EFFECTS OF MICROWAVE RADIATION ON HUMANS

EEEN 566 – MICROWAVE ENGINEERING

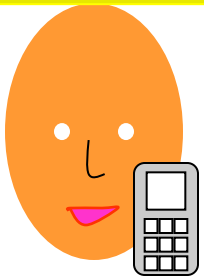
Friday, 28 March 2025

WHERE WE ARE IN THE SYLLABUS

Course Content:

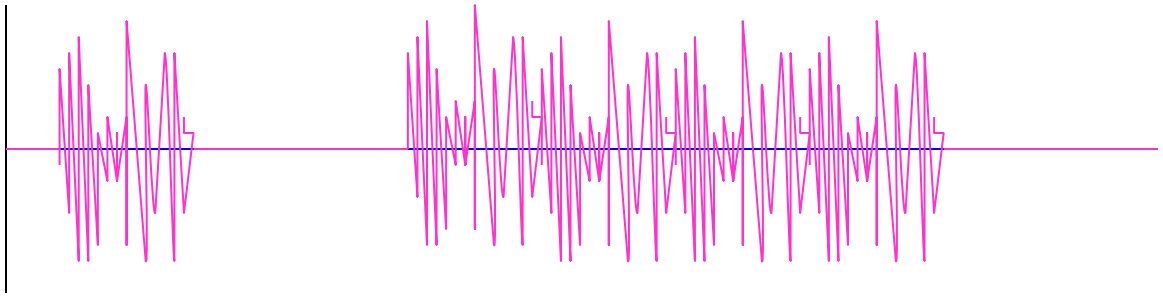
Introduction: Components of RF and microwave design, Behaviour of passive components, Propagation of guided waves. Micro-stripline circuits; Evaluation of attenuation constant for the rectangular waveguide. Waveguides and Components: Review of electromagnetic (EM) spectrum. Rectangular waveguides, Circular Waveguides, Microwave cavities. Microwave antennas: electromagnetic horns; reflector antennas; micro-strip antennas; phased arrays. Micro Strip Antenna. Directional couplers. Circulators, isolators. Wave guide couplings, bends and twists, Transitions, hybrid couplers, Matched load, Attenuators and phase shifters, E-plane, H-plane and Hybrid Tees, Hybrid ring. Waveguide discontinuities: Windows, Irises and Tuning screws, Detectors, wave meters. Strip Lines: Microstrip lines. Parallel strip lines. Coplanar strip lines. Shielded strip lines. Microwave Active circuits: Microwave transistors and tunnel diodes. Microwave FETs. Transferred electron devices: Avalanche transit time devices. Microwave linear beam tubes. Microwave crossed-field tubes. Microwave Communication Systems. Effect of Biological Exposure to microwave radiation. Microwave tubes: Klystron, Reflex Klystron, Magnetron, TWT, BWO: Their schematic, Principle of operation, performance characteristics and application. Microwave semiconductor devices: PIN diode, Tunnel diode, LSA diode, varactor diode, Gunn Devices, IMPATT and TRAPATT, their Principal of operation, characteristics and applications. Microwave Relays: Line-of-site path characteristics, FM radio stations and repeaters, FM microwave systems, analogue FM/AM, analogue versus digital switching arrangements.

POWER TRANSMITTED BY GSM MOBILE TELEPHONES



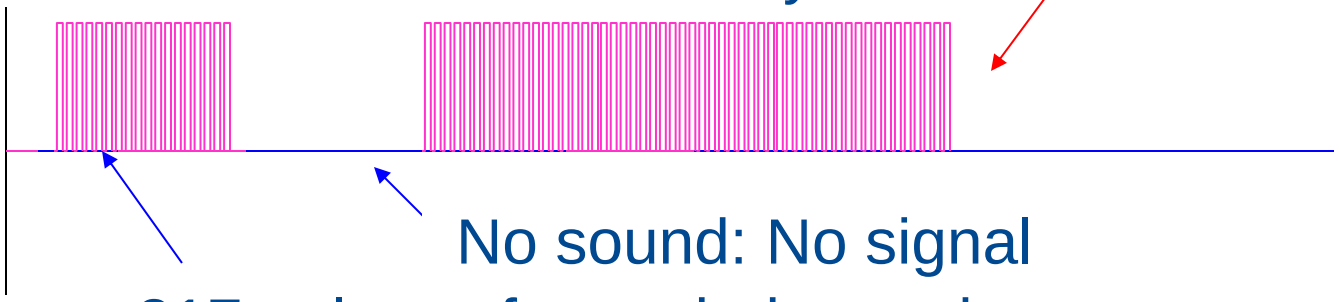
Sound

Hello! How are you?



