The period of wavelength occurrence is 1.06

3.5. - Energy, wavelength, frequency:

Electromagnetic energy is often referet to EM radiation. It is a form of radiant energy which some electromagnetic processes release. - https://en.wikipedia.org/wiki/Electromagnetic_radiation
In equation form, this is:

$$E = (hc) / L$$

E = Energy
h = Planc's constant 6.626 x 10 ^ (- 34) J s = 6.626 E-34 Js
c = the speed of light 3.0 x 10 ^ 8 m / s = 3 E8 m/s
L = Lambda, the wavelength

Example:
How much energy does a light with a wavelength of 123nm has?

E = ?
h = 6.626 x 10 ^ (- 34) j x s
c = 3.0 x 10 ^ 8 m / s
L = 123nm

E = ((6.626 x 10 ^ (-34) j x s) x (3.0 x 10 ^ 8 m / s)) / (123 x 10 ^ (- 9) m)
E = ((6.626 x E-34 j) x (3.0 x E8)) / (123 x E-9)
E = 0.161609756 * E-35 j

3.6. - Voltage gain / loss – decibel calculations

In equation form, this is:

V_dB = 20 log (V2 / V1) (E_dB = 20 log (E_2/E_1))

dB = Decibels
V = Voltage
V1 = typically higher voltage (because we are looking for a delta or a change)
V2 = typically lower voltage

Example:
dB = 20 log (V2 / V1)
dB = 20 log (3000mv / 1000mv)
dB = 20 log (3) *(log = log_10 (3) = 0.48)= 9.5*

L = 123nm

E = ((6.626 x 10 ^ (-34) j x s) x (3.0 x 10 ^ 8 m / s)) / (123 x 10 ^ (- 9) m)
E = ((6.626 x E-34 j) x (3.0 x E8)) / (123 x E-9)
E = 0.161609756 * E-35 j

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Example:
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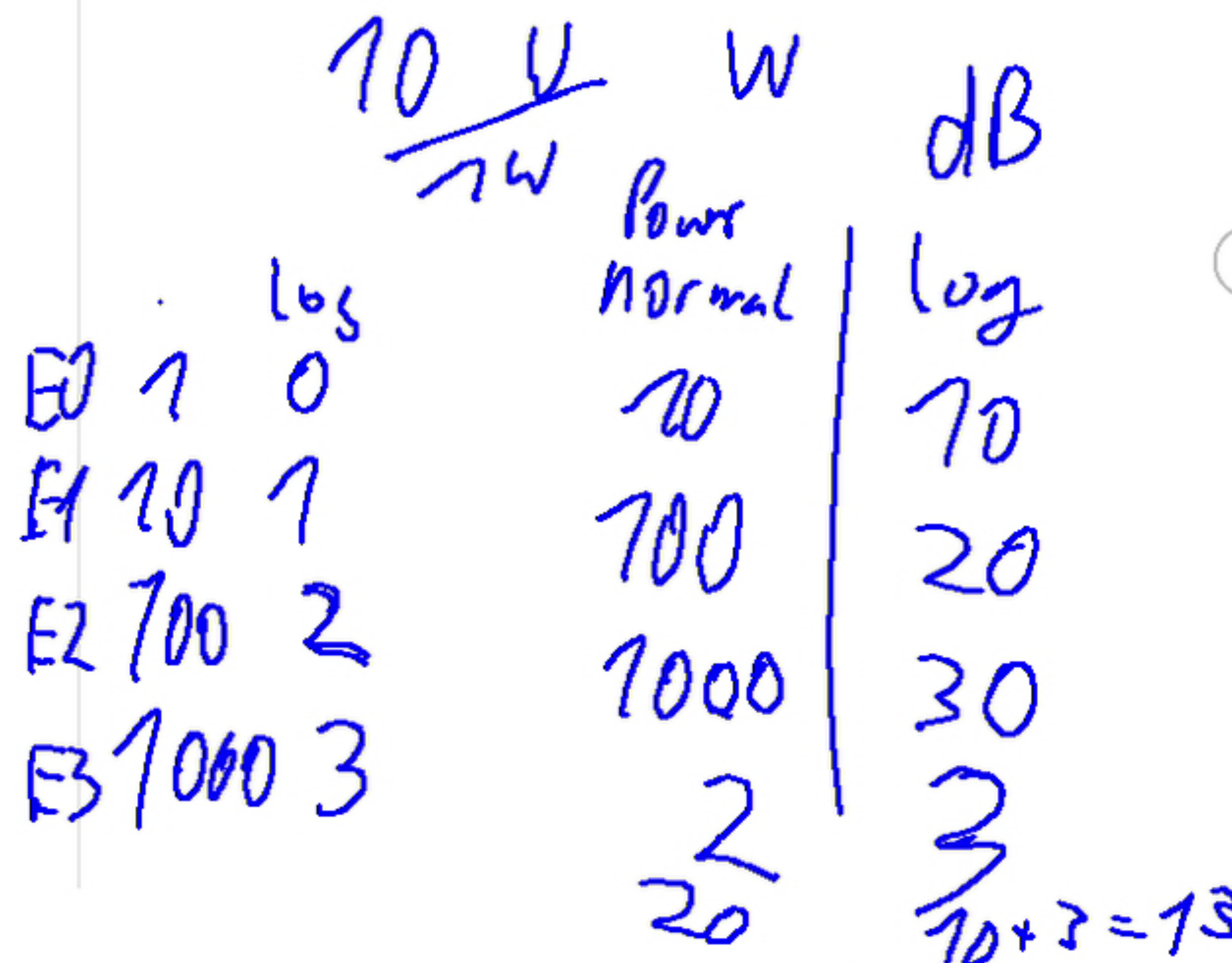
dB = 20 log (3) *(log = log_10 (3) = 0.48)= 9.5*

