LTE link budget example

What is a link budget?

➔ accounting of **all the gains and losses** from the transmitter, **through the medium** (free space, cable, waveguide, fiber, etc.) to the receiver in a telecommunication system

It accounts for

- the attenuation of the transmitted signal due to propagation
- the antenna gains,
- feedline
- miscellaneous losses

A simple link budget equation looks like this:

Received Power (dBm) = Transmitted Power (dBm) + Gains (dB) − Losses (dB)

What is the difference between dBi, dBm and dB?

- dB : it is a RELATIVE measure of two different POWER levels

$P_{(\mathrm{dB})} = 10 \cdot \log_{10}(P1_{(\mathrm{W})}/P2_{(\mathrm{W})})$ *for stating the gain or loss of one device (P1) IN RELATION to another (P2)*

The dB by itself is not an absolute number, but a ratio.

- dBm (*decibel-milliWatt)* : electrical power unit in decibels (dB), referenced to 1 milliwatt (mW)

$P_{(\mathrm{dBm})} = 10 \cdot \log_{10}(P_{(\mathrm{mW})} / 1\mathrm{mW})$

1mW = 0dBm

1W = 1000 mW = 30dBm

1 W = 1000 mW ➔ 1 W = {10log(1000 mW) = 10log(3.10^3) = 10*3 = 30 dBm}

- dBi *(i=isotropic)* : common reference unit for antennas, which states the gain of an antenna as referenced to an ISOTROPIC source

An Isotropic source is the perfect omnidirectional radiator, a true Point Source, and does not exist in nature. It is useful for comparing antennas, as since its theoretical, it is always the same.

Link budget comparison between LTE, GSM and UMTS HSPA

1. Uplink Budget Comparison

RAN Technology		GSM	HSPA	LTE
Data rate (kbps)		12.2	64	64
Transmitter – UE				
a	Max. TX power (dBm)	33	23	23
b	TX antenna gain (dBi)	0	0	0
c	Body loss (dB)	3	0	0
d	EIRP (dBm)	30	23	23
Receiver – BTS/Node B/eNode B				
e	Node B noise figure (dB)	-	2	2
f	Thermal noise (dBm)	-	-108.2	-118.4
g	Receiver noise floor (dBm)	-	-106.2	-116.4
h	SINR (dB)	-	-17.3	-7
i	Receiver sensitivity (dBm)	-114	-123.4	-123.4
j	Interference Margin (dB)	0	3	1
k	Cable Loss (dB)	0	0	0
l	RX antenna gain (dBi)	18	18	18
m	Fast fade margin (dB)	0	1.8	0
n	Soft handover gain (dB)	0	2	0
Maximum path loss		162	161.6	163.4

The uplink link budget has some differences in comparison to HSPA: specifically, the smaller interference margin, no macro diversity gain (Soft handover gain) and no fast fading margin. As can be seen from the table above the link budget was calculated for 64 kbps uplink, which is cannot be classified as a high enough data rate for true broadband service. To guarantee higher data rates for LTE, a low frequency deployment may be required in addition to additional sites, active antenna solutions or local area solutions.

2. Downlink Budget Comparison

RAN Technology		GSM	HSPA	LTE
Data rate (kbps)		12.2	1024	1024
Transmitter – BTS/Node B, eNode B				
a	Max. TX power (dBm)	44.5	46	46
b	TX antenna gain (dBi)	18	18	18
c	Cable loss (dB)	2	2	2
d	EIRP (dBm)	60.5	62	62
Receiver – UE				
e	UE noise figure (dB)	-	7	7
f	Thermal noise (dBm)	-119.7	-108.2	-104.5
g	Receiver noise floor (dBm)	-	-101.2	-97.5
h	SINR (dB)	-	-5.2	-9
i	Receiver sensitivity (dBm)	-104	-106.4	-106.4
j	Interference Margin (dB)	0	4	4
k	Control channel overhead (%)	0	20	20
l	RX antenna gain (dBi)	0	0	0
m	Body loss (dB)	3	0	0
Maximum path loss		161.5	163.4	163.5

The LTE link budget in downlink has several similarities with HSPA and the maximum path loss is similar. The link budgets show that LTE can be deployed using existing GSM and HSPA sites assuming that the same frequency is used for LTE as for GSM and HSPA. LTE itself does not provide any major boost in the coverage. That is because the transmission power levels and the RF noise figures are also similar in GSM and HSPA technologies, and the link performance at low data rates is not much different in LTE than in HSPA.