Encoding to Radio Signal

Hello! How are you?



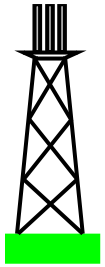
Peak Power: 2 W

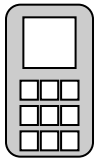
Average power: 0.25 W

No sound: No signal

217 pulses of encoded sound every second

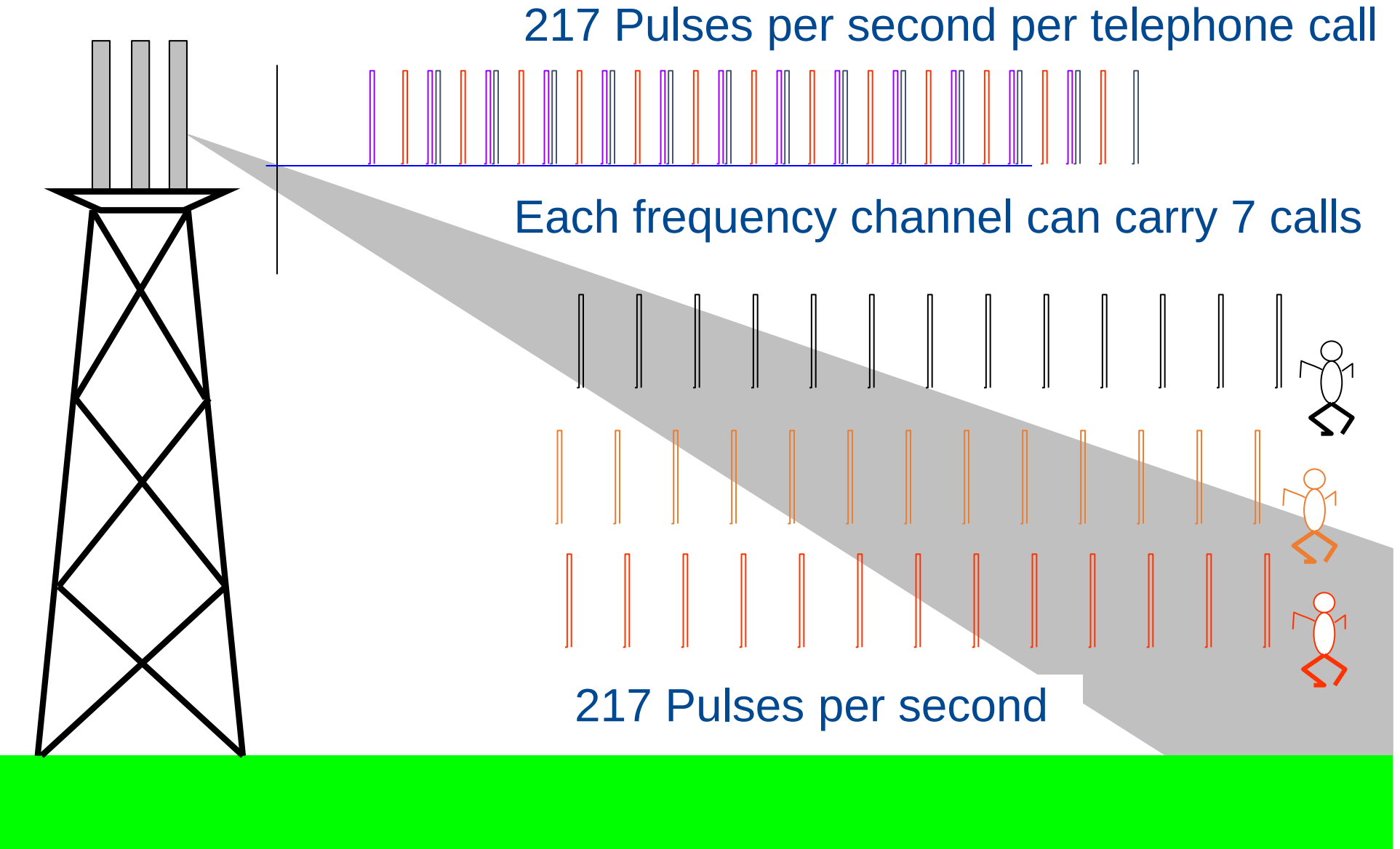
GSM BANDS & HANDSET POWER





	Base station Transmitter Frequencies (MHz)	Handset Transmitter Frequencies (MHz)	Peak Handset Power (Watts)	Usage
GSM900	935 - 960	890-915	2	Necessary for large coverage
GSM1800	1805-1880	1710-1785	1	Necessary for low-range coverage

THE GSM SIGNAL (2)



THE TIMES

Saturday January 20 2007 timesonline.co.uk No 69014 | Newspaper of the year £1.30

Jade Goody evicted from Big Brother

Cancer study ordered into mobile phones

More than 200,000 volunteers are to be monitored for at least five years

▶ Government expert warns of 'hint of a link'

▶ 200,000 join research into long-term users

Philip Webster, Helen Rumbelow, Alice Miles

A mass study of the long-term impact of mobile phones is to be undertaken amid fears that people who have used them for more than ten years are at greater risk from brain cancer.