Example: W as compared to 1 mW
*P_dB = 10 log (P_2/P_1) = 10 log (1 W/1E-3 W) = 10 log (E3) = 10 * 3 = 30*
Answer: 1 W is 30 dB more than 1 mW

dB is used to measure a ratio or a factor



log

$a^b = c$

$2^3 = 8$

$\log_2 8 = 3$

$\log_a c = b$

$\left(\frac{\lambda}{4\pi r}\right)^2 G_T G_R P$

① $\log(a \times b) = \log a + \log b$

$\log G_1 + \log G_2 \cdot \log\left(\frac{\lambda}{4\pi r}\right)^2 + \log P$

$\log(10 \times 100) = \log 10 + \log 100$

$\log(1000) = 1 + 2 = 3$

3

(2) $\log(a)^b = b\log(a)$

$\log(10)^2 = 2\log 10$

$\log(100) = 2$

2

(3) $= \log\frac{a}{b} = \log a - \log b$

dBW

dBm = mwatts

G = 6

dB = −100dB

dBm = −70dBm

$$P_r = P_t G_T G_r \left(\frac{\lambda}{4\pi r}\right)^2$$

1 W

1000 mW

$$10\log P_r = 10\log\left(P_t G_T G_r \left(\frac{\lambda}{4\pi r}\right)^2\right)$$

$$P_r[dB] = 10\log\frac{P_t}{1\times10^{-3}} + \log G_T + \log G_r + \log\left(\left(\frac{\lambda}{4\pi r}\right)^2\right)$$

$$P_r[dB] = P_t + G_T|_{dB} + G_r + 20\log\frac{\lambda}{4\pi r} +$$

$$= P_t + G_T + G_r - 32.4 + 20\log f[GHz] - 20\log R[m]$$

P_t	dBm	dB	comments
100mW	20	−10	max Wifi
2W	33	3	GSM handset
25W	44	14	GSM Base station

$10\log P_t$

$10\log\left(\frac{25}{1\times10^{-3}}\right)$

10×4.4

44

Example WIFI

$P_t = 20\,dBm$

$G_t = 6\,dB$

$G_r = 3\,dB$

$P_{sensitivity} = -96\,dBm$

$P_r > P_{sense} + P_{fade} +$

$> -96 + 20$

$P_r > -76\,dBm$

$P_r = 20 + 6 + 3 - 92.4 - 20\log(f[GHz])$ (7.6)

$- 20 \times \log(R[km])$

$P_r = -84.8 - 20\log(R[km])$

distance	Pr	SNR
1 Km	-84.8	(-84 + 76) = -8
0.1 Km	-64.8	(-64 + 76) = 12
0.01	-44.8	(-44 + 76) = 32

otherwise $N_0W + N_{\text{interference}}$, where $N_0 = k_B T_K$ with k_B as Boltzmann constant and T_K as temperature in Kelvin.

