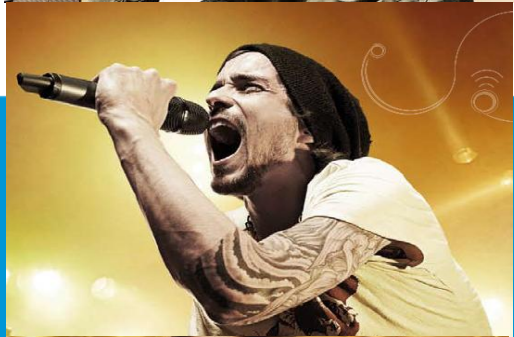


Wireless Systems

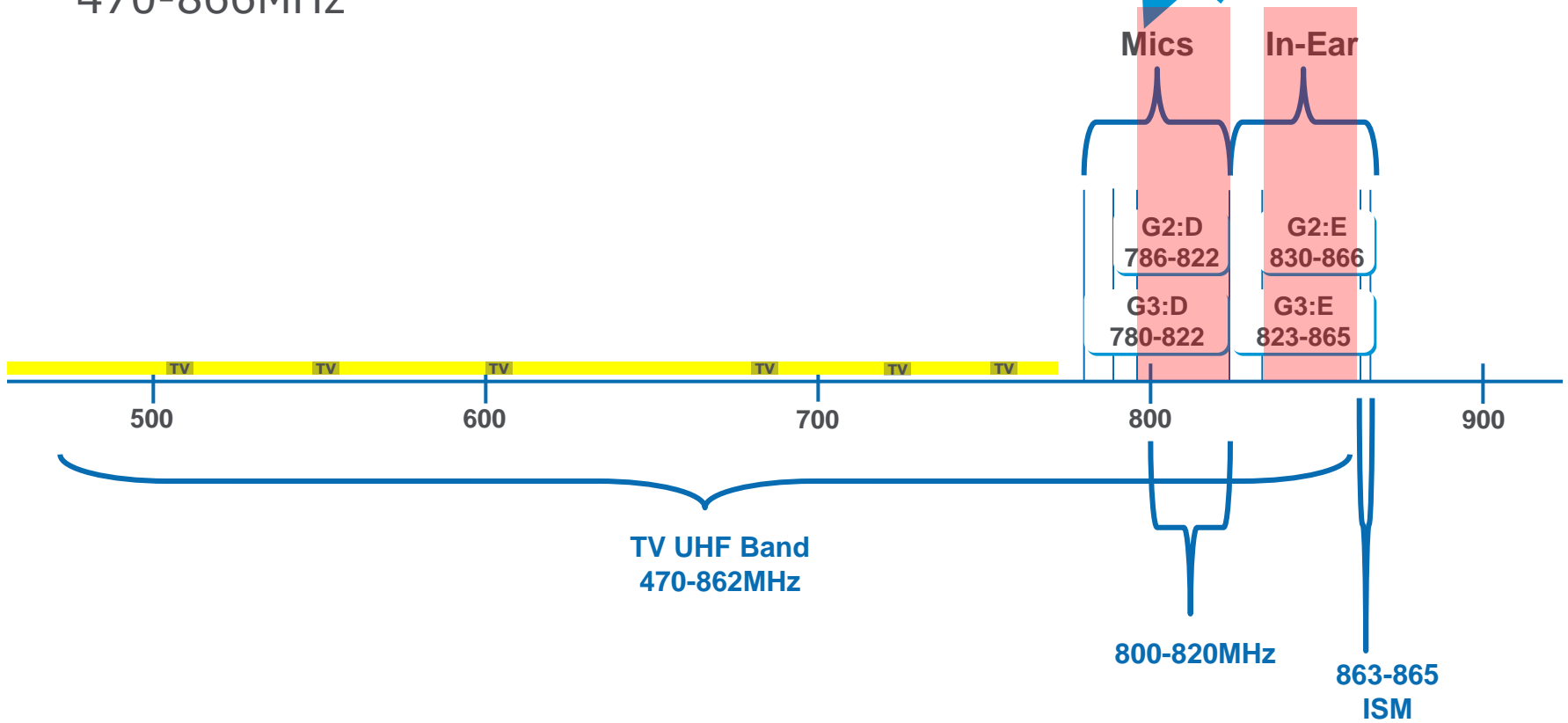


 **SENNHEISER**

Jonas Næsby

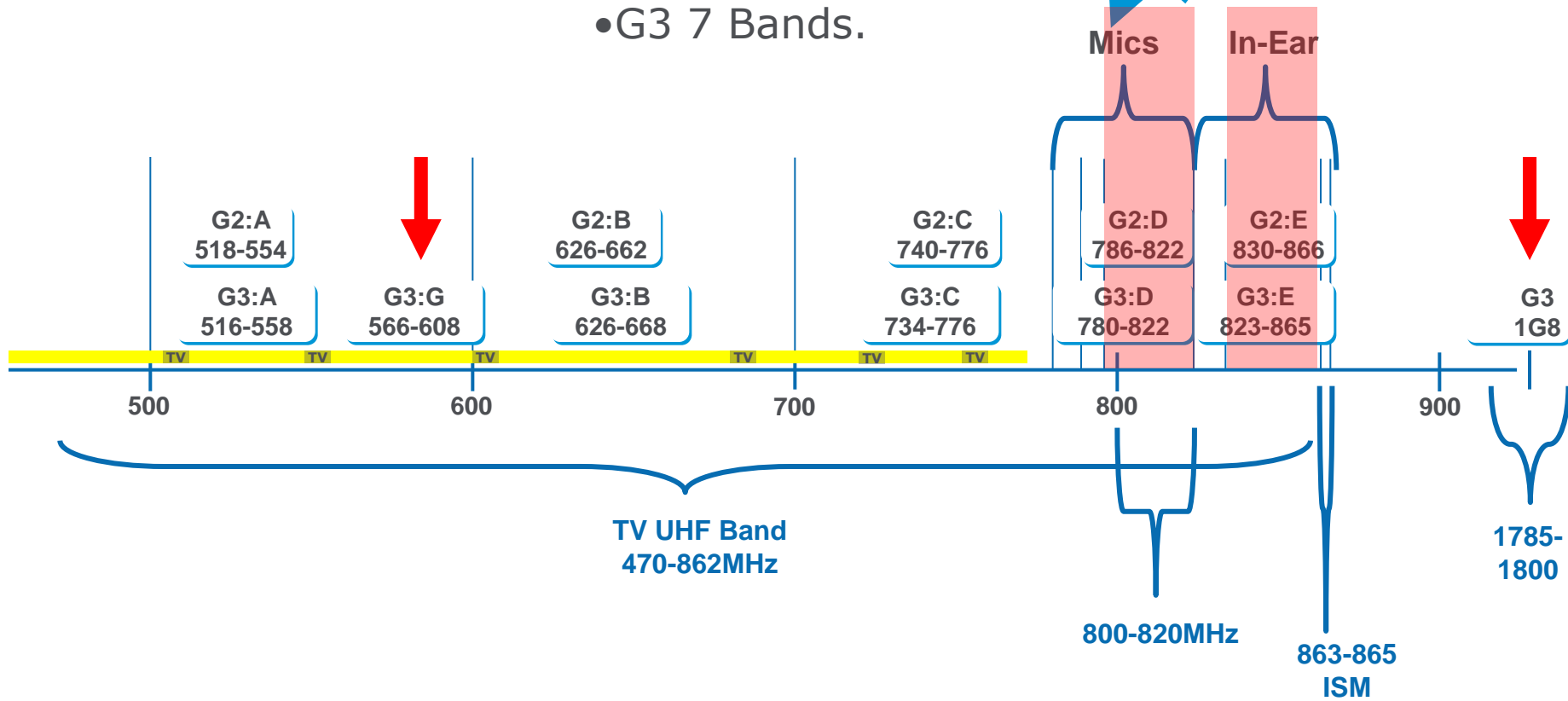
Frequency Ranges

470-866MHz

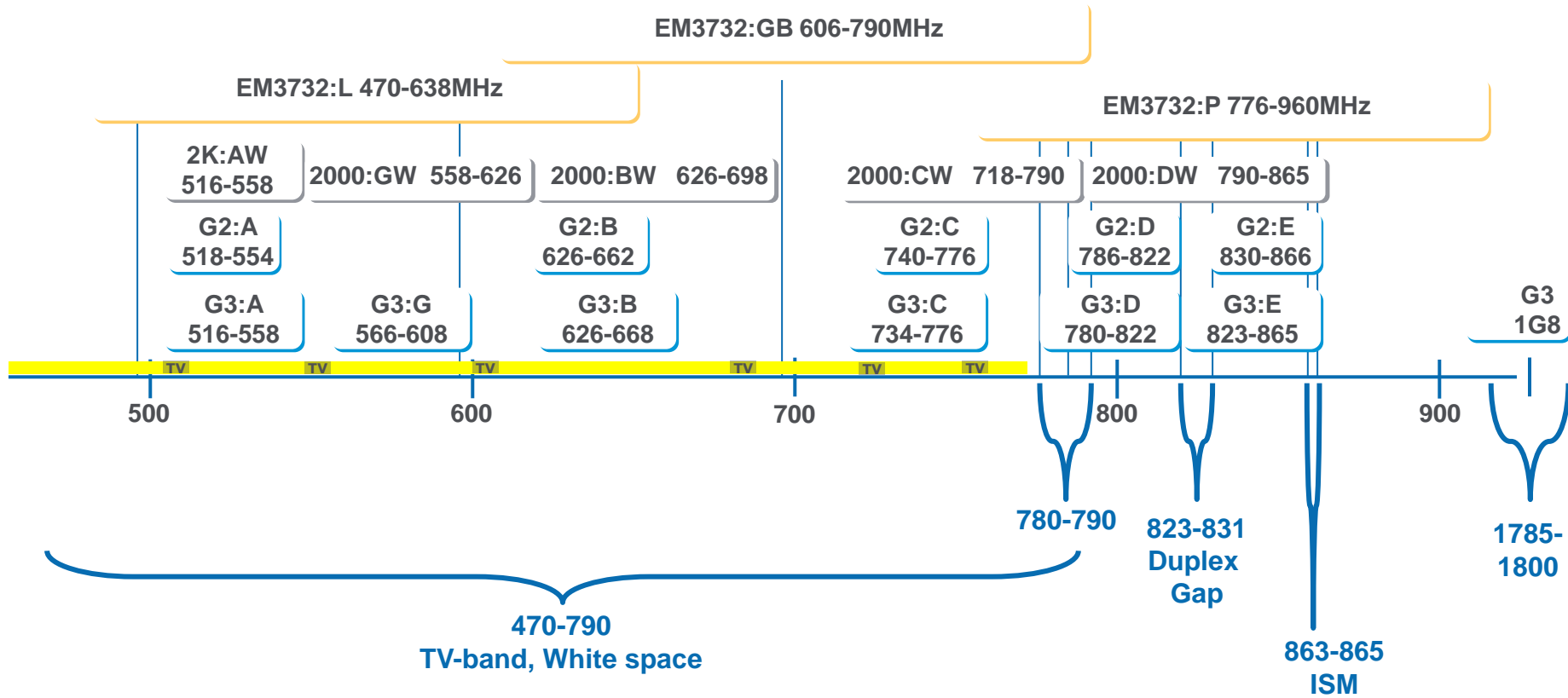


Frequency Ranges

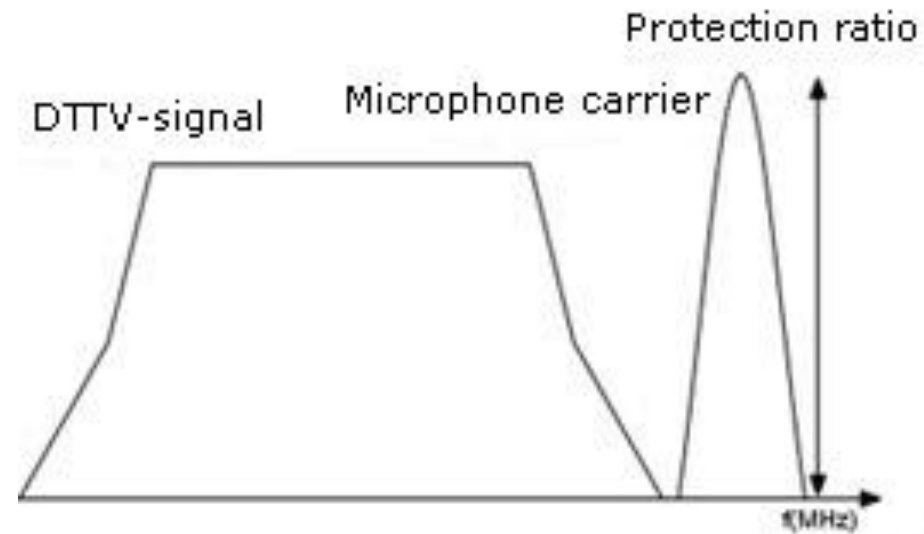
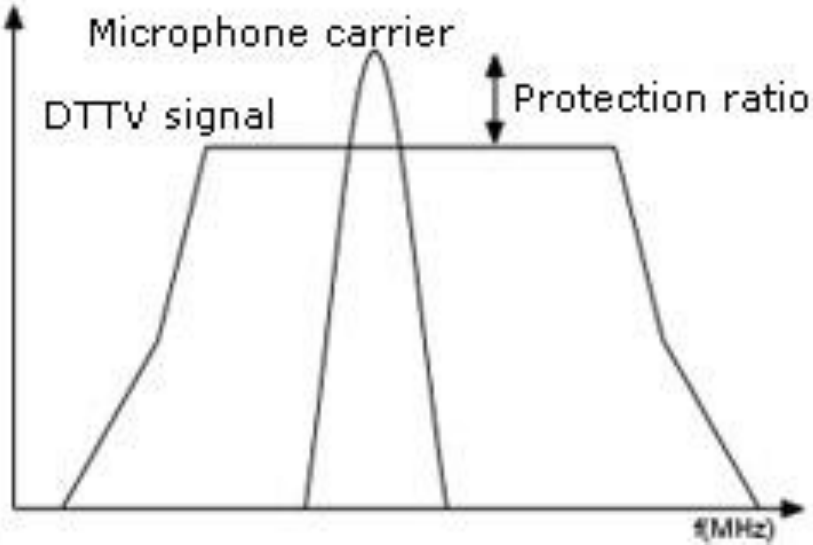
- G2 5 Bands.
- G3 7 Bands.



