards how much exposure a person receives.

Precautionary Guidelines for Mobile Users
Mobile users are advised to take following precautionary measures while using a mobile handset:

1. Keep distance – Hold the cell phone away from body to the extent possible
2. Use a headset (or ear bud) to keep the handset farther from your head.
3. Do not press the phone handset against your head. Radiation level is proportional to the square of the distance from the source -- being very close increases energy absorption much more. The farther your brain is from the handset the better it is.
4. Use a wired headset
5. Limit the length of mobile calls.
6. Use text as compared to voice wherever possible  
7. Put the cell phone on speaker mode  
8. Use a wireless Bluetooth headset  
9. If the radio signal is weak, a mobile phone will increase its transmission power. Find a strong signal and avoid movement – Use your phone where reception is good.
10. Metal & water are good conductors of radio waves so avoid using a mobile phone while wearing metal-framed glasses or having wet hair.
11. Let the call connect before putting the handset on your ear or start speaking and listening – A mobile phone first makes the communication at higher power and then reduces power to an adequate level. More power is radiated during call connecting time.  
12. If you have a choice, use a landline (wired) phone, not a mobile phone.  
13. When your phone is ON, don't carry it in a breast or pants pocket. When a mobile phone is on, it automatically transmits at high power every one or two minutes to check (poll) the network.  
14. Reduce mobile phone use by children as a younger person will likely have a longer lifetime exposure to radiation from cell phones.  
15. People having active medical implants should preferably keep the cell phone at least 15 cm away from the implant.

While purchasing a Mobile Handset check the SAR value of the mobile phone. It can be searched on internet if its model number & make is known.

**Myths and Facts**

Various Myths about Mobile Handsets & Mobile base stations:

<table>
<thead>
<tr>
<th>Myth</th>
<th>Fact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mobile phone use cause headaches.</td>
<td>Headaches are not related to Mobile phone use and there is no scientific evidence.</td>
</tr>
<tr>
<td>It is safer using a mobile phone in a car as the car shields from the radiation.</td>
<td>The RF radiation is increased by Mobile phones when used in a car to overcome the shielding.</td>
</tr>
<tr>
<td>Mobile phones cause brain cancer to the people who use it.</td>
<td>There is no scientific evidence that Mobile Phone can cause brain cancer.</td>
</tr>
<tr>
<td>Mobile Base stations are dangerous and one should have distance from it.</td>
<td>It is the antenna from which we should keep distance not from tower and that too if we are positioned facing antenna at comparable height. At the ground level, the intensity of RF radiation from base station is much lesser than that of from Antenna.</td>
</tr>
<tr>
<td>Nobody is investigating the health effects of RF radiation.</td>
<td>The World Health Organization, many national &amp; international organizations and independent expert groups are coordinating to investigate health effects of RF radiation.</td>
</tr>
</tbody>
</table>
Standards and Guidelines

India has adopted safety standards on permissible exposure level from mobile handsets & mobile base stations as a precautionary measure to reduce the possible impact of EMF radiation on human health. The prescribed standards and guidelines in respect of mobile handsets and mobile base station are:

**Mobile Handsets**

- SAR level for mobile handsets: 1.6 Watt /Kg, averaged over 1 gm of tissue.

- All new design of mobile handsets shall be with the SAR values of 1.6 W/kg averaged over 1 gram tissue effective 1st Sept. 2012. However, the mobile handsets with existing designs which are compliant with 2.0 W/kg averaged over 10 gram tissue, continue to co-exist up to 31st August 2013.

- From 1st Sept. 2013, only the mobile handsets with revised SAR value of 1.6W/kg would be permitted to be manufactured or imported in India.

- SAR test laboratory is being set up in the Telecom Engineering Centre (TEC) for testing of SAR value of mobile handsets imported/manufactured in India and to audit the self certification furnished by the manufacturers/ importers.

- SAR level shall be displayed on the handset.

- All cell phone handsets sold in the market in India shall comply with relevant standards and shall be with hand free devices.