More than 200,000 volunteers, including long-term users, are to be monitored for at least five years to plot mobile phone use against any serious diseases they develop, including cancer and Parkinson's and Alzheimer's diseases.

Professor Lawrie Challis, who is in the final stages of negotiation with the Department of Health and the mobile phone industry for the £3 million that he needs to fund the study, told *The Times* that research has shown that mobiles are very safe in the short term but that there is a "hint of something" for people using them longer.

In an interview, Professor Challis, a world expert on mobile phone radiation, and chairman of the government-funded mobile telecommunications health research programme, emphasised that the "hint" was just that. One European study has found a slight association between the risk of brain tumours and using a mobile for more than ten years. The few long-term users developed more acoustic neuroma brain tumours which were found close to the ear used for phoning.

But, because of the tiny numbers involved, "it could be by chance," he said. Asked whether the mobile phone could turn out to be the cigarette of the 21st century in terms of the damage it could inflict, he replied: "Absolutely."

He said that the study was necessary because all the important breakthroughs in what caused cancers had shown that the effects often took more than ten years to show. "You find absolutely nothing for ten years and then after that it starts to grow dramatically. It goes up ten times. You look at what happened after the atomic bombs at Nagasaki, Hiroshima. You find again a long delay, nothing for ten years. The same for asbestos."

He made plain that he was not put off because many existing studies had shown no dangers. "The fact that you don't see anything in ten years is also more or less what you would expect if there is something happening," he said.

Announcing the new study, he said: "Because there is a hint and because the professional epidemiologists who I trust and who do this all the time feel there is a chance

Continued on page 7, column 6

Leading article, page 20

We want to abolish 'Star Wars', China says

Move to cap GPs' pay

Spy 'breakthrough'

Row mars comeback

Blair aide arrested over 'cover-up'

News, pages 2, 3

DAILY MAIL OF 5th AUGUST 2021

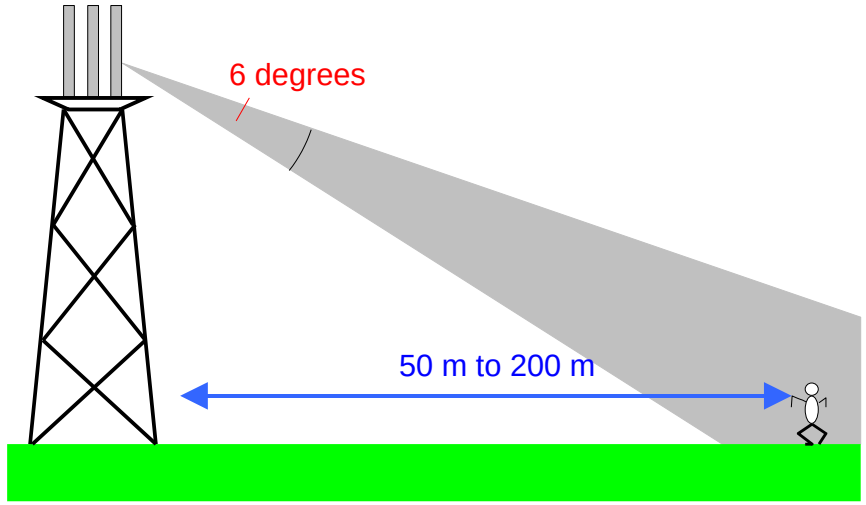
1. They found that using a mobile for 1,000 hours, or roughly 17 minutes per day over a ten-year period, increased the risk of developing cancerous tumours by 60 per cent.
2. Researchers say that radiation from mobile signals 'interfere with cellular mechanisms' and can result in the creation of stress proteins that cause DNA damage, tumours and even cell death in extreme cases.
3. The US Food and Drug Administration (FDA) denies any link, saying there is 'no consistent or credible scientific evidence of health problems caused by the exposure to radio frequency energy emitted by cell phones.'