Frequency Ranges



Digital TV Versus Wireless Microphone



- **Correct results are revealed by spectrum analyzers only at very high resolution bandwidth settings**
- **The signal strength indicator of older receivers may be incorrect or miss DTV or LTE signals**
- **G2 and newer systems are capable of detecting it correctly.**

DVB-T Tool

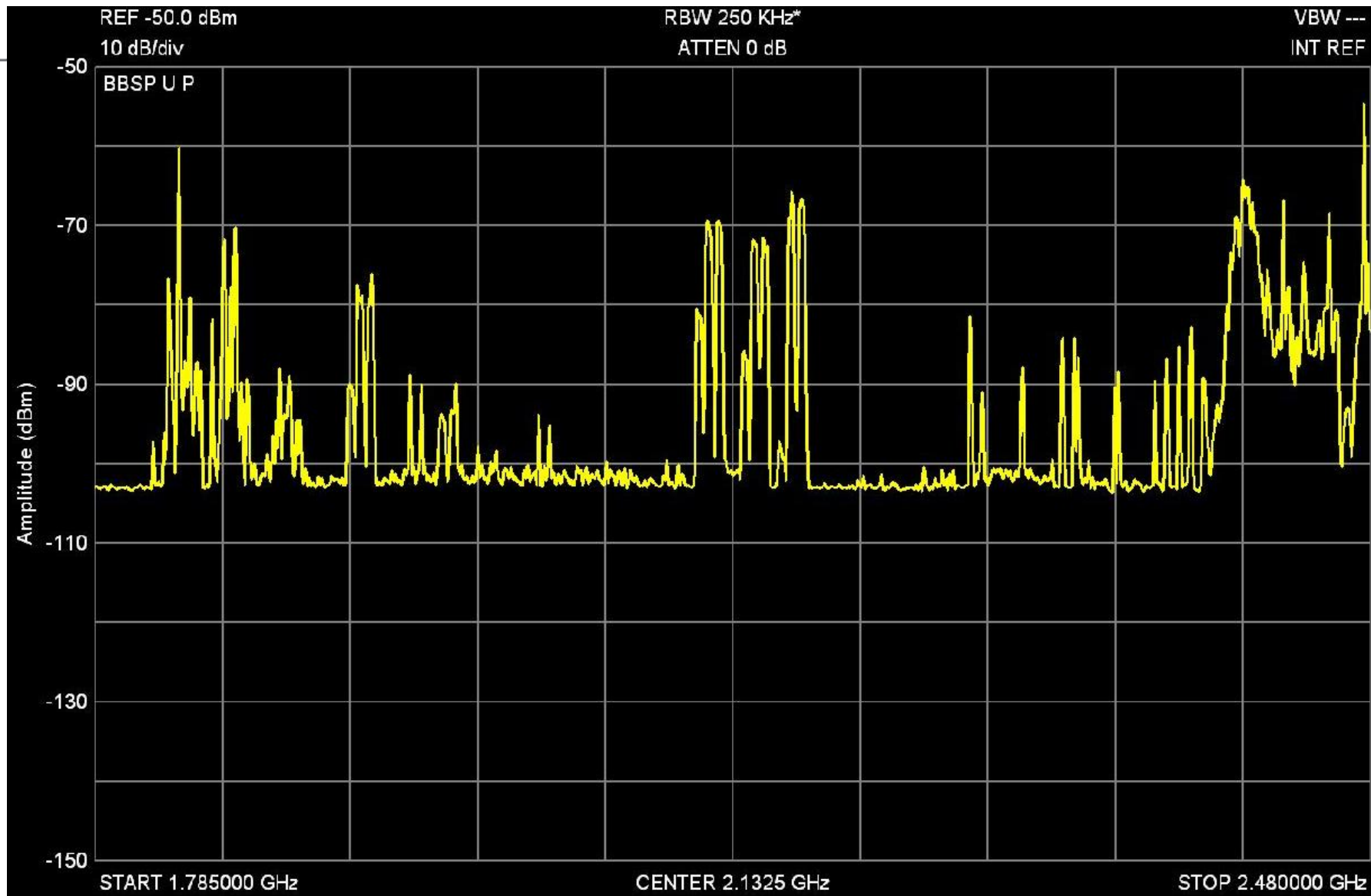
Sennheiser Mics			Series G3	Range B				626 - 668 MHz											
Ch.	Bank 1	Bank 2	Bank 3	Bank 4	Bank 5	Bank 6	Bank 7	Bank 8	Bank 9	Bank 10	Bank 11	Bank 12	Bank 13	Bank 14	Bank 15	Bank			
1	626,300	632,350	638,450 !!	644,550 !!	650,200	656,350	662,750	632,925	626,000	626,000	626,100	626,200	626,050	626,175	626,300	621			
2	626,750	632,800	639,050 !!	645,450 !!	650,750	656,800	663,150	635,425	626,875	626,400	626,500	626,600	626,450	626,575	626,700	621			
3	627,450	633,750	639,450 !!	646,650	651,600	657,450	663,950	639,350 !!	627,500	627,000	627,100	627,200	626,950	627,075	627,200	621			
4	628,450	634,350	640,200 !!	647,200	652,800	657,850	664,500	640,050 !!	630,175	627,800	627,900	628,000	627,550	627,675	627,800	621			
5	628,900	635,700	640,750 !!	648,050	653,250	659,050	665,650	648,500	632,625	629,000	629,100	629,200	628,000	628,125	628,250	621			
6	629,700	636,200	641,550 !!	648,500	654,300	659,900	666,100	653,950	634,800	630,600	630,700	630,800	628,550	628,675	628,800	621			
7	630,800	636,900	642,600 !!	649,150	654,700	660,900	667,050	655,350	639,625 !!	632,800	632,900	633,000	629,200	629,325	629,450	621			
8	631,750	637,300	643,450 !!	649,650	655,600	661,600	667,550	656,250	640,825 !!	636,000	636,100	636,200	630,550	630,675	630,800	631			
9	640,550 !!	628,850	628,550	630,500	630,500	626,250	627,550	659,025	650,525	638,400 !!	638,500 !!	638,600 !!	631,250	631,375	631,500	631			
10	646,100	641,600 !!	649,700	636,050	641,750 !!	637,000	629,750	665,175	661,700	643,200 !!	643,300 !!	643,400 !!	632,700	632,825	632,950	631			
11	653,300	647,150	655,700	659,600	665,300	640,900 !!	642,450 !!	665,675	663,625	647,200	647,300	647,400	633,450	633,575	633,700	631			
12	659,150	665,300	663,050	666,800	665,900	652,150	649,700	667,275	668,000	651,600	651,700	651,800	635,150	635,275	635,400	631			
13	635,450	643,100 !!	629,000	627,950	626,150	627,050	626,250	631,200	626,375	659,000	659,100	659,200	636,550	636,675	636,800	631			
14	636,500	643,850 !!	630,200	632,300	627,500	628,000	630,750	633,750	627,900	662,400	662,500	662,600	639,150 !!	639,275 !!	639,400 !!	631			
15	642,650 !!	648,200	634,100	632,900	628,100	631,350	632,950	636,025	628,425	667,600	667,700	667,800	640,950 !!	641,075 !!	641,200 !!	641			
16	651,200	652,250	648,050	635,450	629,900	631,900	634,450	638,500 !!	629,125	628,175	628,275	628,375	642,100 !!	642,225 !!	642,350 !!	641			
17	655,100	653,000	650,600	638,300 !!	631,250	632,700	637,300	640,450 !!	629,575	629,475	629,575	629,675	644,000 !!	644,125 !!	644,250 !!	641			
18	658,100	656,450	657,350	651,950	633,050	638,750 !!	638,950 !!	643,650 !!	630,975	631,300	631,400	631,500	648,650	648,775	648,900	641			
19	659,900	658,250	661,400	653,300	633,800	643,700 !!	640,450 !!	653,000	631,525	633,850	633,950	634,050	653,200	653,325	653,450	651			
20	661,550	661,250	662,600	660,200	636,050	647,300	644,250 !!	655,875	633,350	637,625	637,725	637,825	654,000	654,125	654,250	651			
21	662,300	662,300	664,250	661,850	636,800	653,100	647,450	660,050	636,375	640,150 !!	640,250 !!	640,350 !!	657,950	658,075	658,200	651			
22	665,750	663,050	666,050	662,450	646,550	666,100	653,850	661,200	641,400 !!	641,175 !!	641,275 !!	641,375 !!	660,300	660,425	660,550	661			
23	666,650	664,550	666,500	665,150	658,850	667,050	656,100	662,500	642,250 !!	649,950	650,050	650,150	661,250	661,375	661,500	661			
24	667,700	666,950	667,700	666,200	660,200	667,850	661,200	667,700	643,975 !!	654,975	655,075	655,175	666,350	666,475	666,600	661			
25	632,900	626,150	626,450	626,150	626,600	629,400	626,800	636,750	644,725 !!	657,675	657,775	657,875	667,600	667,725	667,850	661			
26	638,150 !!	626,900	627,650	633,950	635,450	630,450	630,150	641,425 !!	646,200	660,975	661,075	661,175							
27	646,850	628,100	632,000	640,850 !!	639,350 !!	636,250	636,450	651,150	653,875	661,900	662,000	662,100							
28	650,150	641,150 !!	633,200	642,200 !!	649,400	639,500 !!	637,800		655,050	664,625	664,725	664,825							
29	651,800	653,600	656,450	643,250 !!	658,250	643,250 !!	639,800 !!		660,625	665,250	665,350	665,450							
30		655,700	659,450	659,150	661,250	650,650	640,850 !!		661,275	664,125	664,225	664,325							
31		660,350	660,650	663,650	662,450	663,700	651,350		667,050	663,375	663,475	663,575							
32		665,900	667,250	667,550	664,100	664,500	659,100		643,375 !!										

Avoid channels marked !! as they will be in conflict with TV. Note that more suitable frequency plans for your specific need may be calculated by Sennheiser upon request.