- SAR value information of the mobile handsets shall be available on the manufacturer's web site & in the handset's manual. The information on SAR values shall be made available to the consumer at the point of sale.

- Mobile hand set manufactured and sold in India or Imported from other countries shall be checked for compliance of SAR limit.

- The manufacturers in India shall provide self declaration of SAR value of the handset. In respect of imported handset from other countries, manufacturers apart from self declaration of SAR shall specify the SAR information in user documents for verification by the appropriate authority. Suitable amendments in the Indian Telegraph Rule under Indian Telegraph Act 1885 are being enacted for strict compliance.

- Manufacturer's mobile handset booklet shall contain the safety precautions:

- List of SAR values of different mobile phones shall be uploaded on DoT/TEC website.
Mobile Base Stations

Radio waves from base stations in India comply with international health and safety guidelines. The exposure limit for the radio frequency field (Base station) emissions prescribed by the Department of Telecom, Government of India, is as below:

<table>
<thead>
<tr>
<th>Type of Exposure</th>
<th>Frequency Range</th>
<th>Power Density (Watt/Sqmtr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Public</td>
<td>400-2000 MHz</td>
<td>f/2000</td>
</tr>
<tr>
<td></td>
<td>2-300 GHz</td>
<td>1</td>
</tr>
</tbody>
</table>

f: frequency in MHz

- The prescribed safe RF exposure limit is f/2000 (in India), where f is in MHz. Exposure limits in India are:
  - At 900 MHz, power density is 0.45 watt/m² &
  - At 1800 MHz, power density is 0.9 watt/m²

- Provision for continuous online monitoring and display of radiation level in mobile network frequency range at prominent places in metro/cities and ONLINE data transfer to the central server.

- The mobile service providers apart from self-certification for compliance of radiation norms on EMF exposure shall measure the radiation level of prominent places in mobile network frequency range and have portable EMF measuring instrument for measurement wherever necessary for information of general public.

- A national data base with the information of all base stations, their emission compliance status (i.e. compliant / non-compliant) to be made available on DoT website for public information.

- New technology low power transmitters shall be installed with in-building solutions for the future expansion of telecom network in the country.
Frequently Asked Questions: Mobile Phones & Human Health

**Question:** What is Electro Magnetic Radiation?
**Answer:** Electromagnetic Radiation (EMR) is a form of energy which travels from one place to another. It is electromagnetic in nature, i.e., it consists of waves of electric and magnetic energy moving together through space at the speed of light. We are exposed to both natural and man-made radiation. The electromagnetic radiation may occur naturally such as ultraviolet light from the sun and as made by lightning. The EMR, generated artificially/man-made, are used for fixed and mobile radio communication, radio and television broadcasting, radar and other innumerable applications. The radio waves carry signal for television, cellular phone etc.

**Question:** What is RF?
**Answer:** RF stands for “radiofrequency” energy or radiation. Normally the terms “radiofrequency field” or “Electromagnetic field” are used interchangeably which indicate the presence of electromagnetic or RF energy.

**Question:** What is non-ionizing radiation?
**Answer:** Non-ionizing radiation has lower energy and ionizing radiation. It is not strong enough to cause the ionization of atoms & molecules. The RF energy is a non-ionizing radiation. The electromagnetic fields radiation from mobile handsets and antenna are non-ionizing radiation.

**Question:** What is Specific Absorption Rate (SAR)?
**Answer:** SAR is an indication of the amount of radiation that is absorbed into the body over a given time. The rate at which the radio frequency energy is absorbed in the body tissue is the Specific Absorption Rate (SAR) which has the unit, Watt/Kg.

**Question:** Whether the radiations from mobile towers are harmful to the public?
**Answer:** There is no conclusive scientific evidence of possible adverse effect of EMF radiation on Health. The cause and effect has not yet been established.