⌘ Shannon - formula

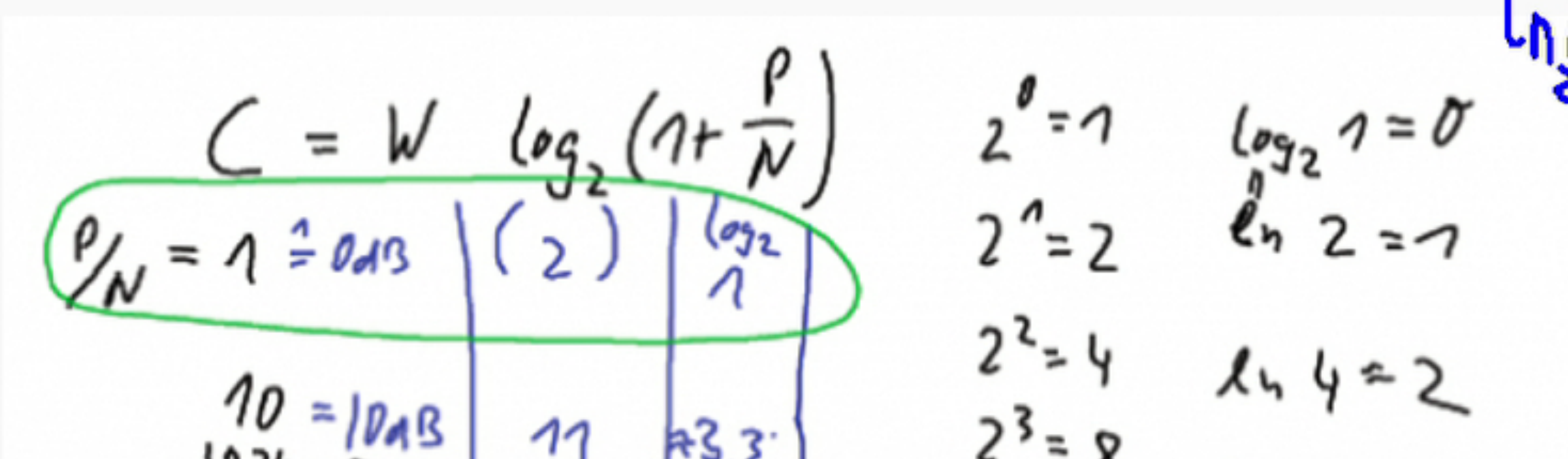
$C = W \log_2(1 + P/N)$ [bits/s]

Exercises

- calculate capacity for *W*= 200 kHz, 3.8 MHz, 26 MHz, (all cases P/N = 0 dB, 10 dB, 20 dB)
- If the SNR is 20 dB, and the bandwidth available is 4 kHz, what is the capacity of the channel?
- If it is required to transmit at 50 kbit/s, and a bandwidth of 1 MHz is used, what is the minimum S/N required for the transmission

[source: Wikipedia, Telektronikk 2002]

Comments



$N_0 W$

otherwise $N_0 W + N_{\text{interference}}$, where $N_0 = k_B T_K$ with k_B as Boltzmann constant and T_K as temperature in Kelvin.

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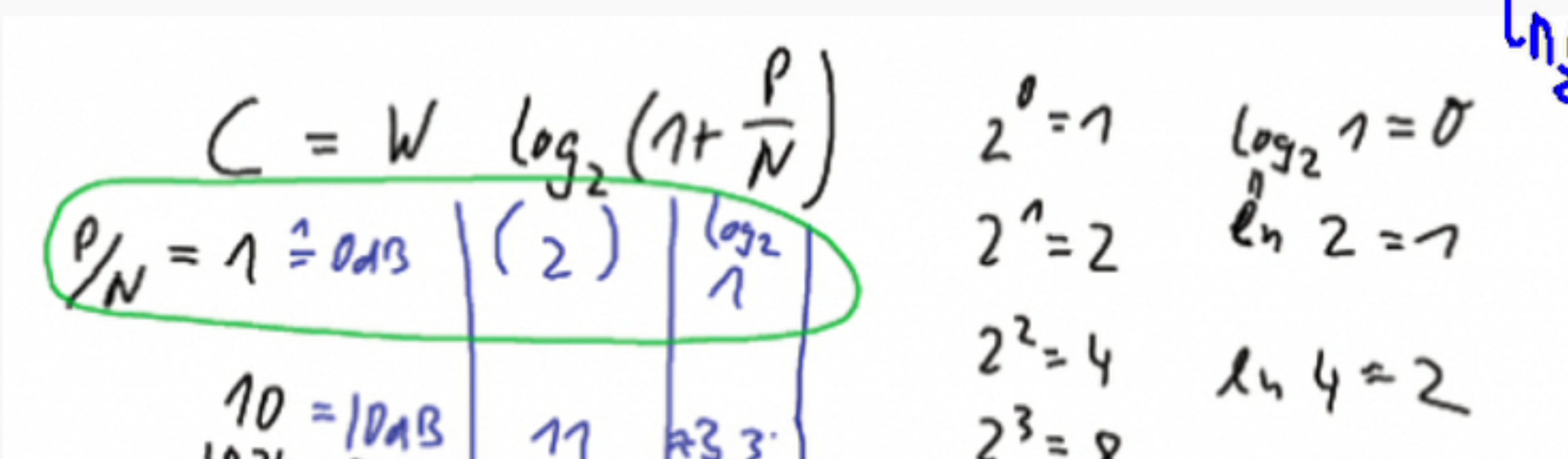


Typical Mobile

$P_T = 25W$

$G_T = 14 dB$

$G_R = 3 dB$

typical examples

I. Receive Power

II. Shannon Capacity

R = 0.1 km, 1 km, 3 km, 10 km

f = 900 MHz, 2.1 GHz

$P_R = ?$

Typical WLAN

$G_T + P_T = 20 dBm$ (rule!)