Free channels	26	28	24	26	30	27	26	21	25	27	27	27	21	21	21	2
Max Free	30															
TV transmitters at Stockholm Nacka																
TV Ch.	f1	<	f0	>	f2											
39	614,00	<	618,00	>	622,00											
42	638,00	<	642,00	>	646,00											
50	702,00	<	706,00	>	710,00											
55	742,00	<	746,00	>	750,00											
56	750,00	<	754,00	>	758,00											
53	726,00	<	730,00	>	734,00											



Save Our Spectrum - 1800 vs. 2400

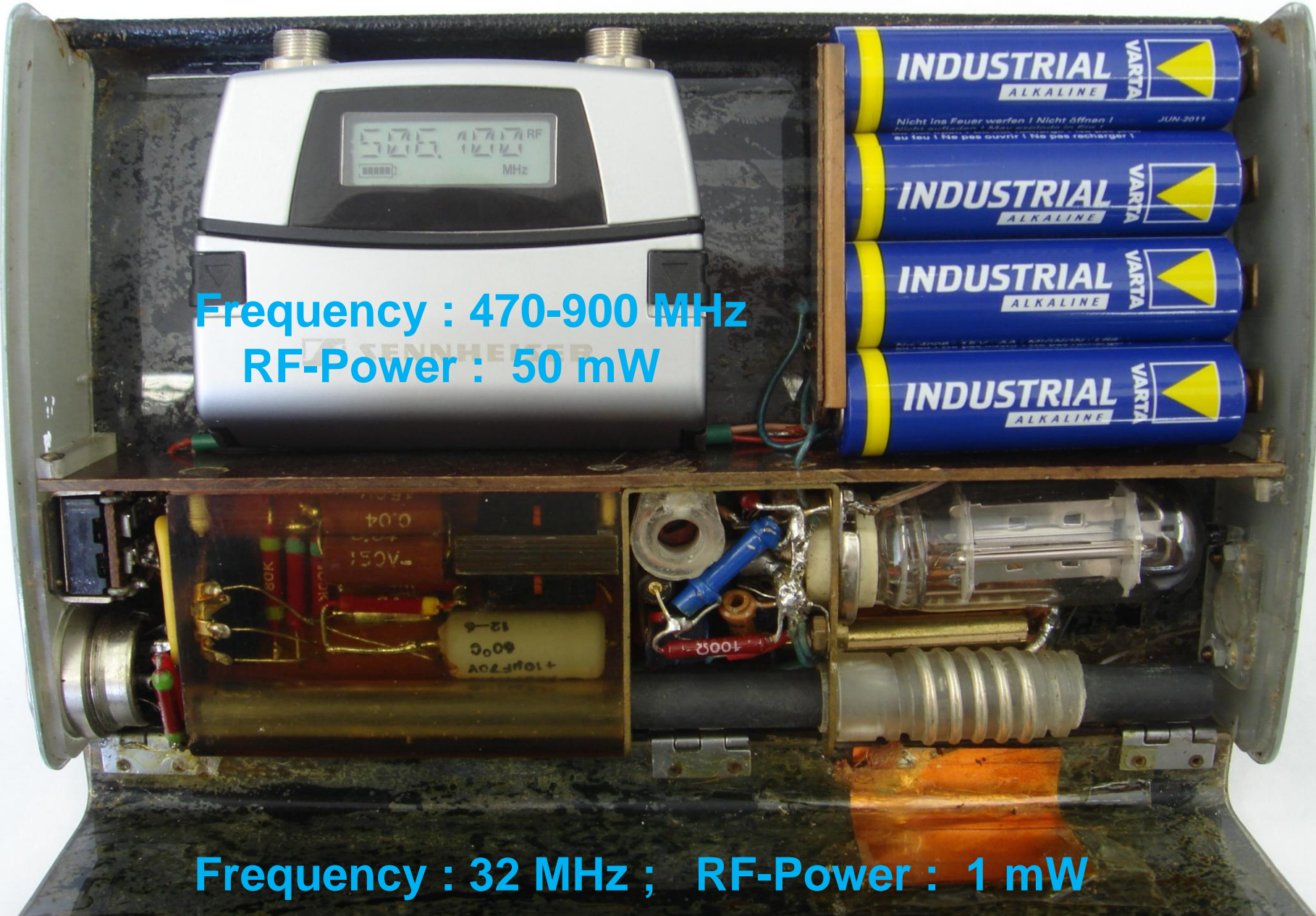


Since 1957 Sennheiser "Mikroport" stands for radio microphones on stage and in TV Studios



The first "Mikroport System"





Frequency : 470-900 MHz
RF-Power : 50 mW

Frequency : 32 MHz ; RF-Power : 1 mW

What Do You Need ?

Transmitter . .

A Device That Converts Audio Signals
Into Electromagnetic Waves . . .

Receiver . .

A Device That Converts Electromagnetic
Waves Into Audio Signals

*Antenna, Cable, Batteries, Combiner, Splitter, . . .
Spectrum Analyzer*

Basic Components

Transmitter - Pocket / Hand Held / Plug On / IEM

Microphone - Tie Clip / Hand Held / Headset

Receiver - Diversity - Pocket / IEM

Antennas - Omni / Directional / Active / Circular

Batteries - Alkaline / Lithium / Re Chargeable

Bodypack Transmitter

RF- Power : 50 mW

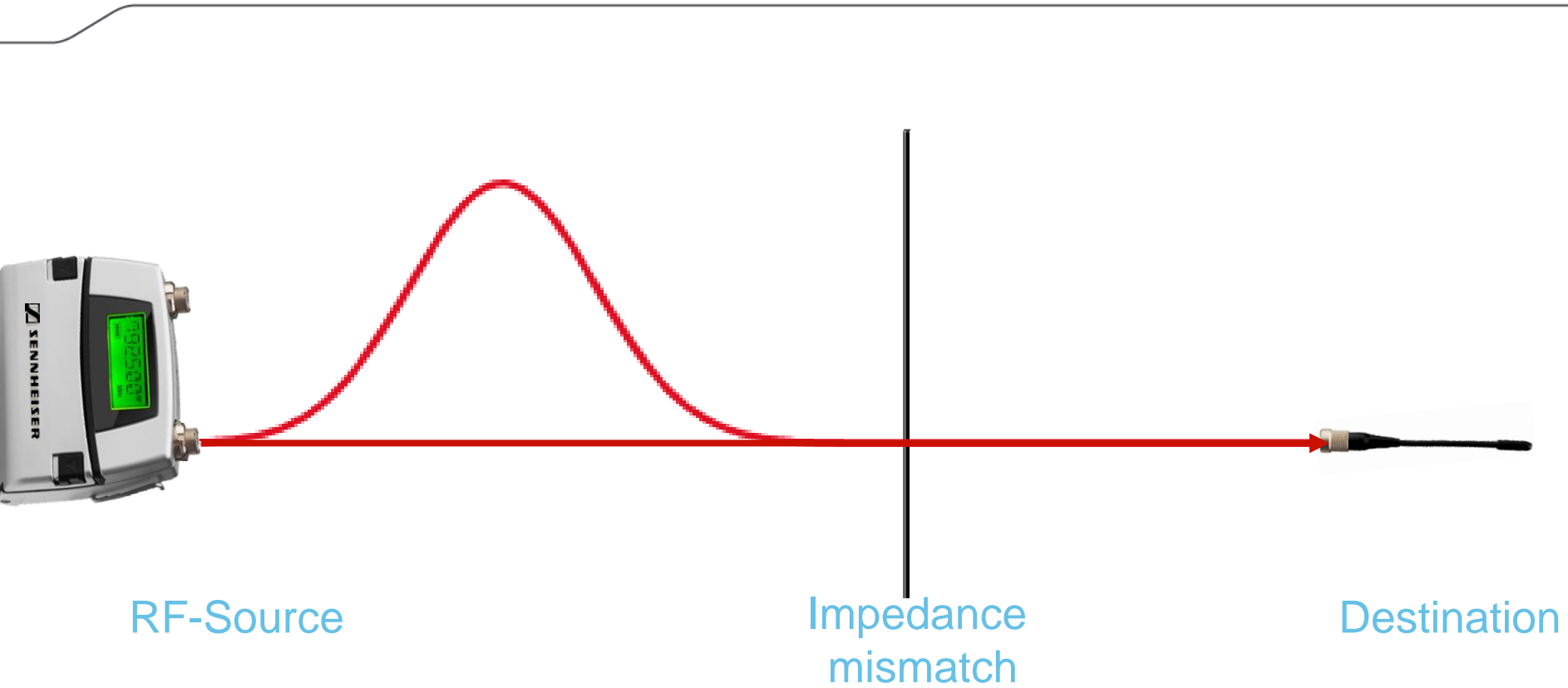
**RF-Power is measured directly
at the Antenna connector**

**Radiated Power (ERP) : 0.25 - 40
mW**



Detuning of antenna reduce the radiated power !

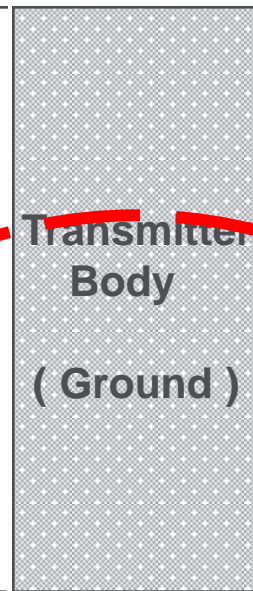
Antenna detuning



Handheld Transmitter Antenna



Antenna



Transmitter
Body
(Ground)

Antenna

Ground Plane Antenna

Set Up



- Power Supply
- Data
- Audio out
- Antennas

Then Switch On.....

What comes first?

Transmitter?



Receiver?



First, Switch On The Receiver (s)!

Select Frequency



RF level check

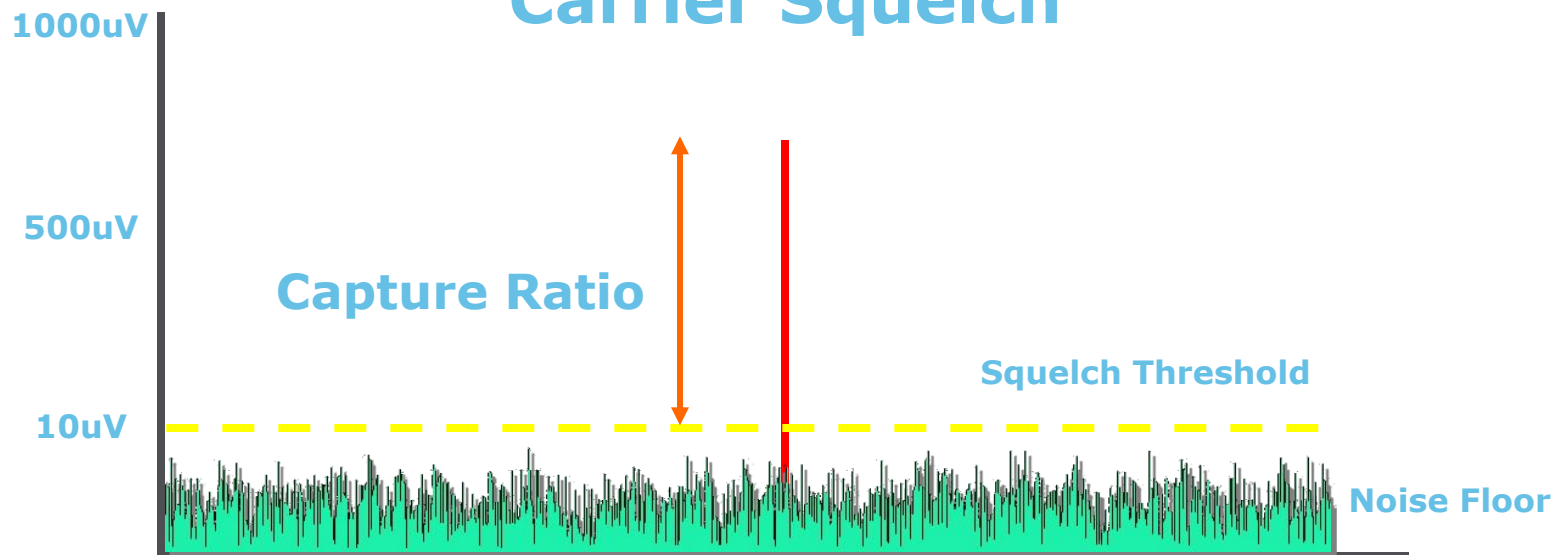
No indication = Free Frequency

Consider Deviation

Squelch ?

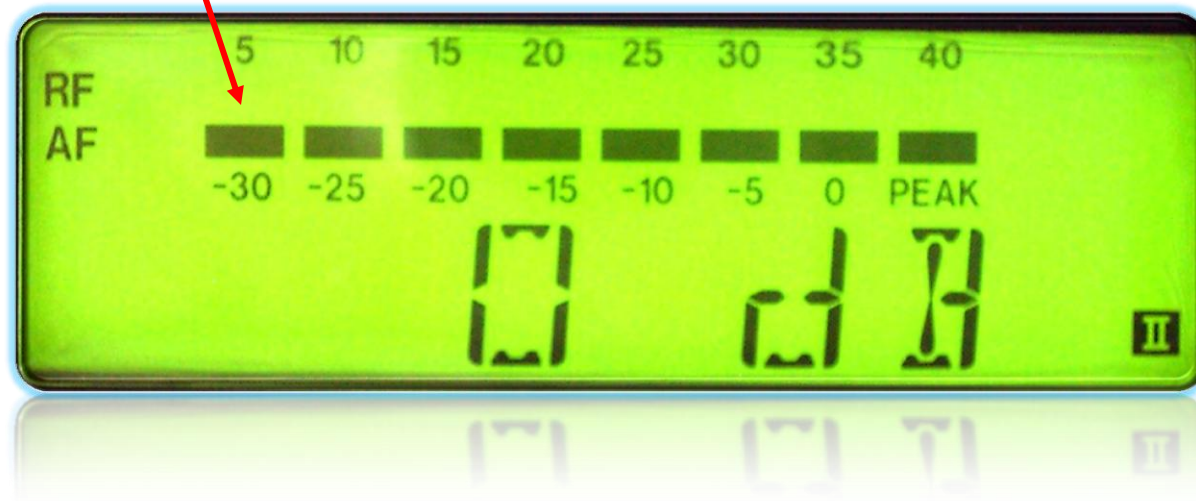
A Circuit Within a Receiver That Mutes The Receiver Until The Signal Strength Exceeds a Predefined Level