Spending 17 minutes a day on a mobile phone increases cancer risk, study claims | Daily Mail Online

ISSUES OF CONCERN IN THE RESEARCH

1. The public was concerned about the safety issues surrounding mobile phones and BTS.
2. Of concern were, the **interactions of the microwaves** emitted by:
   a) Mobile phones
   b) Base stations

   with human tissue

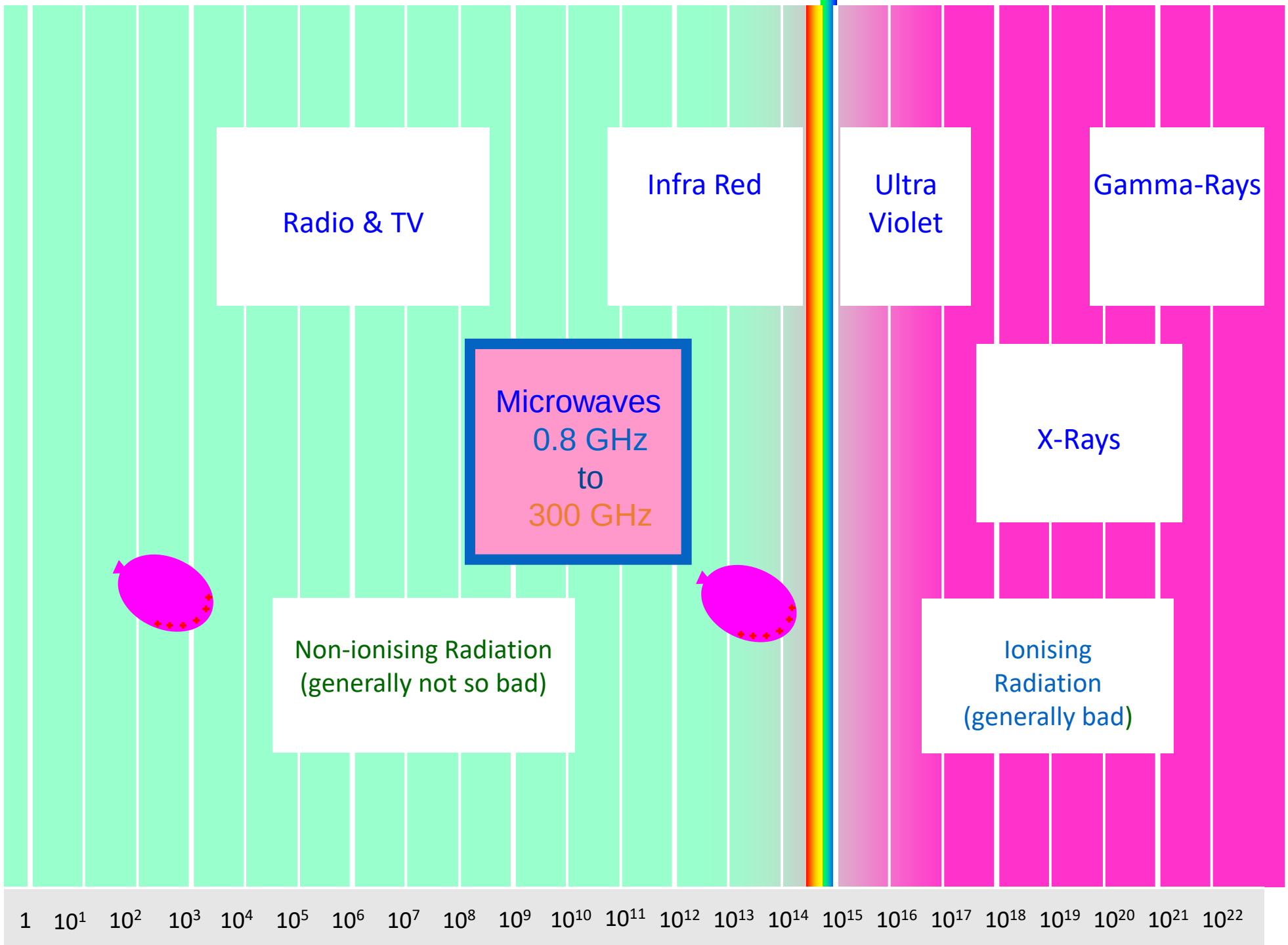


RESEARCH WAS NOT LIMITED TO GSM

Research was extended to include:

a) ‘WiFi’ Wireless Networking
b) Bluetooth devices
c) Wireless keyboards and mice
d) DECT cordless phones
e) Baby Monitors
f) ‘Walkie Talkie’

- All involve electromagnetic waves in the radio and microwave part of the spectrum


Radio & TV
Infra Red
Ultra Violet
Gamma-Rays
Microwaves
0.8 GHz
to
300 GHz
X-Rays
Non-ionising Radiation
(generally not so bad)
Ionising Radiation
(generally bad)
1
10^1
10^2
10^3
10^4
10^5
10^6
10^7
10^8
10^9
10^10
10^11
10^12
10^13
10^14
10^15
10^16
10^17
10^18
10^19
10^20
10^21
10^22

SUMMARY-INTERACTION OF WAVES & MATTER

1. Electromagnetic waves interacting with matter can be
   a) Reflected
   b) Absorbed
   c) Transmitted
2. Exactly what happens depends on
   a) **frequency of the electric field**
   b) **natural frequencies** of the atoms and molecules
3. Microwaves emitted by mobile phone system are absorbed by human tissue.