**Question:** What precautions should be adopted to reduce exposure to cell phone radiation?
**Answer:** Precautions adopted to reduce exposure to cell phone radiation:
- Keep mobile call short. The less you talk on mobile phone, the less exposure to radiation you will have. So by keeping mobile call short, the exposure will be limited.
- When signal is poor avoid using mobile phone.
- Use a headset or put the cell phone on speaker mode.
- Keep distance – hold the cell phone away from body to the extent possible.
- Do texting as compared to voice call wherever possible?

**Question:** What is the benefit of display of SAR value on mobile handsets?
**Answer:** If SAR rating of each individual phone model is displayed on mobile phone it will enable user to have informed choice when purchasing a handset. Lower value SAR is desirable.

**Question:** What is mobile phone & mobile phone base station and how do they work?
**Answer:** A mobile phone is a low power, two way Radio and it contains a transmitter and a receiver. The mobile phone emits Radio Frequency Radiation for transmitting
the information to mobile base station and it receives the information also. Mobile phone base stations, which are also known BTS, work as multi-channel two-way radios. Antennas, which produce RF radiation, are mounted on either transmission towers or roof-mounted structures. These structures are to be of a certain height so that coverage could be wider. When you communicate on a mobile phone, you are connected to a nearby base station. From that base station your phone call goes into the regular fixed-line phone system. Since the mobile phone and its base stations communicate using a two way radio communication, they produce RF radiation to communicate and therefore expose the people near them to RF radiation.

**Question**: Whether, the increased use of mobile phones in India has raised public concern in possible health issues associated with exposure to electromagnetic energy?

**Answer**: The increased use of mobile phones in India has raised public interest in possible health issues associated with exposure to electromagnetic energy. People are concerned about possible harmful emissions from mobile phone handsets & base stations. So far there is no conclusive scientific evidence of possible adverse effect of EMF radiation on Health.

**Question**: What research has been carried out on the health risks of mobile phones?

**Answer**: Worldwide, more than 100 large scale studies have been conducted, but no conclusive evidence have been found on health risks. The cause & effect relationship has not yet been established.

**Question**: Is there a need for a safety distance to mobile tower antennas or masts?

**Answer**: Yes, there is a recommended safe distance (i.e. compliance boundary) from the antenna. It ranges from 30 to 75 meters right in front at height comparable to the lowest mobile tower antenna depending upon the number of antennas deployed.

**Question**: How is the actual level of radiation in the field tested?

**Answer**: Telecommunications Engineering Centre (TEC) specified revised Test Procedure for Measurement of Electromagnetic Fields from Base Station Antennas based on new national radiation standards effective from 1st September 2012 and is available on TEC Web site [http://www.tec.gov.in](http://www.tec.gov.in) In case a citizen has a concern regarding the measurements or EMF exposure level at any BTS site, the local TERM Cell may be contacted for getting the measurements of EMF exposure in their vicinity. The Contact details of the TERM Cell officers are available at [http://dot.gov.in/vtm/Contact%20details_TERM_new.xls](http://dot.gov.in/vtm/Contact%20details_TERM_new.xls)

**Question**: What is the difference between EMF Radiation from mobile phone towers and mobile phones?

**Answer**: Radiation emitted from cell phone is of a short-term, repeated nature (coherent) at a relatively high intensity, whereas Radiation emitted from BTS (mobile towers) is of long duration but is of a very low intensity.
## The Key Reference Websites

<table>
<thead>
<tr>
<th>Organization</th>
<th>Website</th>
</tr>
</thead>
<tbody>
<tr>
<td>World Health Organization (WHO)</td>
<td><a href="http://www.who.int/emf">www.who.int/emf</a></td>
</tr>
<tr>
<td>U.K. Health Protection Agency</td>
<td><a href="http://www.hpa.org.uk">www.hpa.org.uk</a></td>
</tr>
<tr>
<td>Department of Telecommunication</td>
<td><a href="http://www.dot.gov.in">www.dot.gov.in</a></td>
</tr>
<tr>
<td>Telecom Engineering Centre</td>
<td><a href="http://www.tec.gov.in">www.tec.gov.in</a></td>
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