Carrier Squelch



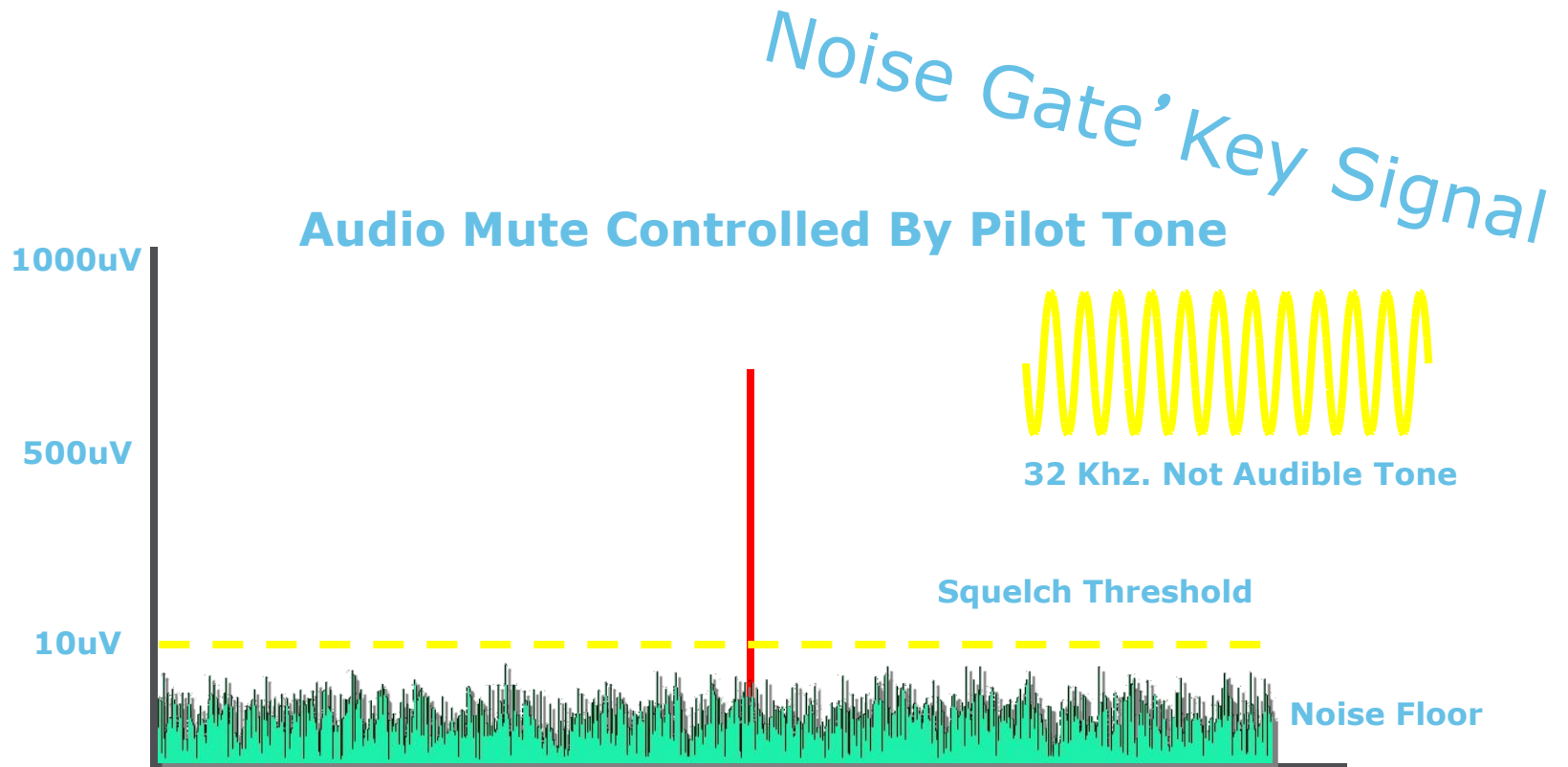
Squelch / Audio Mute

No RF signal



But peak level at the Rx audio out!

Pilot Tone Squelch



What Is Diversity ?