SPECIFIC ARBSORPTION RATE (SAR)

All Mobile devices are rated according to How much energy is absorbed by a human body of a given mass.

S.A.R.

Specific Energy **A**bsorption **R**ate

WHAT IS SPECIFIC ARBSOPTION RATE (SAR)?

1. **Specific Absorption Rate (SAR)** is the unit of measurement for the amount of radio frequency energy absorbed by a body when using a wireless device.
2. SAR value is measured in terms of watts per kilogram (W/kg).
3. Mobile RF exposure limits used are expressed in the terms of SAR, which is a measure of the electric/magnetic field strength and power density for transmitters operating at frequencies from 300 kHz to 100 GHz.
4. Government regulatory agencies around the world require that any wireless device must be evaluated to meet the RF exposure limits set in the government SAR regulations.

HOW TO CALCULATE SPECIFIC ARBSORPTION RATE (SAR)

Specific Absorption Rate = $\frac{\sigma E^2}{M_d}$

Where

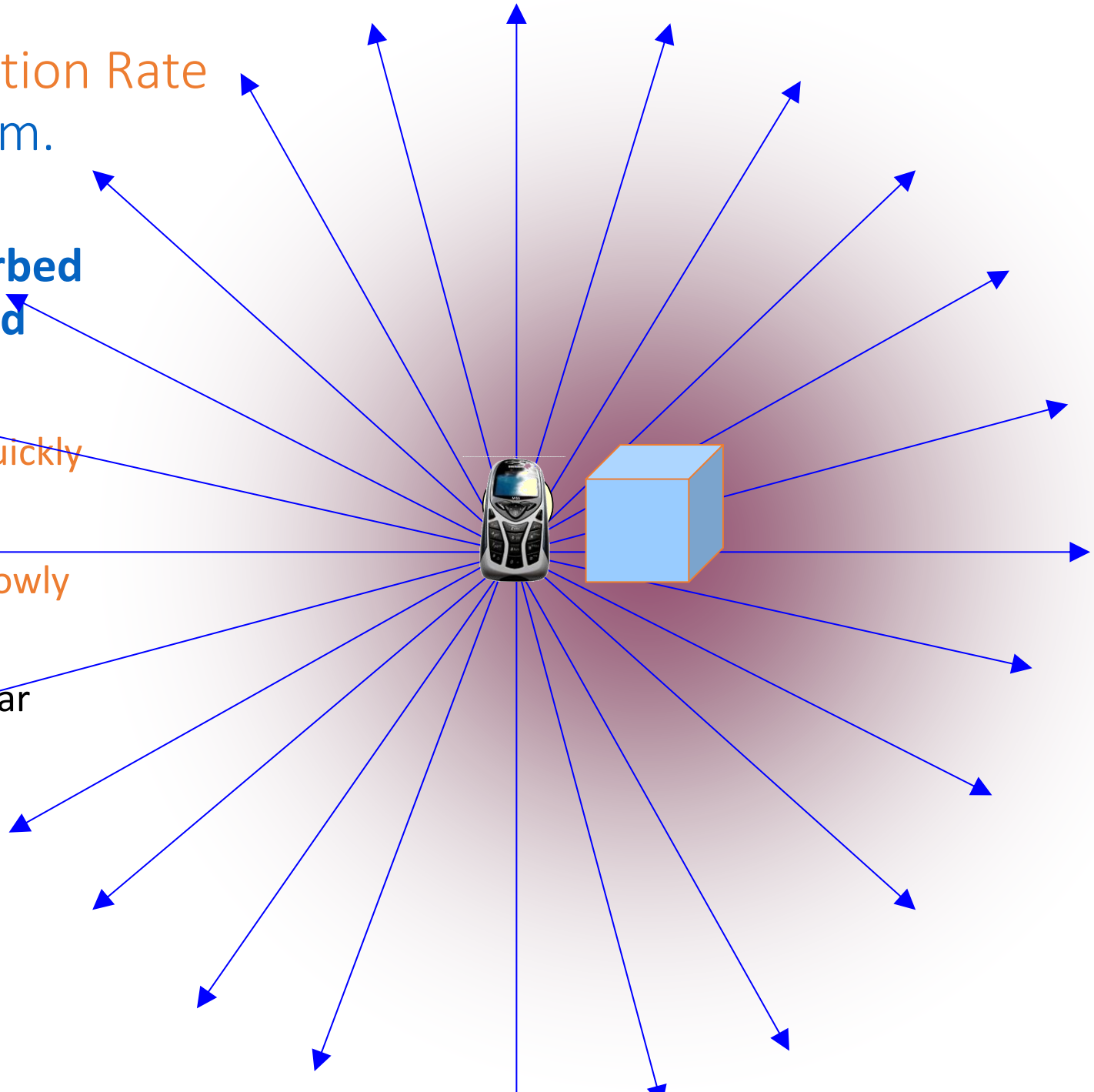
σ = conductivity of material

E = Electric field (RMS)

M_d = Mass density

Specific energy Absorption Rate (SAR) watts per kilogram.

- Measures **energy absorbed per kilogram per second**
- A high **SAR** means
  - a substance heats up quickly
- A low **SAR** means
  - a substance heats up slowly
- **SAR** is a property of an emitting device in a particular position with respect to an absorbing substance

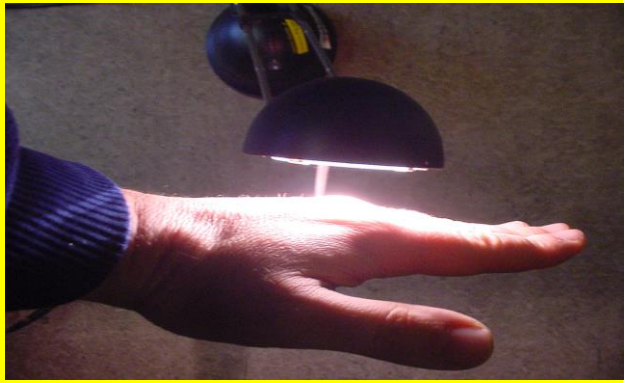


ONLINE CALCULATORS OF SAR

The following are common online calculators of SAR

1. Specific Absorption Rate (SAR) Calculator -RF Amplifiers - Elite RF (eliterfllc.com)
2. Specific Absorption Rate (SAR) Calculator - everything RF

- **1 cm from 20 W source**
  - 20 W absorbed in hand