$G_R = 6 dB$

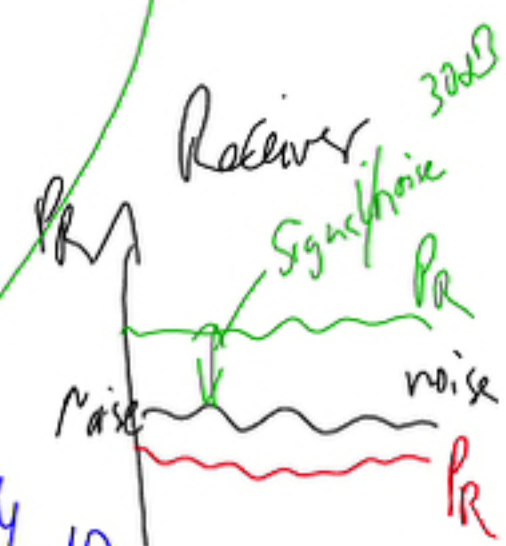
f = 2.4, 5.2 GHz

R = 1, 10, 50 m, 150 m?

$P_{sens\ GSM} = -104\ dBm$ (?)

$P_{sens\ UMTS} = -112\ dBm$ (?)

$P_{sens\ WLAN} = -95\ dBm$



Shannon

$$C = B \log_2\left(1 + \frac{S}{N}\right)$$

B ← Bandwidth

S/N ← results from P_R / P_{Noise}

P_R ← $-P_{sens} + P_{fade}$

P_{fade} ← 20dB

	P_{sens}
GSM	-104
LTE	-116
4 MHz	-110
Wifi	-95

(Source:R Rækken, G. Løvnes, Telektronikk)

why almost equal distribution? What effect?

⌘ETSI urban pedestrian

- Outdoor to indoor and pedestrian test environment, based on Non LOS (NLOS)
- Base stations with low antenna height are located outdoors, pedestrian users are located on streets and inside buildings and residences
- TX power is 14 dBm, *f = 2000* [illegible]*/MHz* and *r* is distance in m
- Assumes average building penetration loss of 12 dB
- Path loss model: $L_{pedest} = 40 \log r + 30 \log f + 49$ [dB]

⌘COST Walfish-Ikegami Model

- taking into consideration propagation over roof tops
- assumes antennas below roof top
- Path loss model: $L_{rooftop} = 45 \log (r + 20) + 24$ [dB]

⌘Alternative Street Microcell Path-loss

- Outdoor propagation, consists of "adding of paths"
- *c* is angle of street crossing. *c = 0.5* for 90 deg crossing
- k_0 = 1 and d_0 = 0
- Path loss model: $L_{micro} = 20 \log \frac{4\pi d_n}{\lambda}$ [dB]
- illusory distance $d_n = k_n s_{n-1} + d_{n-1}$ with $k_n = k_{n-1} + d_{n-1} c$

