Measuring Radiofrequency and Microwave Radiation from Varying Signal Strengths

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Limits and Guidelines

• OSHA
  – From 10 MHz to 100 GHz 10 mW/cm² - 0.1 hr

• FCC
  – Varies with frequency range
  – For occupational worker and general public

• IEEE

• ACGIH
  – Both also vary with frequency
Typical Variable Standard (IEEE)
Frequency Dependent

- Controlled Environments
- Uncontrolled Environments

$kH\Omega$, MHz, GHz

$V/m$, $A/m$
FCC Standard  47 CFR 1.1310

Limits for Maximum Permissible Exposure (MPE)
Occupational Exposure

<table>
<thead>
<tr>
<th>Frequency range (MHz)</th>
<th>Electric field strength (V/m)</th>
<th>Magnetic field strength (A/m)</th>
<th>Power density (mW/cm²)</th>
<th>Averaging time (minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.3-3.0</td>
<td>614</td>
<td>1.63</td>
<td>*(100)</td>
<td>6</td>
</tr>
<tr>
<td>3.0-30</td>
<td>1842/f</td>
<td>4.89/f</td>
<td>*(900/f²)</td>
<td>6</td>
</tr>
<tr>
<td>30-300</td>
<td>61.4</td>
<td>0.163</td>
<td>1.0</td>
<td>6</td>
</tr>
<tr>
<td>300-1500</td>
<td></td>
<td></td>
<td>f/300</td>
<td>6</td>
</tr>
<tr>
<td>1500-100,000</td>
<td></td>
<td></td>
<td>5</td>
<td>6</td>
</tr>
</tbody>
</table>

*f = frequency in MHz  
* = Plane-wave equivalent power density
Compliance Follows Unity Rule

\[ E_T = \sum_{i=1}^{n} \frac{pp_i}{rr_{123}} + ... 1^n < \]

Where \( E \)

\( E_{total} \) is

\( p \) power measured

\( s \) source

\( r \) regulatory requirement at power \( i \)
Multiple Sources Contribute
Types of RF Signals

- Continuous output
  - Signal emitted at all times

- Pulsed output
  - Can be at regular intervals
    - Weather radar

- Irregular output
  - Police, ambulance, etc.
Interfering Radiations

- Wireless LAN
- Wi-Fi Hotspots
- Cell phones, towers
- Radio towers
- Security radios
- Ambulance, Fire, Police
- HDTV – high power

- Hospitals
- HVAC systems
- Elevator controls
- Cleaning equipment
- Light ballasts
- Paper shredders
**Different Frequencies Different Powers**

<table>
<thead>
<tr>
<th>Device</th>
<th>Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wireless LAN</td>
<td>1 – 5 W</td>
</tr>
<tr>
<td>Wi-Fi Hotspots</td>
<td>2 – 10 W</td>
</tr>
<tr>
<td>Cell phones, towers</td>
<td>10 W</td>
</tr>
<tr>
<td>Radio towers</td>
<td>100 kW</td>
</tr>
<tr>
<td>Security radios</td>
<td>5 W</td>
</tr>
<tr>
<td>Ambulance, Fire, Police</td>
<td>100 – 1000 W</td>
</tr>
<tr>
<td>HDTV</td>
<td>1 million watt transmitters</td>
</tr>
</tbody>
</table>
Power Summing - Peak Power

• Typical instruments are set for peak power
  – Irregardless of frequency
  – Sums over a broad range
  – Different correction factors for each frequency
  – Orientation affects reading
  – Irregardless of time averaging
  – Irregardless of spatial averaging

• Good if you never go over 1 mW/cm²
Contribution from Various Single Sources

![Diagram showing single RF source powers in mW/cm².](attachment:diagram.png)
Total Power from Multiple Sources

![Graph showing multiple contributions to total power with single peak measurement.](attachment:graph.png)
Are You Out of Compliance?

- Measured Power in mW/cm²
  - 25 mW/cm² @ 2.5 MHz
  - 0.75 mW/cm² @ 125 MHz
  - 0.5 mW/cm² @ 900 MHz

- Standard -- % limit
  - 100 mW/cm² -- 25%
  - 1 mW/cm² -- 75%
  - 3 mW/cm² -- 17%

Out of compliance IF:
Sources all radiating at once - in a broad field
For six minutes continuously - over whole body
In Compliance

- Know the generating frequency
- Know the pulse frequency
- Know the human exposure potential
Conclusion

• Monitor all sources
• Consider multiple sources
• Know frequency distribution
• Work with your radiofrequency and microwave equipment owners
• Trust their knowledge