  - Intensity 8000 watts per square metre
  - SAR 200 watts per kilogram



- 10 cm from 20 W source
  - 2 W absorbed in hand
  - Intensity 200 watts per square metre
  - SAR 20 watts per kilogram

- **1 metre from 20 W source**
  - 0.02 W absorbed in hand
  - Intensity 5 watts per square metre
  - SAR 0.2 watts per kilogram

POTENTIAL MICROWAVE HAZARD

The potential hazard from mobile phones and other wireless devices arises from

the absorption of microwave radiation

Mobile phones

- only emit a watt or two
- This makes it difficult to experiment.

Microwave ovens

- emit a few hundred watts
- makes experiments easy

MOBILE PHONE SAR RATING

■ Certification information (SAR)

THIS MODEL PHONE MEETS THE EU REQUIREMENTS FOR EXPOSURE TO RADIO WAVES.

Your mobile phone is a radio transmitter and receiver. It is designed and manufactured not to exceed the limits for exposure to radiofrequency (RF) energy recommended by The Council of the European Union. These limits are part of comprehensive guidelines and establish permitted levels of RF energy for the general population. The guidelines were developed by independent scientific organisations through periodic and thorough
ubstantial safety margin designed to
l health.

unit of measurement known as the
mmended by The Council of the
n conducted using standard operating
certified power level in all tested
the highest certified power level, the
well below the maximum value. This is
power levels so as to use only the
closer you are to a base station

lic, compliance with the European
es as one essential requirement the
nd any other person. The highest SAR
ce against the standard was 0.43 W/kg.
els of various phones and at various
xposure.