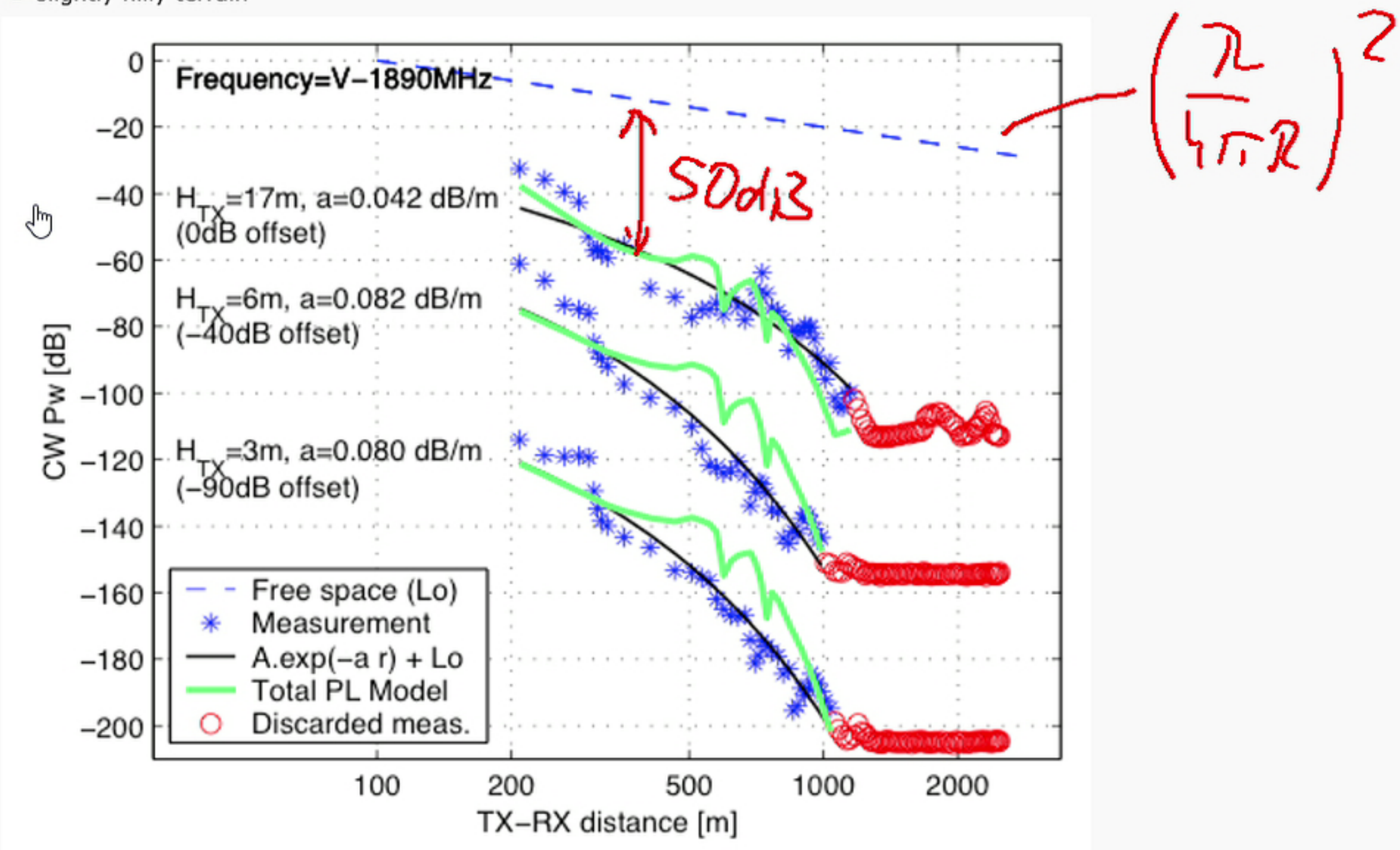
⌘ETSI vehicular

- larger cells (typical few km)
- TX power 24 dBm for mobile phone, transmit antenna height Δh over roof top (typical 15 m), distance *r* in km, *f = 2000 Unik/MHz*

UNIK4700h15-Ra | IoTSec:Managed | Radio propagatio | UNIK4700/UNIK | Friis Equation - (| LarsLundheim-Te | shannon equatic | C2-Outdoor

cwi.unik.no/wiki/C2-Outdoor

- slightly hilly terrain



(Source:István Z Kovács Ph.D.Lecture,CPK, September6, 2002, p.27/45)