True Diversity

Antenna Phase
Diversity

Rota-versity

Ratio Diversity

Digital Posiphase
Diversity

Real, True and Genuine Diversity

Antenna Diversity

Panning Diversity

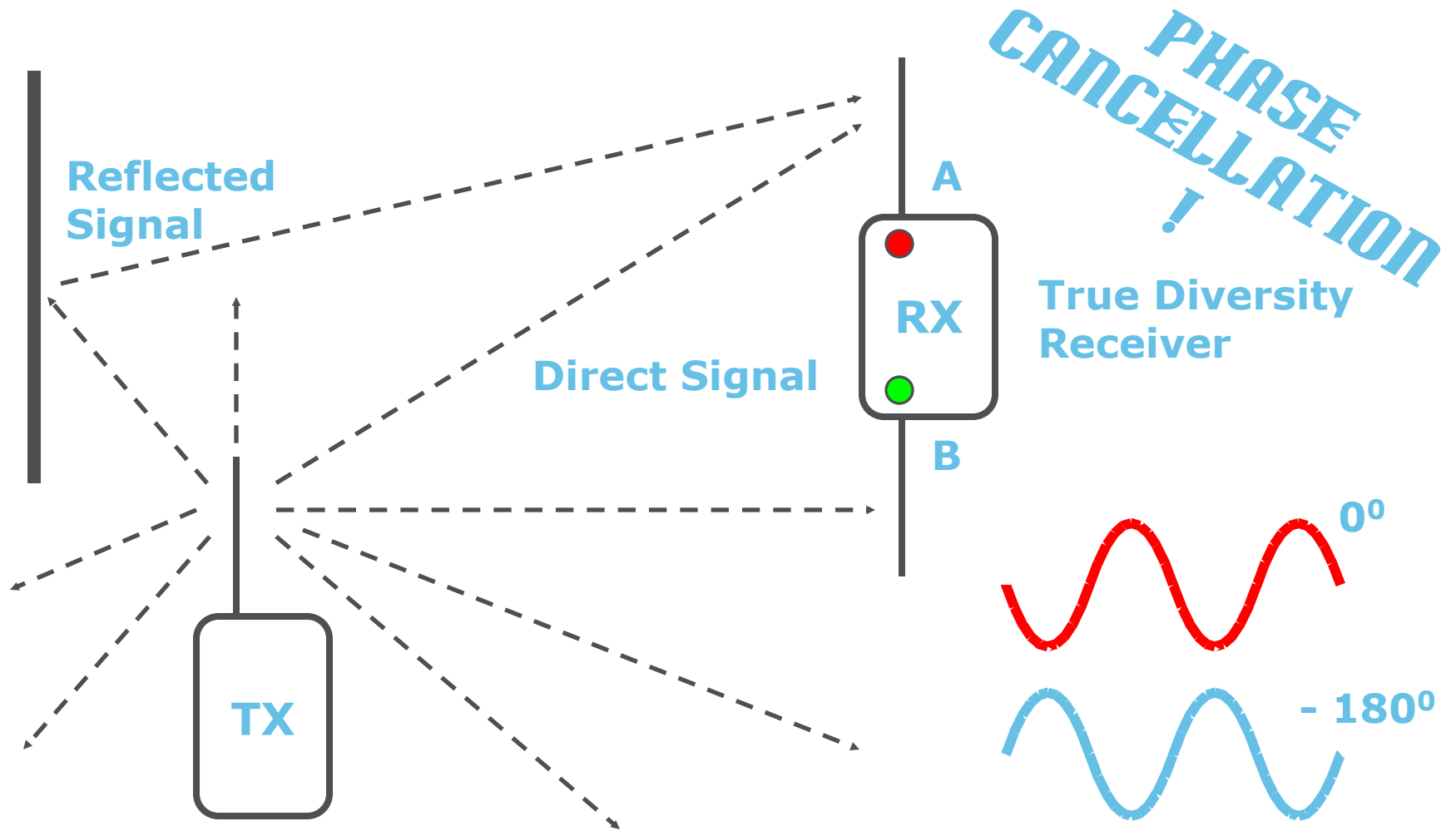
Adaptive Diversity

Space Diversity

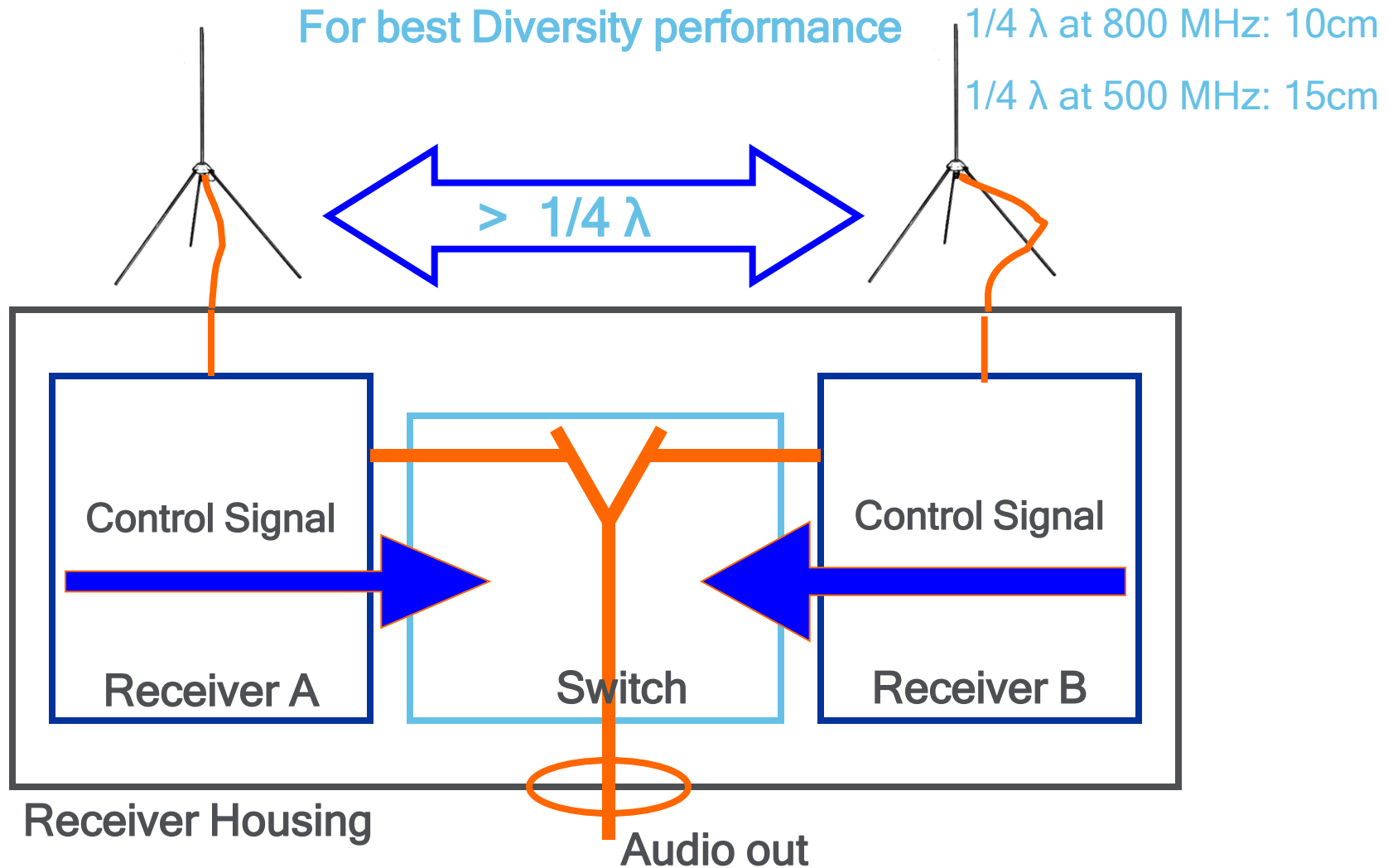
Sennheiser EM 2050 Touring Receiver



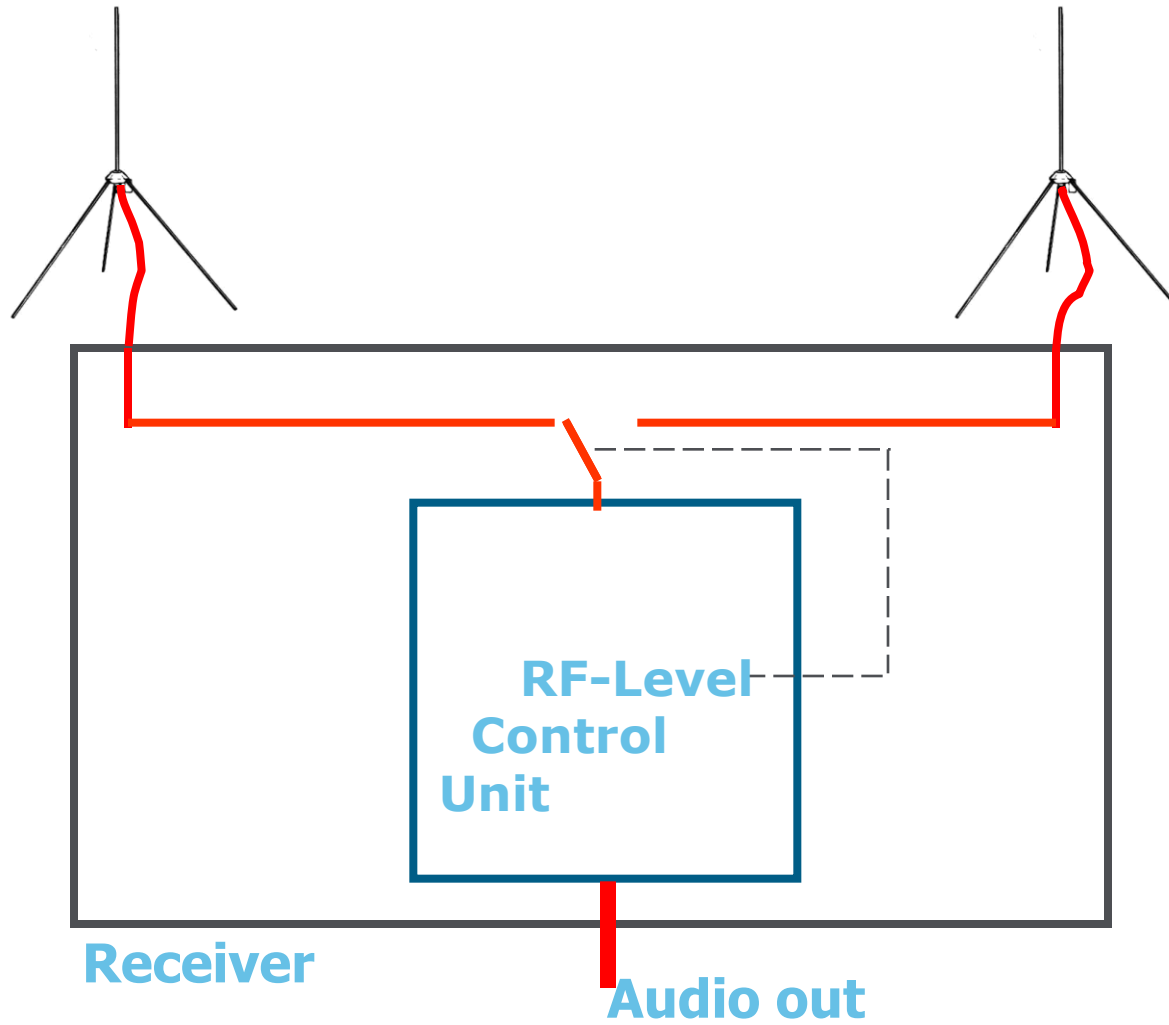
Diversity ?



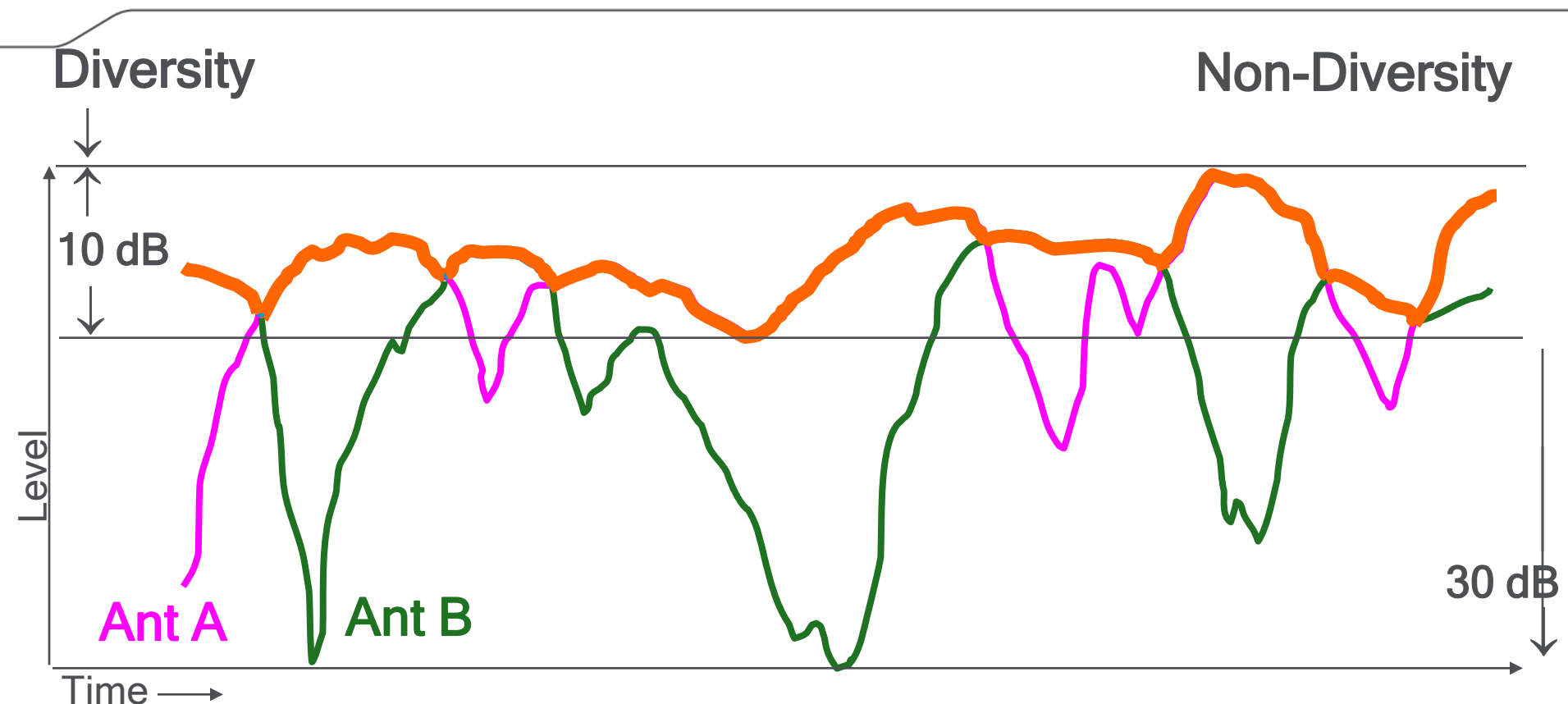
True Diversity



Simple Diversity



Min./Max. RF-Signals



True Diversity creates smoother RF voltages in the receiver !
= better Sound Quality

Antennas:

...are the eyes of the receiver

“Line of sight” between Tx & Rx antennas gives best results

Allow a minimum distance of 4 meters between Rx & Tx antennas in order to smooth out RF voltage

Detuning of Rx-antennas is avoided by some distance to metal structures

Antennas:

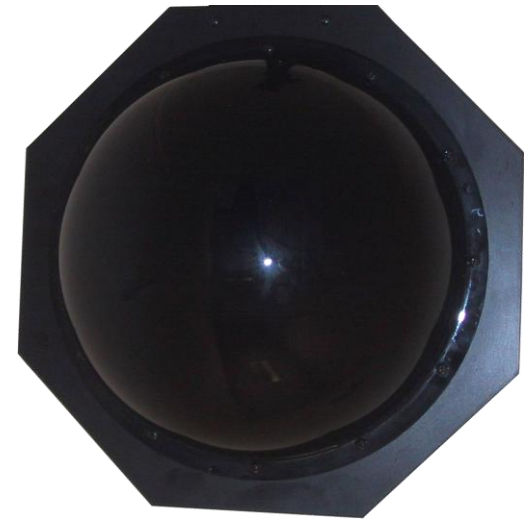
Basic Transmit / Receive Antennas



Omni - Linear



Directional - Linear



Directional - Circular

Indoors: In buildings reflections are essential: Omni or little directivity works best

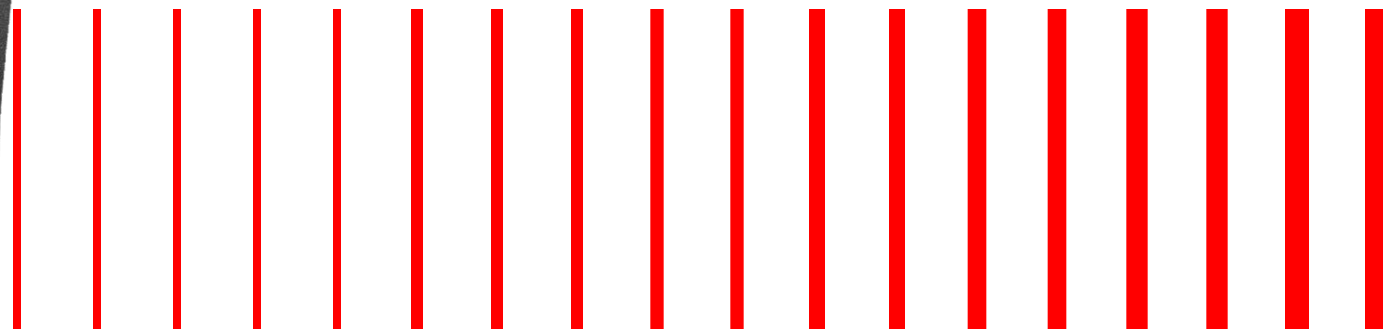
Outdoors: Little or no reflections: Directivity will help to stabilize the signal

