GSM frequency planning

Band: 890-915 and 935 - 960 MHz

Channel spacing: 200 kHz (but signal bandwidth = 400 kHz)

Absolute Radio Frequency Channel Number (ARFCN)

lower band: \( F_l(n) = 890.2 + 0.2 (n - 1) \) MHz

upper band: \( F_u(n) = F_l(n) + 45 \) MHz

\( n = 1, 2, \ldots, 124 \)
Mobile Station

- Vehicular
- Handheld

maximum peak power

<table>
<thead>
<tr>
<th>class</th>
<th>output power</th>
<th>tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>20 W (43 dBm)</td>
<td>2 .. 2.5 dB</td>
</tr>
<tr>
<td>2</td>
<td>8 W (39 dBm)</td>
<td>2 .. 2.5 dB</td>
</tr>
<tr>
<td>3</td>
<td>5 W (37 dBm)</td>
<td>2 .. 2.5 dB</td>
</tr>
<tr>
<td>4</td>
<td>2 W (33 dBm)</td>
<td>2 .. 2.5 dB</td>
</tr>
<tr>
<td>5</td>
<td>0.8 W (29 dBm)</td>
<td>2 .. 2.5 dB</td>
</tr>
</tbody>
</table>

Adaptive power control in Mobile

- to save power
- to avoid interference
- 15 steps each of 4 dB
- range +43 dBm (20 Watt) ... + 13 dBm (20 mWatt)
- Controlled by base station
Base station

maximum peak power

<table>
<thead>
<tr>
<th>Class</th>
<th>Maximum Peak Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>320 Watt</td>
</tr>
<tr>
<td>2</td>
<td>160 Watt</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>8</td>
<td>2.5 Watt</td>
</tr>
</tbody>
</table>

Adaptive power control: 15 steps

Output spectrum base station

- Width 400 kHz (at -30 dB 200 kHz away from carrier)
- -60 .. -70 dB at 400 ... 1800 kHz away from carrier
- Also: spurious emissions and switching transients
Link Budget

- relevant to radio coverage
- relates transmit power, path losses, penetration losses, fade margin etc to received power
- relates noise floor and man-made noise levels to required receive power

<table>
<thead>
<tr>
<th>BTS-MS</th>
<th>MS-BS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmit power</td>
<td>[ \text{----} ]</td>
</tr>
<tr>
<td>Path loss</td>
<td>[ \text{----} ]</td>
</tr>
<tr>
<td>Penetration loss</td>
<td>[ \text{----} ]</td>
</tr>
<tr>
<td>Fade margin</td>
<td>[ \text{----} ]</td>
</tr>
<tr>
<td>Minimum required receive power</td>
<td>[ \text{--------} ]</td>
</tr>
<tr>
<td>Required SNR</td>
<td>[ \text{--------} ]</td>
</tr>
<tr>
<td>Manmade noise figure</td>
<td>[ \text{--------} ]</td>
</tr>
<tr>
<td>Noise floor</td>
<td>[ \text{--------} ]</td>
</tr>
<tr>
<td></td>
<td>M-B</td>
</tr>
<tr>
<td>--------------------------</td>
<td>-----</td>
</tr>
<tr>
<td>Noise Figure</td>
<td>8</td>
</tr>
<tr>
<td>Interference degradation margin</td>
<td>3</td>
</tr>
<tr>
<td>RX Antenna cable loss</td>
<td>4</td>
</tr>
<tr>
<td>Lognormal margin</td>
<td>5</td>
</tr>
<tr>
<td>Fade margin</td>
<td>9 .. 19 dB</td>
</tr>
<tr>
<td>TX isolator, combiner, filter</td>
<td>0</td>
</tr>
<tr>
<td>TX antenna cable</td>
<td>0</td>
</tr>
<tr>
<td>TX Antenna gain</td>
<td>0</td>
</tr>
<tr>
<td>Indoor loss</td>
<td>10</td>
</tr>
</tbody>
</table>
Equipment with integral antenna:

- Include effect of antenna in link budget

For omnidirectional antenna (0 dBi)

\[ E \ (\text{dBµV/m}) = P \ (\text{dBm}) + 20 \log F(\text{MHz}) + 77.2 \]

For \( F = 925 \ \text{MHz} \)

\[ E \ (\text{dBµV/m}) = P \ (\text{dBm}) + 136.5 \]
Receiver Performance

**ETSI 05.05 Recommendations**

- BER for interference-free operation:
  - At -85 dBm (52 dBµV/m)
    - static channel: $BER \leq 10^{-4}$ (0.01%)
    - fading channel: $BER \leq 3 \times 10^{-2}$ (3 %)

- Receiver sensitivity
  - handheld: -102 dBm (35 dBµV/m)
  - other MS and BS: -104 dBm (33 dBµV/m)

**Discussion:**

Compare with Thermal Noise Floor:

$kT_0 = 4 \times 10^{-17}$ watt/Hz (-174 dBm/Hz)

$B_N = 400$ kHz (+56 dB w.r.t. 1 Hz)

$SNR_{BS} = 14$ dB

Man-made noise factor at 900 can exceed 14 dB!
Interference rejection

ETSI 05.05 Requirements

cochannel channel interference: $z = 9$ dB

200 kHz adjacent channel: $z = -9$ dB

400 kHz adjacent channel: $z = -41$ dB

600 kHz adjacent channel: $z = -49$ dB
Frequency planning

Aspects to be considered

• Propagation Data
  Macroscopic: path loss
  Microscopic: fade margins
  Use terrain heights, building, vegetation from data base

• Demographic data

• Road traffic data

• Logistic data (e.g. in military transportable networks)
Different approaches to frequency planning

0) Coarse planning (no terrain data used)

1) coverage limited
   step 1: find coverage of base station
   step 2: make interference matrix
   step 3: find useful map coloring pattern (recursively ?)
   recursive approach: change transmit powers
   This changes coverage and interference; redo 1-2-3
   Example: Broadcasting, Netherlands PTT Ceasar

2) Interference limited
   step 1: assign frequencies and powers to base stations
   step 2: find coverage and interference zones
   recursive approach: modify powers and frequencies
   Example: Ericsson plannings tool

3) Dectralized Dynamic Channel Assignments (DCA)
   • DECT system, not for GSM
Accuracy of cell planning

Depends on
• accuracy of propagation models
• resolution and accuracy of terrain data

Data bases
• often based on satellite images
• available from several companies

Measurements
When a new planning tool is used for first time in a new country, one needs to adjust propagation models.