http://cwi.unik.no/wiki/File:Kovacs1890MHz.png

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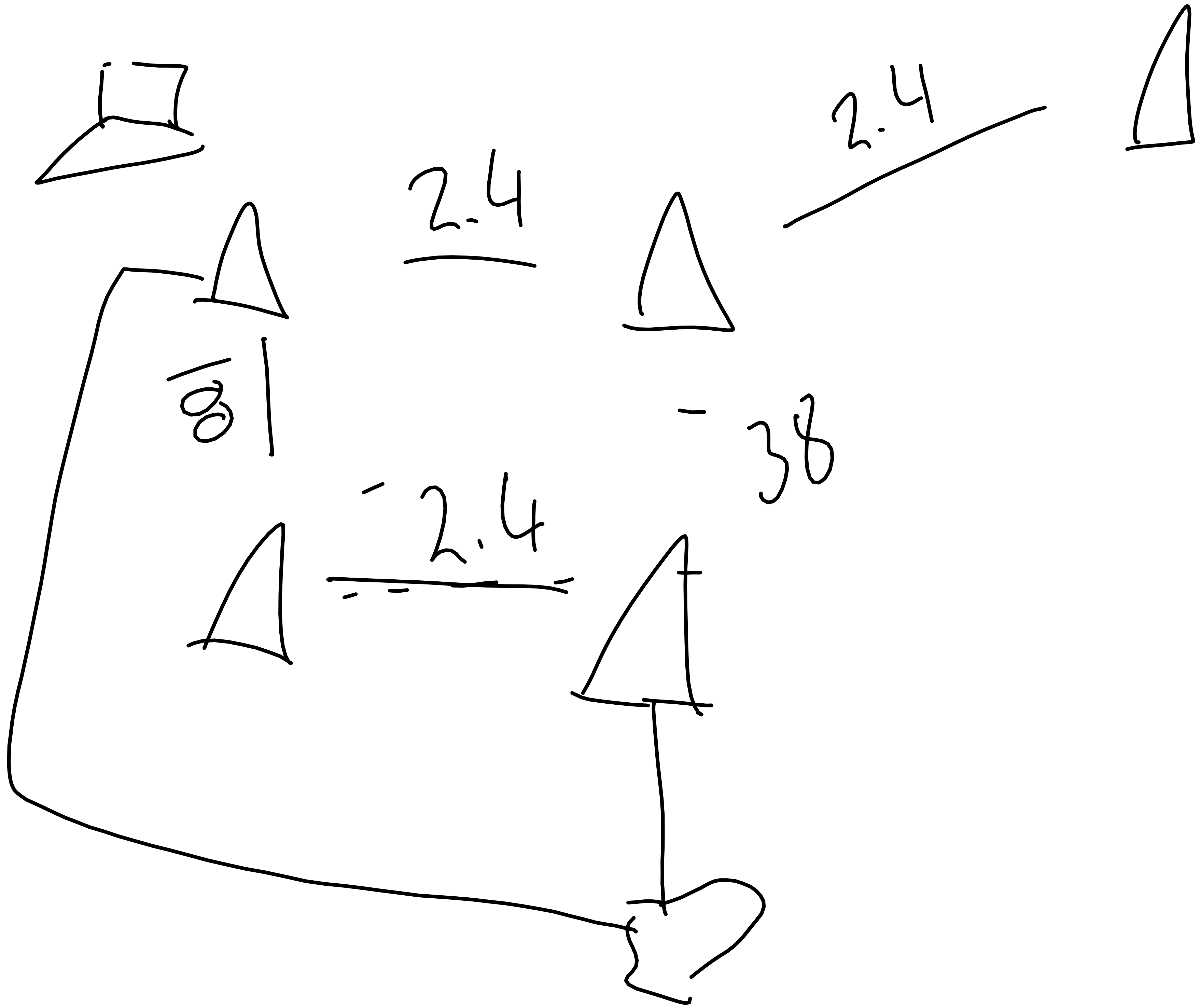
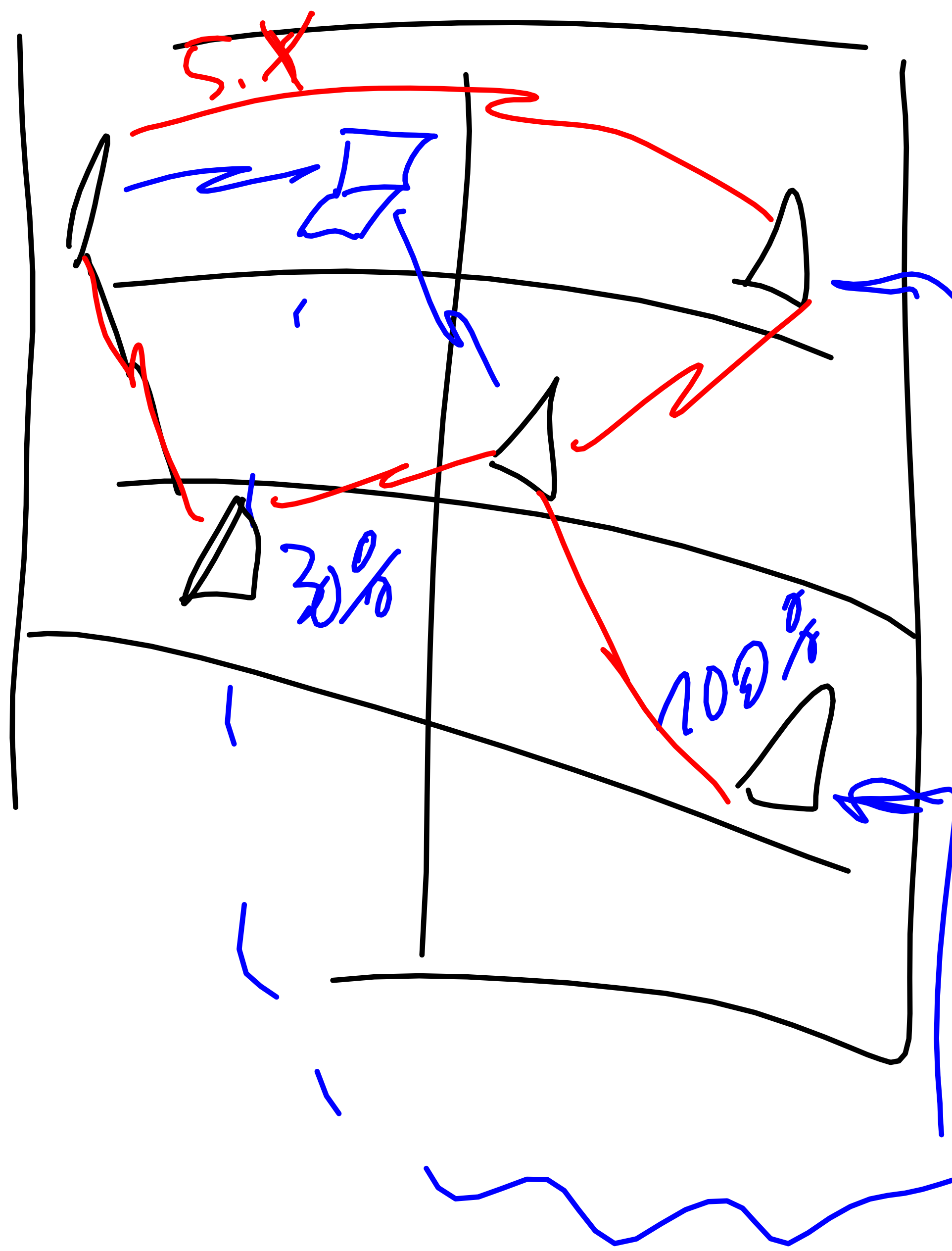
29.10.2015