Polarisation Of Antennas

Antenna
Vertical



Antenna
Vertical

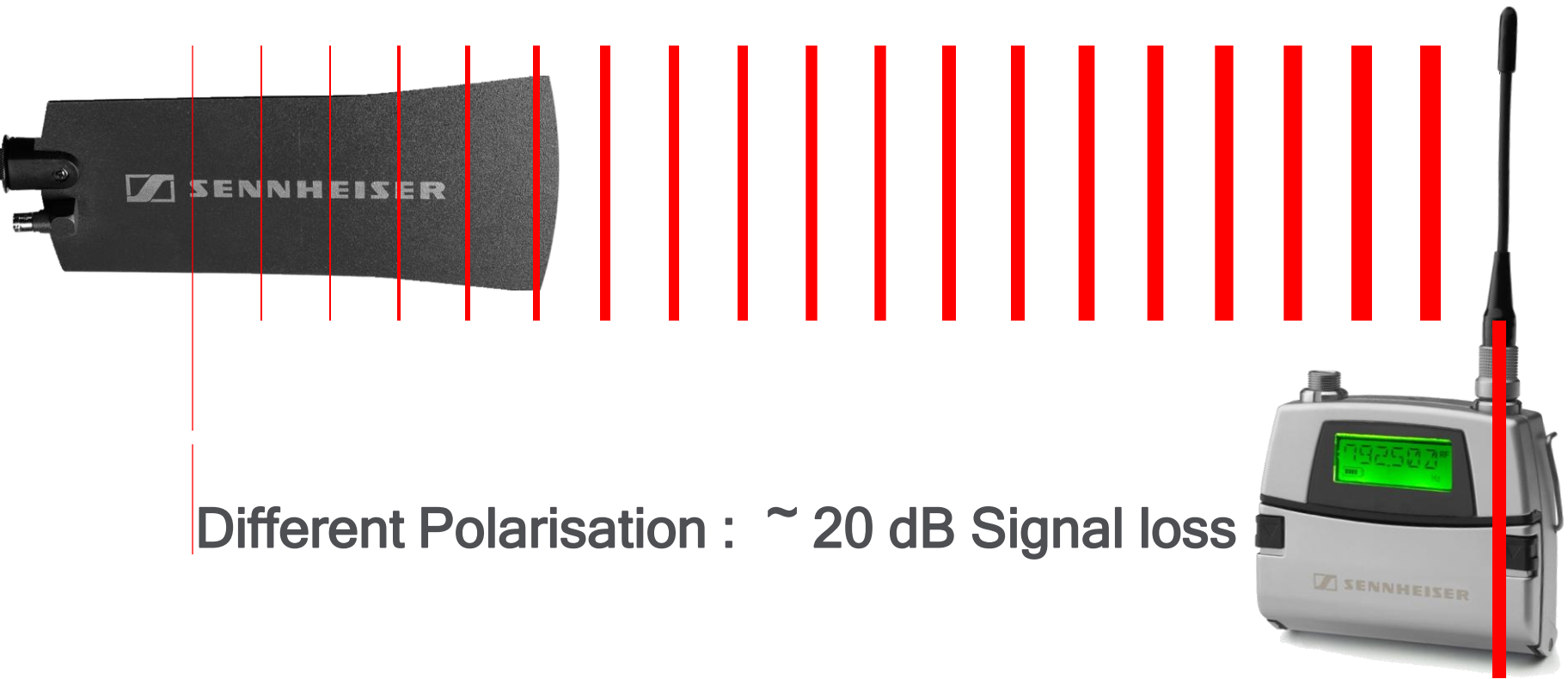


Equal Polarisation: Best Level

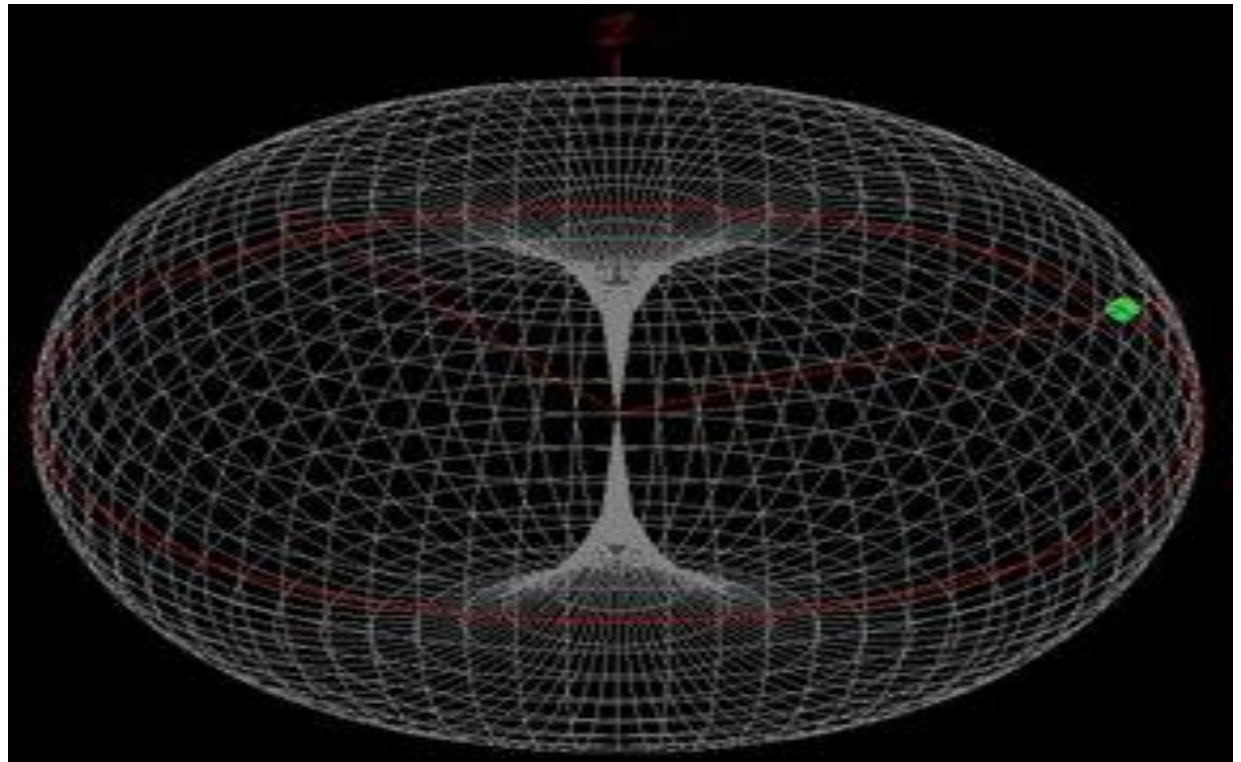
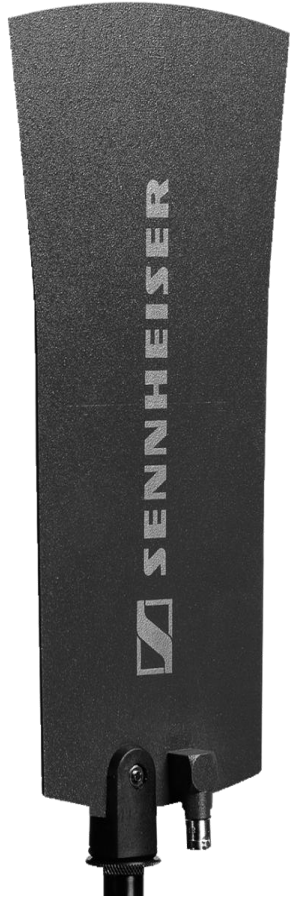
Polarisation Of Antennas

Antenna
Horizontal

Antenna
Vertical

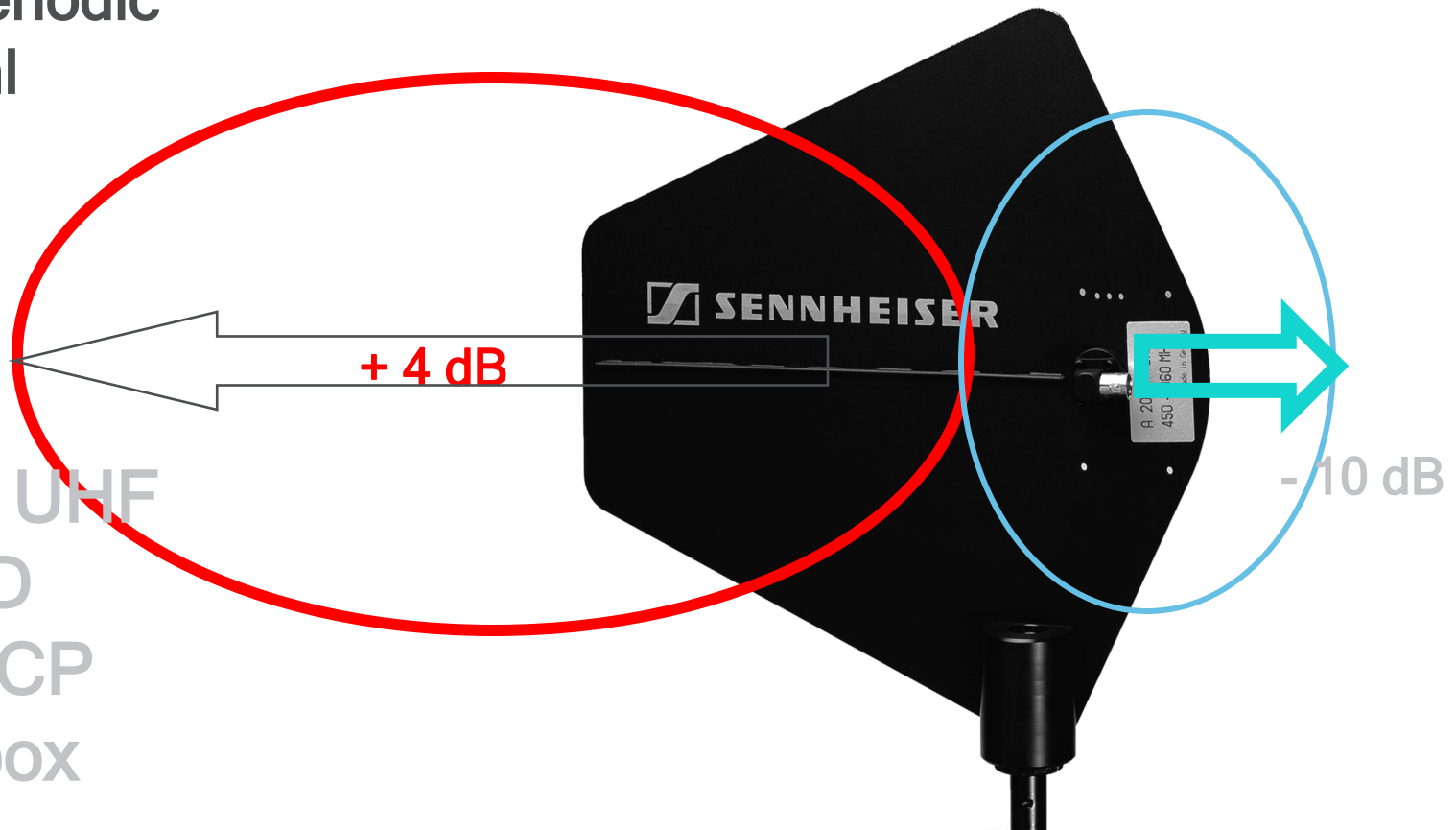


Omni Dirrectional Antenna



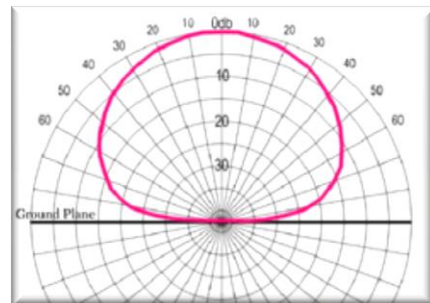
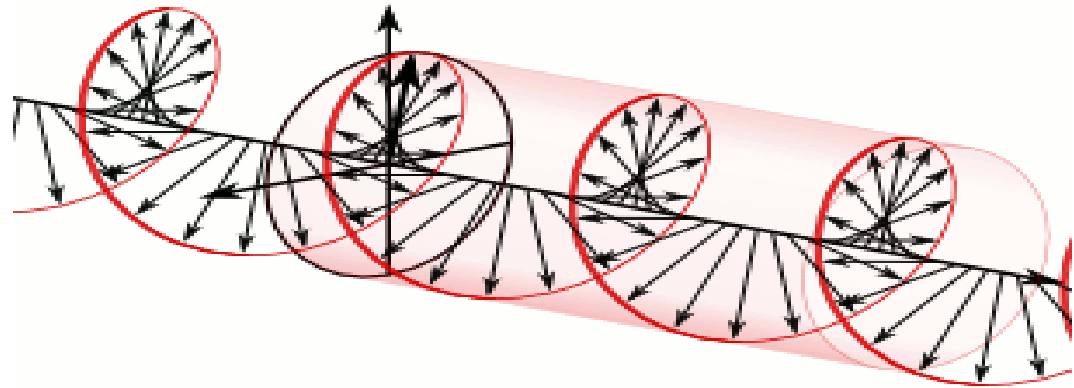
Directional Antenna

