PCS (Lecture 2)

Outline of a cellular communication system:

- Base station subsystem (Radio Access Network)
  (BSS or RAN)

- Base station BBS

- Home (MS)

- Tower

- BSC

- MSC

- E164

- VLR

- HLR

- Au Interlace (Om)

- HSC - Home Switching Center (Switch)

- GMSC - Gateway MSC

- HLR - Home Location Register

- VLR - Visiting Location Register

HS → Mobile station (Handset, Mobile terminal, Terminal/user equipment, cell phone)

* Usually the only system element that users are aware of.
* Usually not the name of a cell phone.

Audio Processing

DSP Processing

- Encryption
- Interleaving

RF Processing

Audio Processing

DSP Processing

- Decryption
- Demodulation
Audio processing - conversion of audio into electrical signal

* Voice is in the frequency range 200Hz - 2kHz
* Typically sampled at 8 kHz (8 samples/sec)
* Only 8 bits per sample = 8 kHz / 8 bits = 1 kHz channel
* Cellular systems use vocoders that convert voice signals into 8 kHz/channel

DSP processing - adjusts the sound to wireless channel

* Error control coding
* Interleaving
* Encryption
* Frame Packing

RF processing - converts signals from baseband to RF

* Modulation
* Frequency modulation (done at IF and RF frequencies)
* Multiplication
* Nulling

BSS - Base station subsystem

Consists of two hops of elements

* Base stations (BS)
* Base station controllers (BSCs)
BS → base station

- BS links multiple nodes
- Individual nodes communicate with individual nodes
- BS performs all RF processing
- Coverage area served by a single BS is called a cell

BSC → base station controller

- Responsible for mobility management (supported by HLR)
- May be integrated with MSC
- Can serve as many as 200 base stations

MSC → Mobile Switching Center

- IISW switch with some added functionality to support mobility
- Responsible for routing the calls through wireless network
- Contains new data base

HLR - Home location register - information about users that consider the network as a home network
VLR - Visitor location register - information about users that are roaming on a given network
Calculation with dB (review)

Suppose that we have a quantity \( X \) and a reference quantity \( X_{ref} \). Then, the value of \( X \) with respect to \( X_{ref} \), expressed in dB, is given by

\[
X_{dB} = 10 \log \left( \frac{X}{X_{ref}} \right)
\]

In certain cases both \( X \) & \( X_{ref} \) are going to be powers.

Example: Assume \( X = 20W \), \( X_{ref} = 1W \)

\[
X_{dB} = 10 \log \left( \frac{20W}{1W} \right) = 12 \text{ dB}
\]

Often, different values are used for reference quantity. To avoid the ambiguity associated with the choice of the reference value, an additional symbol is attached to dB. For example:

\[
X_{[dBm]} = 10 \log \left( \frac{P}{1mW} \right)
\]

\[
X_{[dBW]} = 10 \log \left( \frac{P}{1W} \right)
\]

\[
X_{[dBu]} = 10 \log \left( \frac{P}{1uW} \right) = 10 \log \left( \frac{P}{1mW} \right) + 10 \log (1000)
\]

\[
X_{[dBm]} = X_{[dBW]} + 20 \rightarrow \text{conversion between dBW and dBm}
\]

Why do we use dB?

\*

Compression of dynamic range:

\[
P_{max} \sim 1 \text{MW}
\]

\[
P_{min} \sim 10^{-14} \text{W}
\]

\[
22 \text{ orders of magnitude}
\]
* Simplification of mathematical operations.

One should note that dB is unitless measure. As a result, any gain can be expressed in dB as well.

\[ g_{[\text{dB}]} = 10 \log (G) \]

For example:

\[ G = 1000 \]

\[ g_{[\text{dB}]} = 10 \log (1000) = 20 \text{ dB} \]

\[ G = 0.001 \]

\[ g_{[\text{dB}]} = 10 \log (0.001) = -20 \text{ dB} \]

**Linear/dB conversion tables**

<table>
<thead>
<tr>
<th>Linear gain</th>
<th>Gain in dB</th>
<th>Linear gain</th>
<th>Gain in dB</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>( \frac{1}{2} )</td>
<td>-3</td>
</tr>
<tr>
<td>4</td>
<td>6</td>
<td>( \frac{1}{4} )</td>
<td>-6</td>
</tr>
<tr>
<td>10</td>
<td>10</td>
<td>( \frac{1}{10} )</td>
<td>-10</td>
</tr>
<tr>
<td>100</td>
<td>20</td>
<td>( \frac{1}{100} )</td>
<td>-20</td>
</tr>
<tr>
<td>1000</td>
<td>30</td>
<td>( \frac{1}{1000} )</td>
<td>-30</td>
</tr>
<tr>
<td>10000</td>
<td>40</td>
<td>( \frac{1}{10000} )</td>
<td>-40</td>
</tr>
<tr>
<td>100000</td>
<td>50</td>
<td>( \frac{1}{100000} )</td>
<td>-50</td>
</tr>
</tbody>
</table>

**Summary of important log rules**

\[ 10\log(AB) = 10\log(A) + 10\log(B) \]

\[ 10\log(A^n) = n\times 10\log(A) \]

\[ 10\log\left(\frac{A}{B}\right) = 10\log(A) - 10\log(B) \]
### Examples:

<table>
<thead>
<tr>
<th>Direct gain</th>
<th>gain in dB</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.125</td>
<td>29</td>
</tr>
<tr>
<td>0.0001</td>
<td>-43</td>
</tr>
<tr>
<td>2 \cdot 10^{-7}</td>
<td>-67</td>
</tr>
<tr>
<td>8 \cdot 10^{-5}</td>
<td>59</td>
</tr>
<tr>
<td>8.74 \cdot 10^{-9}</td>
<td>-84.27</td>
</tr>
</tbody>
</table>