2.4
2.4
8
38
2.4



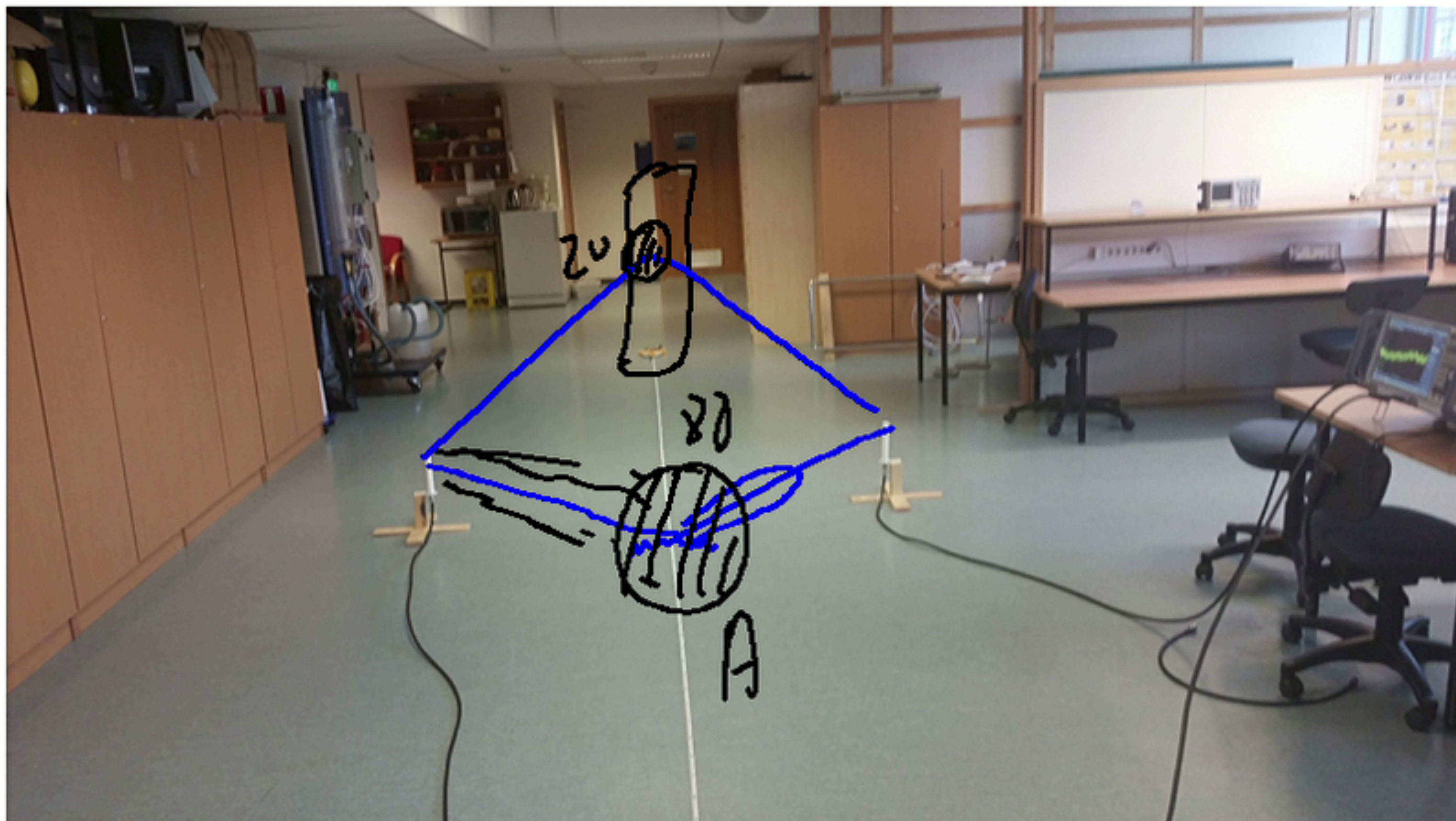
- adaptive radio
- interference
- managed access