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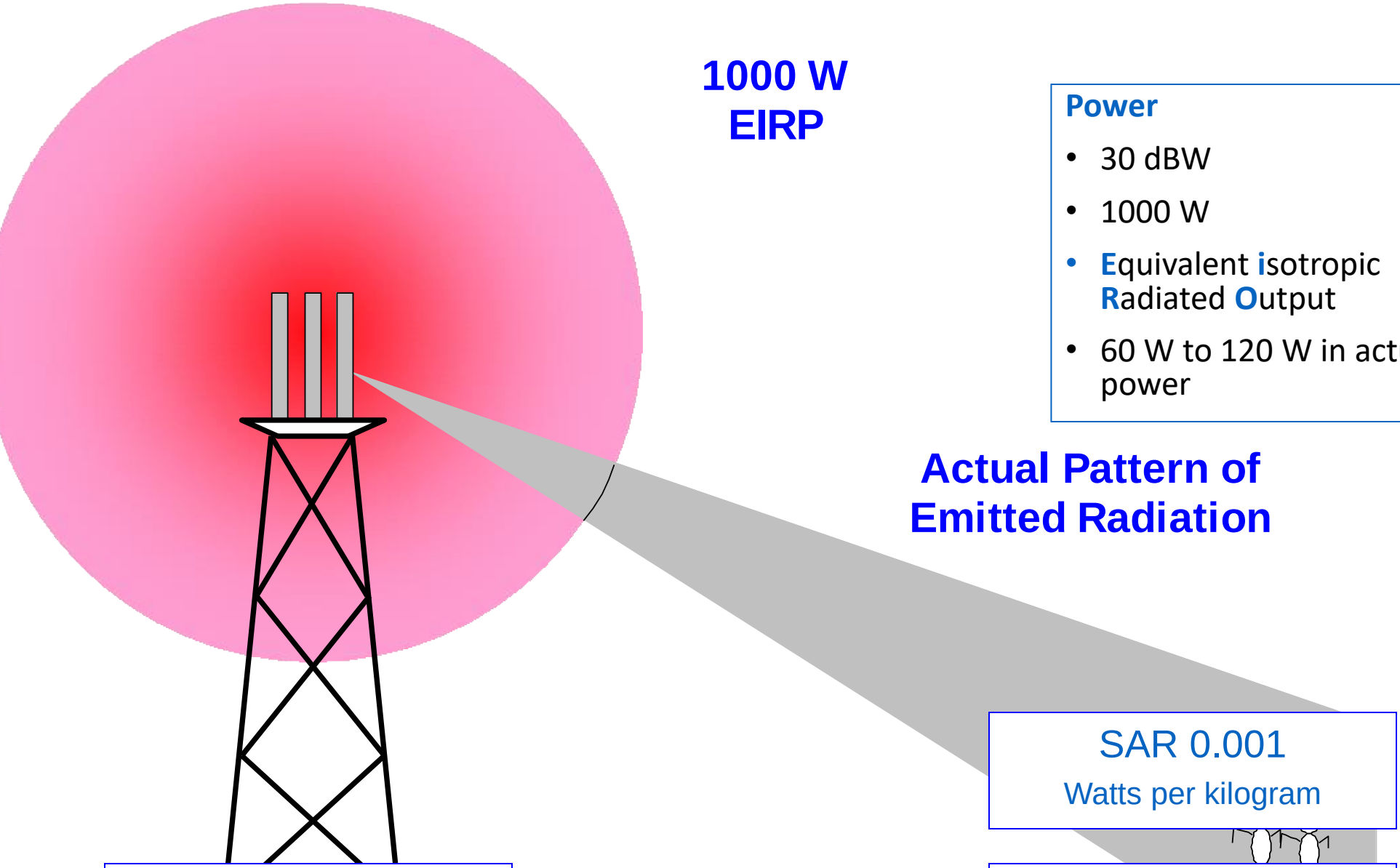


1000 W EIRP

Power

- 30 dBW
- 1000 W
- **E**quivalent **i**sotropic **R**adiated **O**utput
- 60 W to 120 W in actual power