- Yagi Antenna
- LogPeriodic
- Helical
- Patch



A 2003 UHF
A 12 AD
A 5000CP
Lunchbox

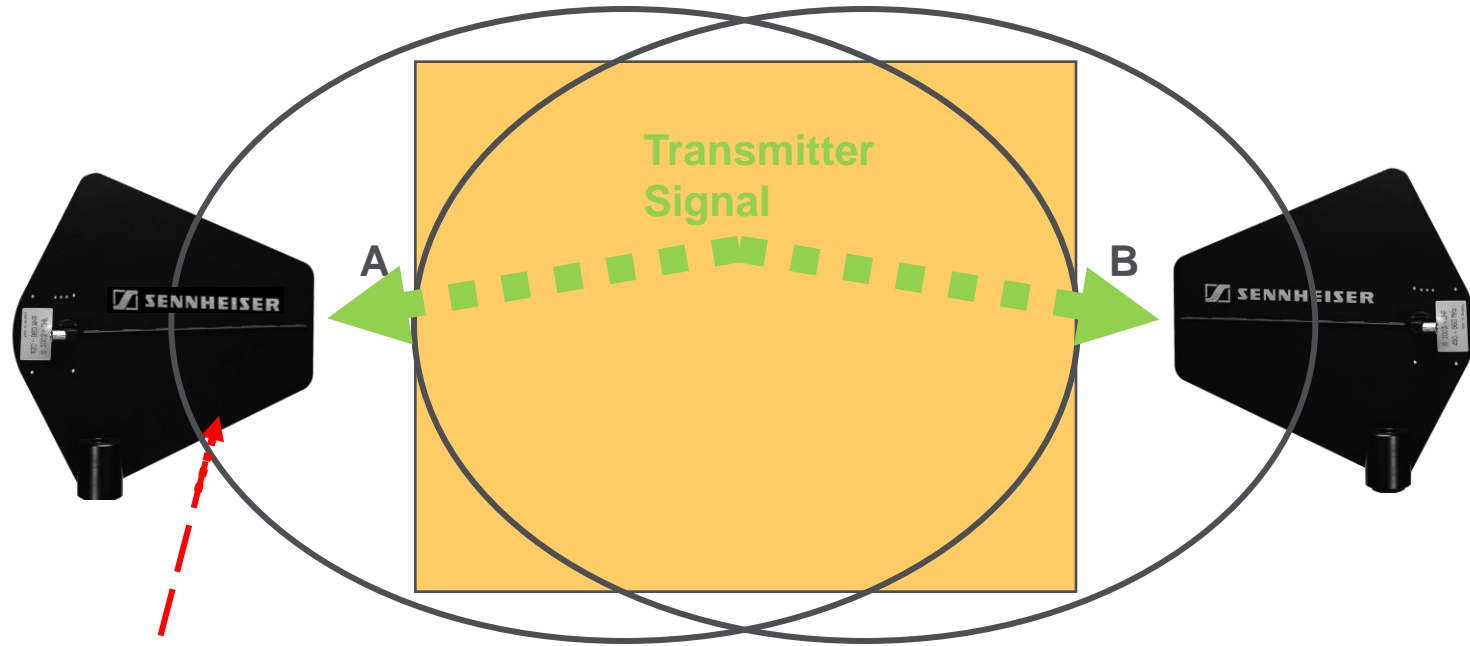
Circular Polarized Antenna



Antenna Placement



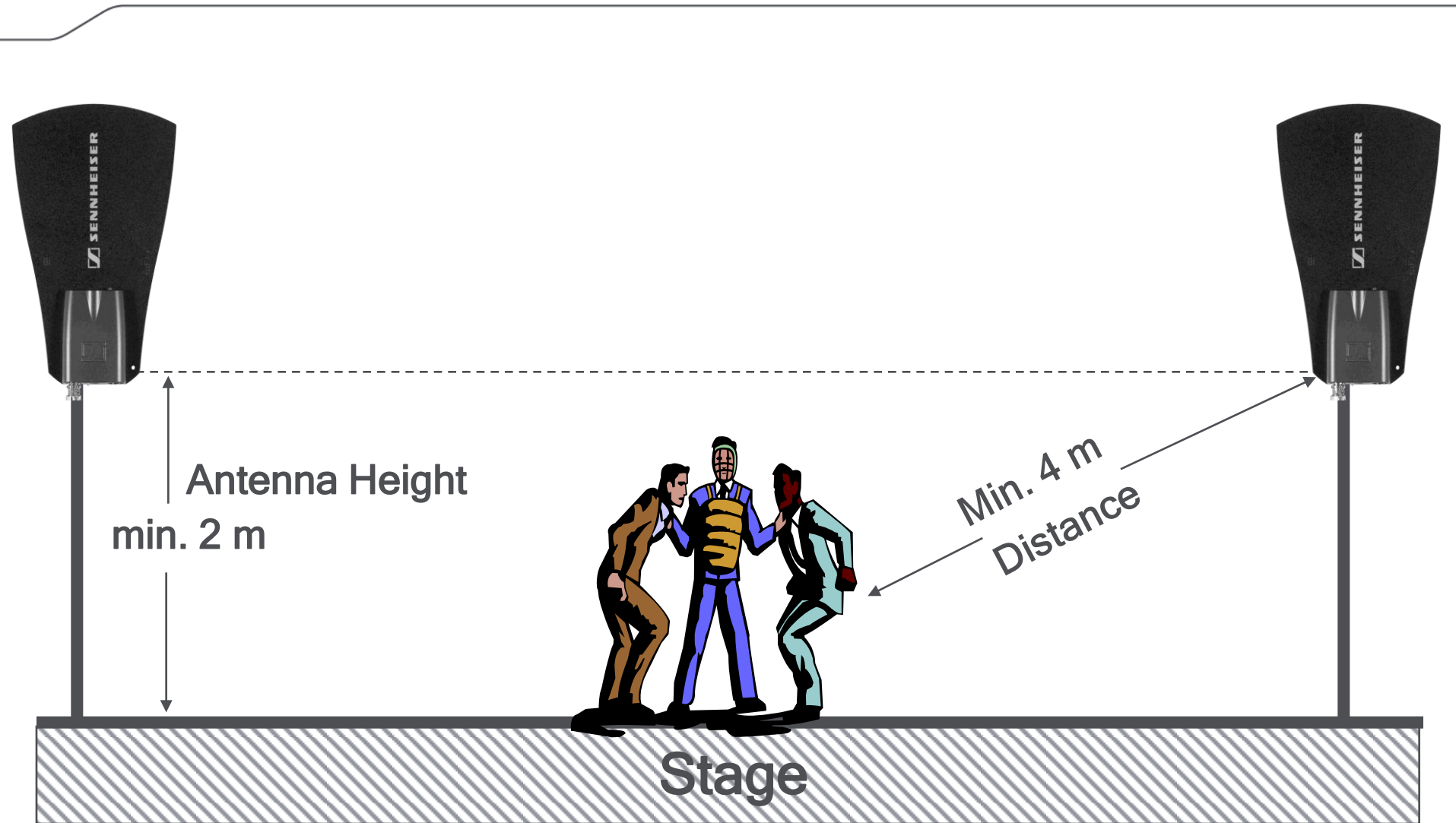
Outdoor Stage Directional Antennas



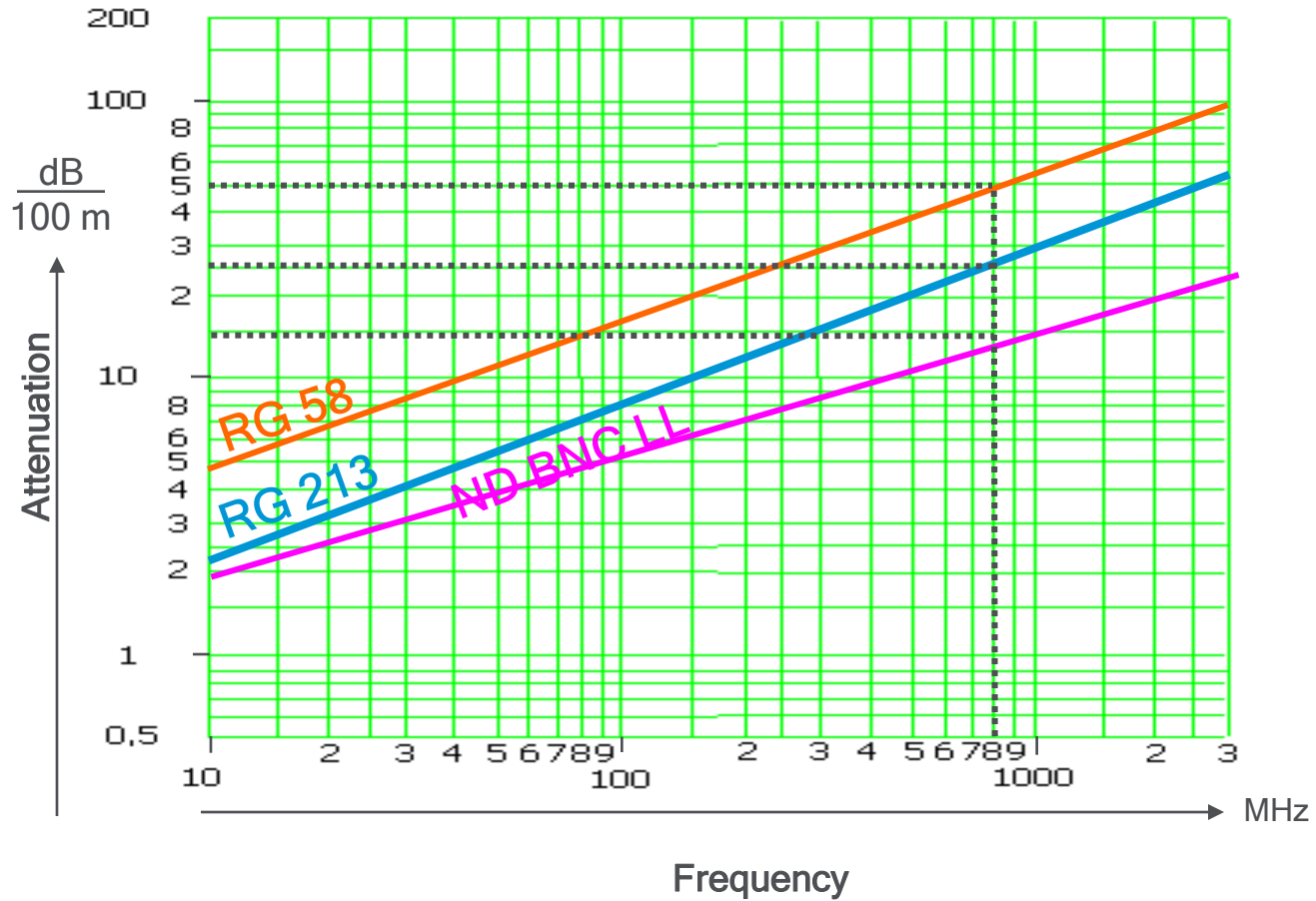
Interference

Transmitter Signal much stronger than **Interference**

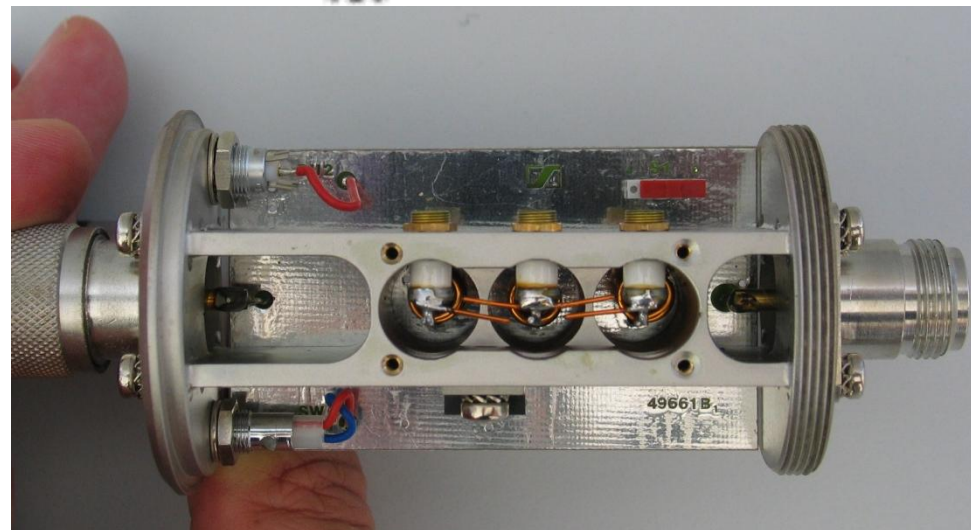
Antenna Positioning



RF Cable Loss



Antenna Boosters

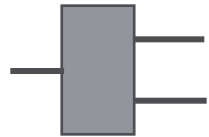


New Systems



Antenna Splitter

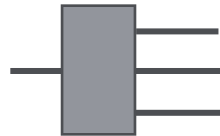
Splitter 1 : 2



Distribution Loss

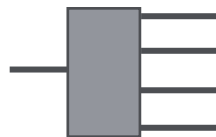
- 4 dB

Splitter 1 : 3



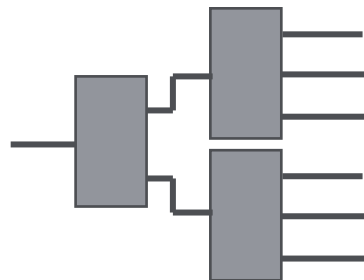
- 7 dB

Splitter 1 : 4



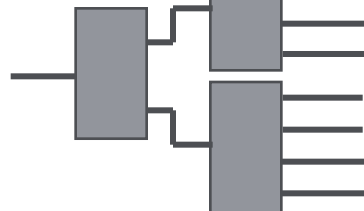
- 8 dB

Splitter 1 : 6

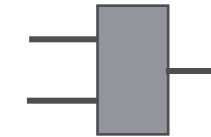


- 11 dB

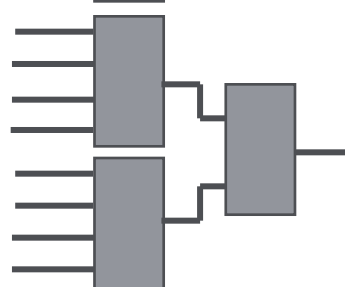
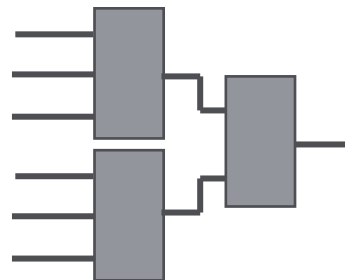
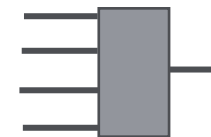
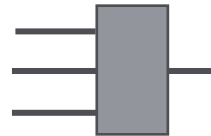
Splitter 1 : 8