Setup

UTD

1) rays
↳ area

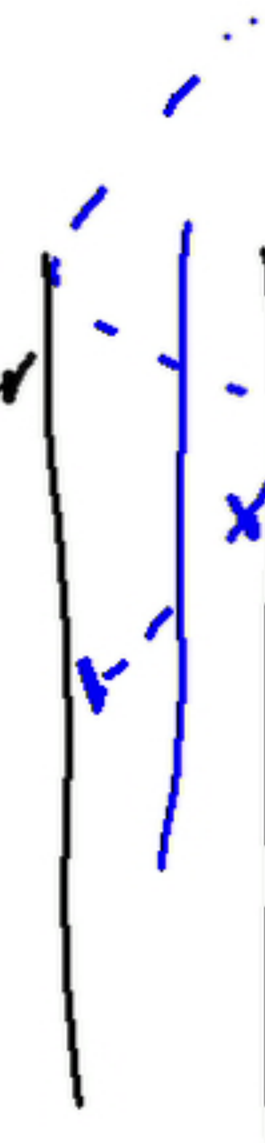
2) weight

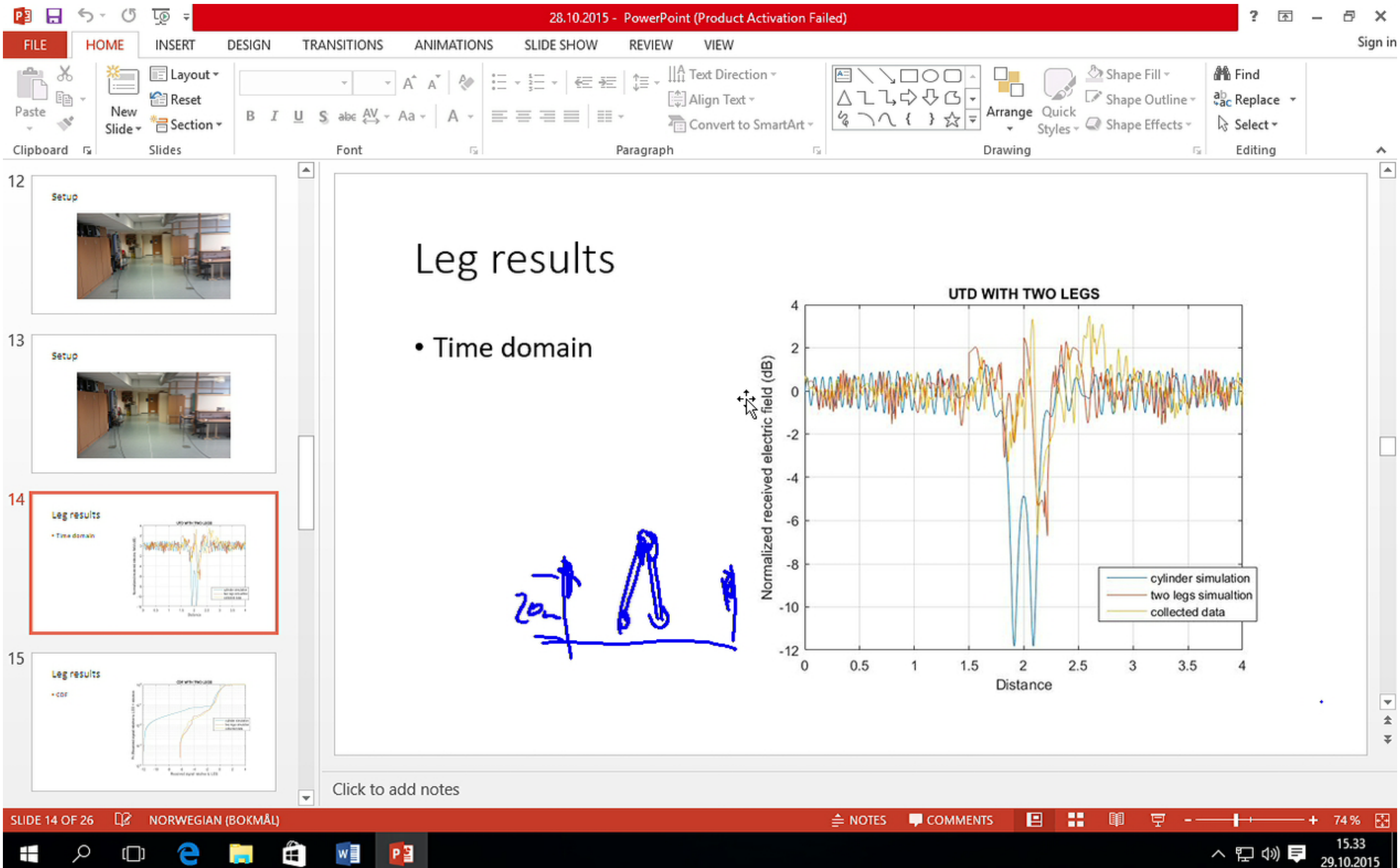


Setup

2.4 GHz

40 x 40 absorber

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Layout
Reset
New Slide
Section
Text Direction
Align Text
Convert to SmartArt
Arrange
Quick Styles
Shape Fill
Shape Outline
Shape Effects
Find
Replace
Select
Clipboard
Slides
Font
Paragraph
Drawing
Editing
12
Setup
13
Setup
14
Leg results
15
Leg results
Leg results
• Time domain
UTD WITH TWO LEGS
Normalized received electric field (dB)
Distance
cylinder simulation
two legs simualtion
collected data
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NORWEGIAN (BOKMÅL)
NOTES
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74 %
15.33
29.10.2015