Actual Pattern of Emitted Radiation

SAR 0.001

Watts per kilogram

0.3

Watts per square metre

0.01

Watts per square metre

COMPARISON OF SAR FOR GSM BTS & HANDSETS

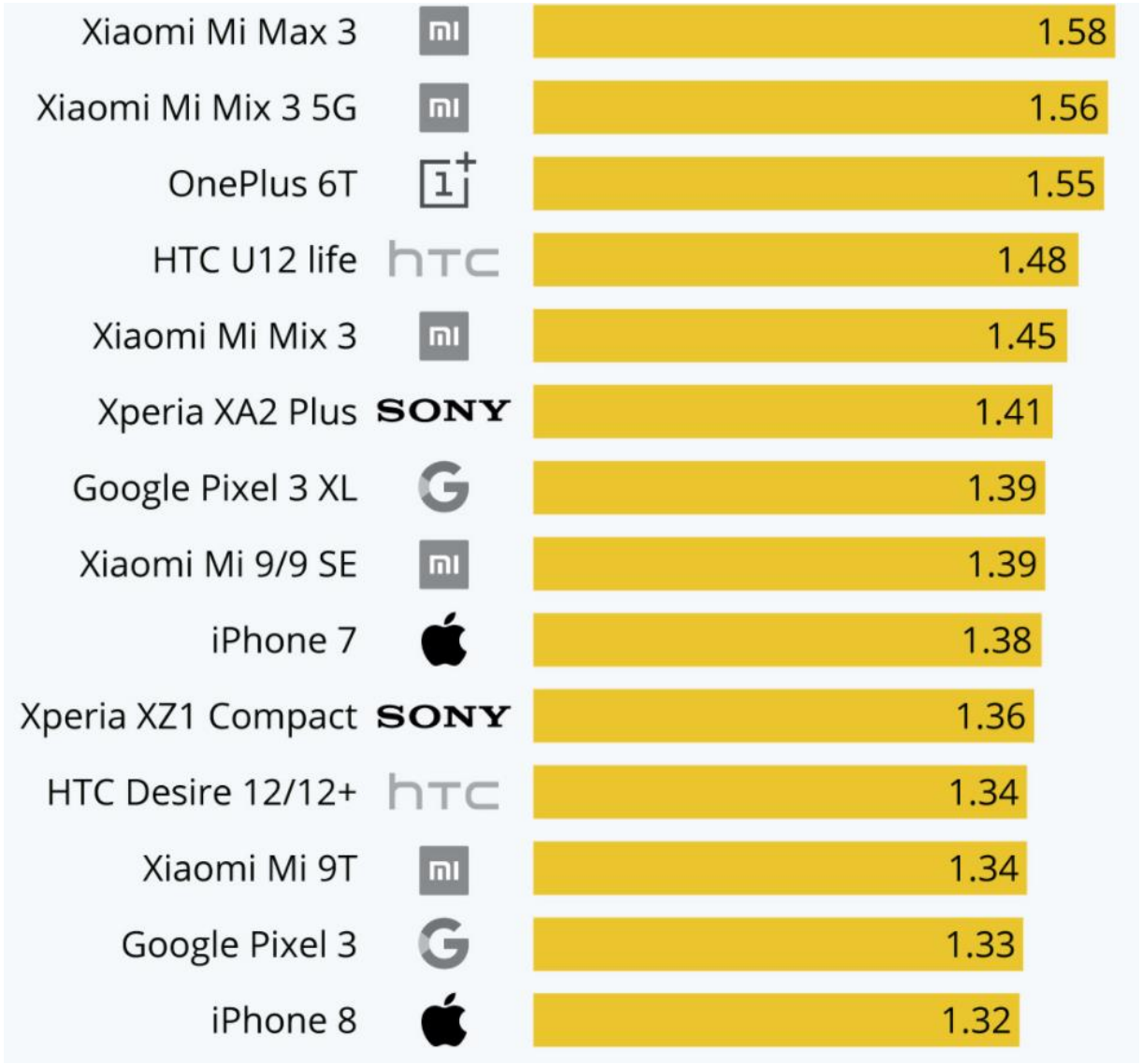
	Power Watts	**Intensity** Watts per square metre	**Maximum SAR** Watts per kilogram
Handset	1	200	**About 1**
Base Station	60	0.01	**About 0.001**

- Base station SAR is extremely low
  - But the public is more concerned about BTS than handsets

HOW TO CHECK SAR OF YOUR PHONE

1. To check for the SAR value, Dial ***#07#** USSD code in your mobile phone.
2. **1.6W/Kg** is the threshold value for the radiation level.
3. If SAR value is less than 1.6 W/Kg, It is ok to use that phone.
4. If SAR values exceeds this threshold limit, consider take necessary steps to avoid radiation affects.

SAR RATING OF PHONES



Office Memorandum dated 17082012.pdf (dot.gov.in)

PRECAUTIONS WHEN USING PHONES

Here are some recommended precautions to be taken :

1. Don’t talk on phone for more than 30 mins continuously.
2. Use earphones/ headphones while you are talking.
3. Use alternate ears for speaking on phone.
4. Don’t put your phone on shirt /Pant pockets. Keep it on desk or your bag if possible.
5. Don’t keep it near to your bed while sleeping. Consider switching it off or put it in flight mode.

SAR FOR WiFi

- **WiFi**
  - 802.11(b), 802.11(g), 802.11(n)
- **Operates at 2.4 GHz**

Power Watts	**Intensity (at 1 metre)** Watts per square metre	**SAR (at 1 metre)** Watts per kilogram
0.1	**Less than 0.01**	**About 0.0001**

SO WHAT SHOULD POLICY MAKERS & REGULATORS DO?

- Ban mobile phones ?
  - The ‘Precautionary principle’
  - How many deaths or cancers would be ‘acceptable’?
  - How many lives are saved by mobile phones?
- Reduce mobile phone power ?
  - Increase the number of mobile phone masts
- Reduce mast power ?
  - Increase the mobile phone handset power
  - Increase the number of masts
- Ban mobile phone use while driving ?
  - Done: has it been effective?