- 12 dB

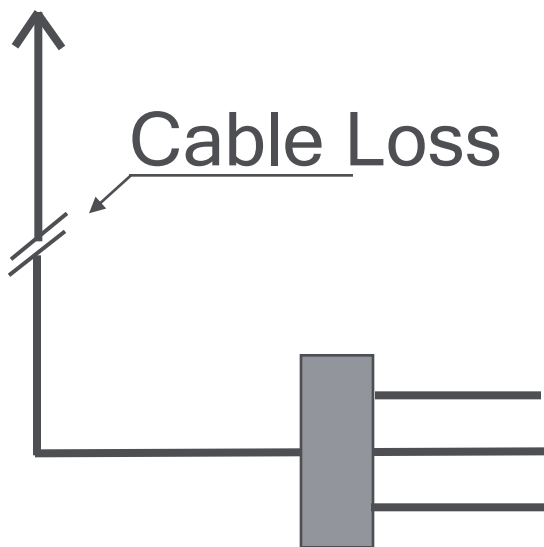


Combiner



RF - Signal Distribution

Antenna



1 dB 20 % Loss

3 dB 50 % Loss



6 dB 75 % Loss

10 dB 90 % Loss



20 dB 99 % Loss

40 dB 99.9% Loss

Power ratio

Active Splitters / Multicouplers / Distribution Amplifier

ASA 1

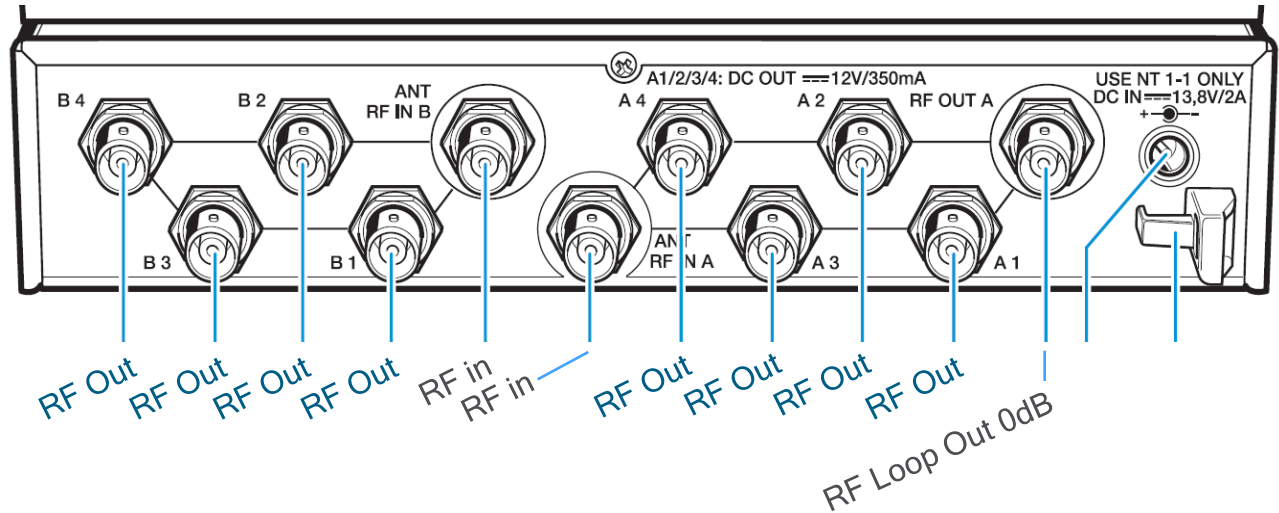
2x 1in, 4out or

1x 1in, 8out

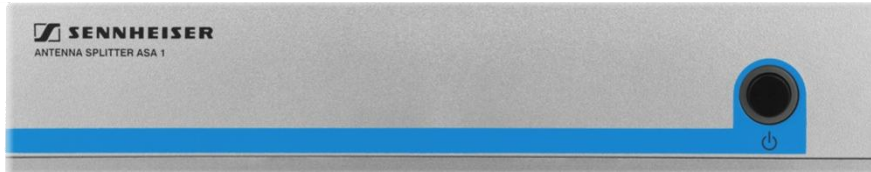
DC to 4x RX

ASA 3000

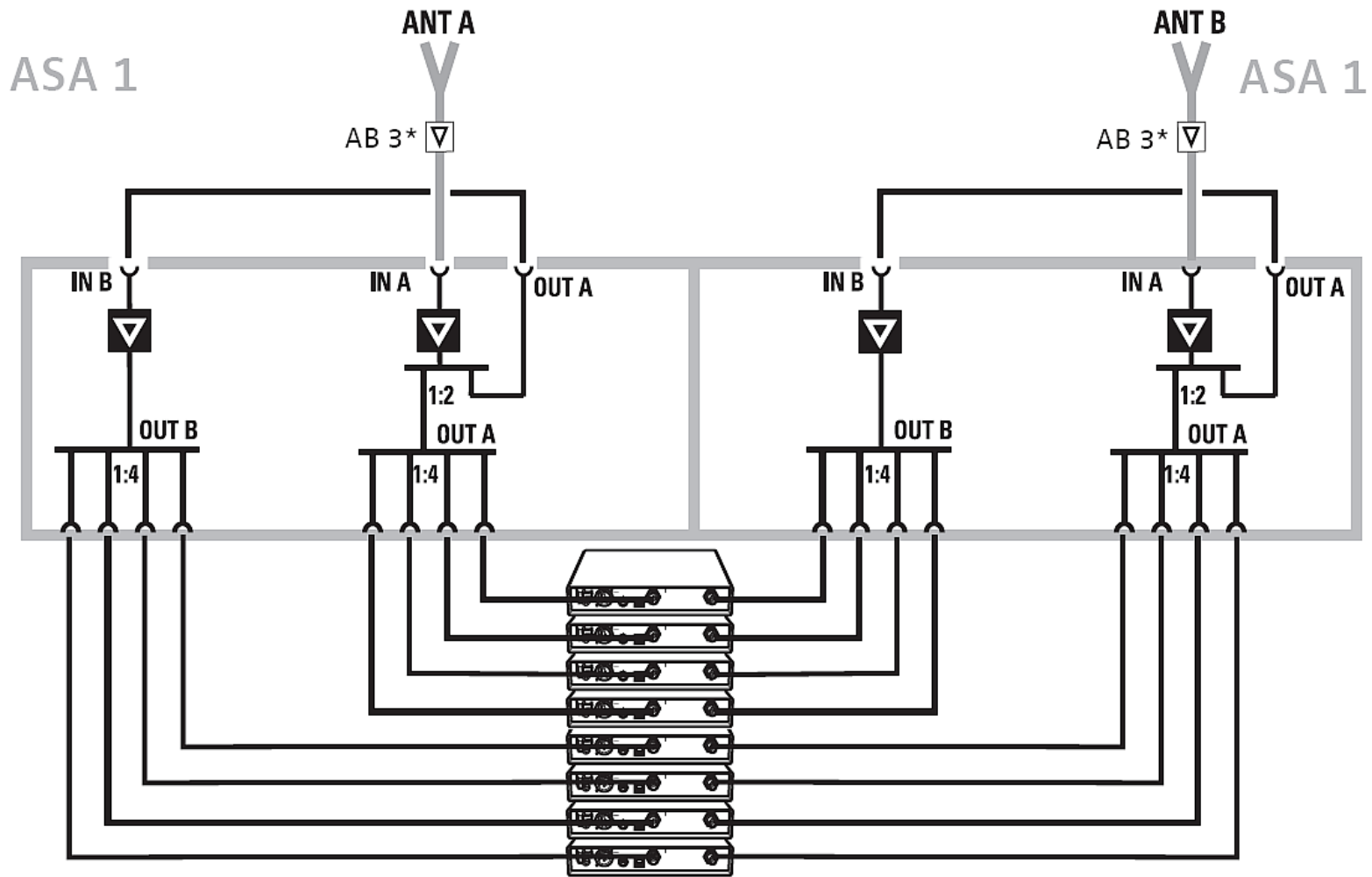
2x 1in 8out



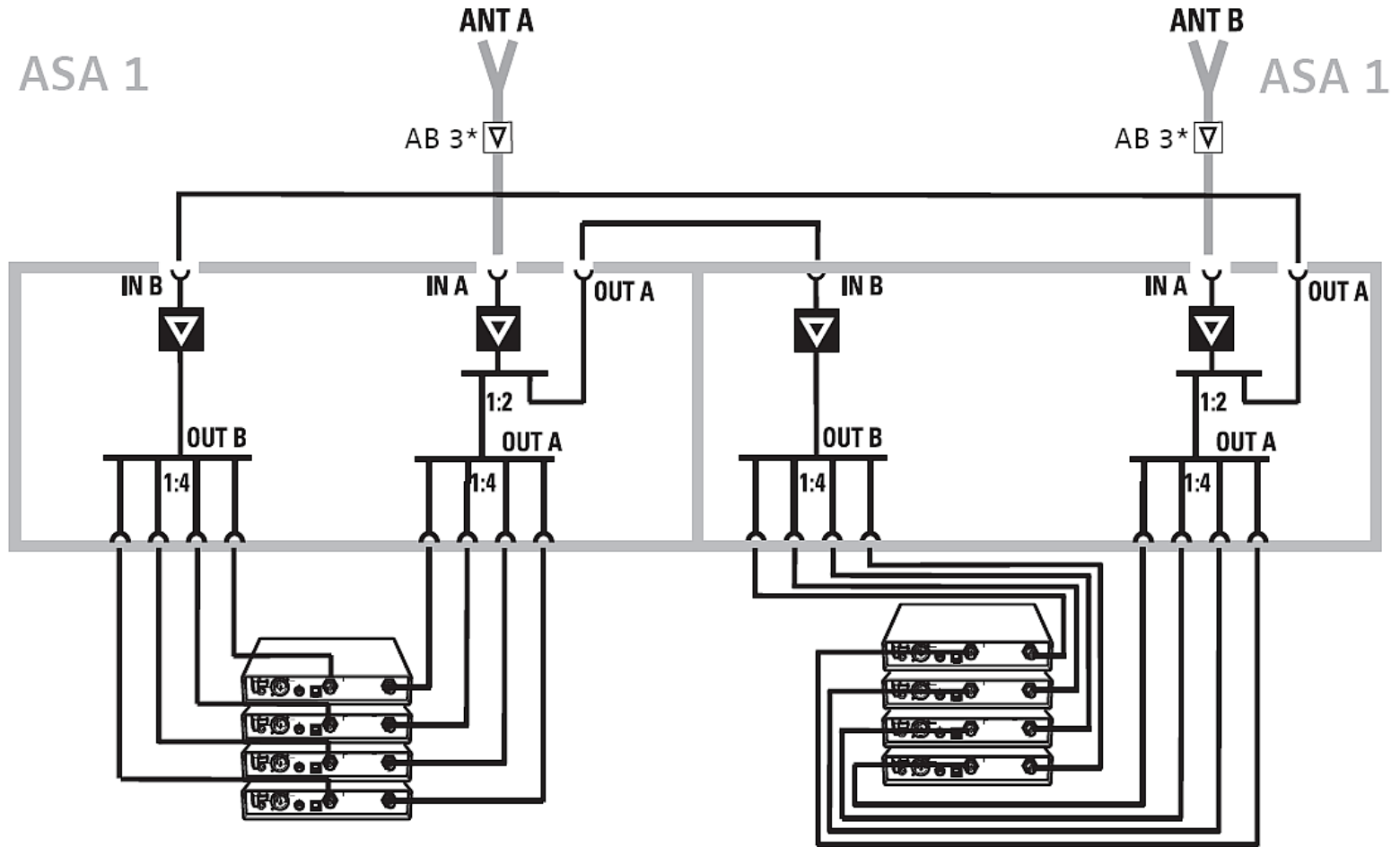
ASA1 - 8 Channels



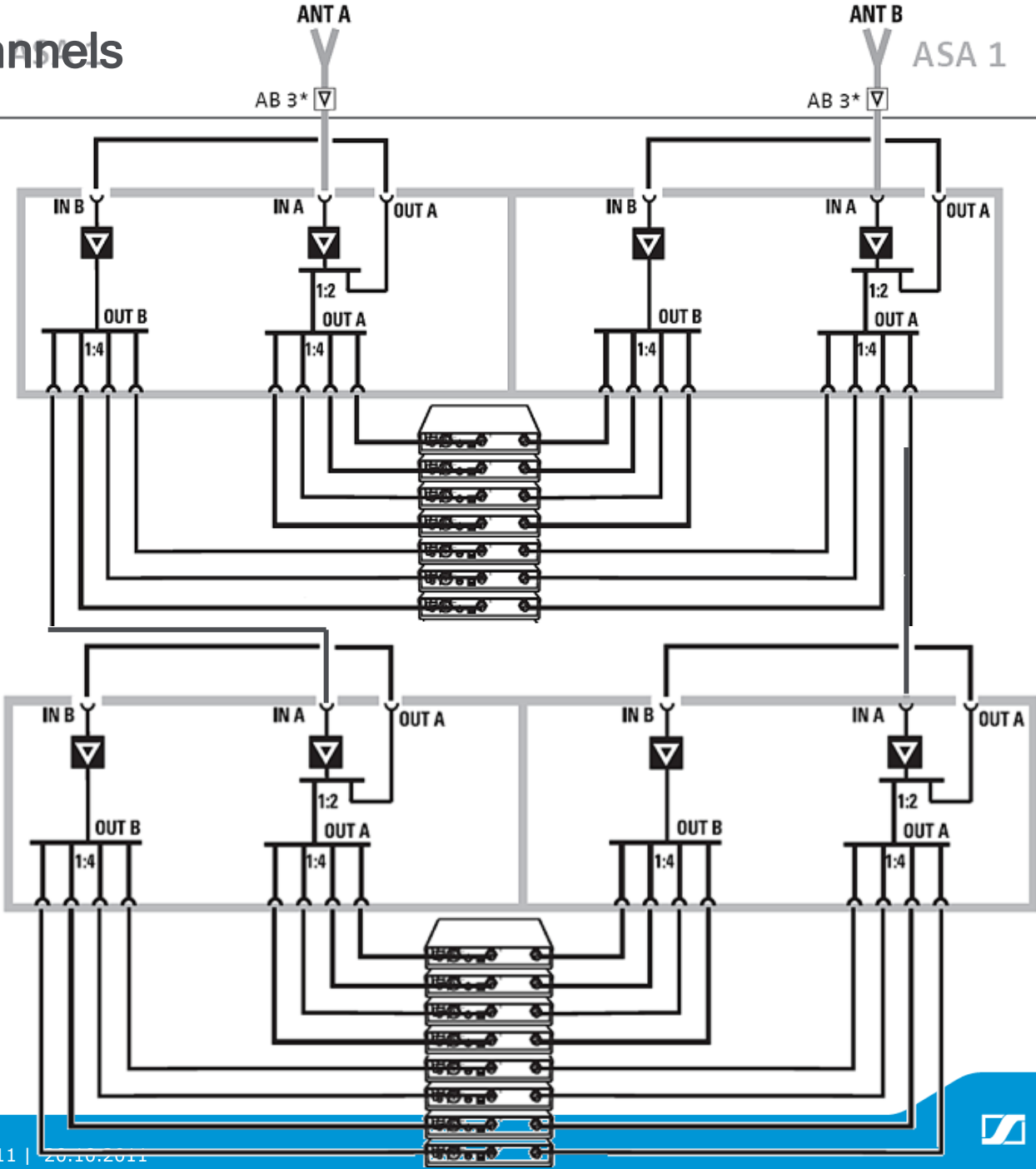
8 Channel wiring Solution A



8 Channel wiring Solution B



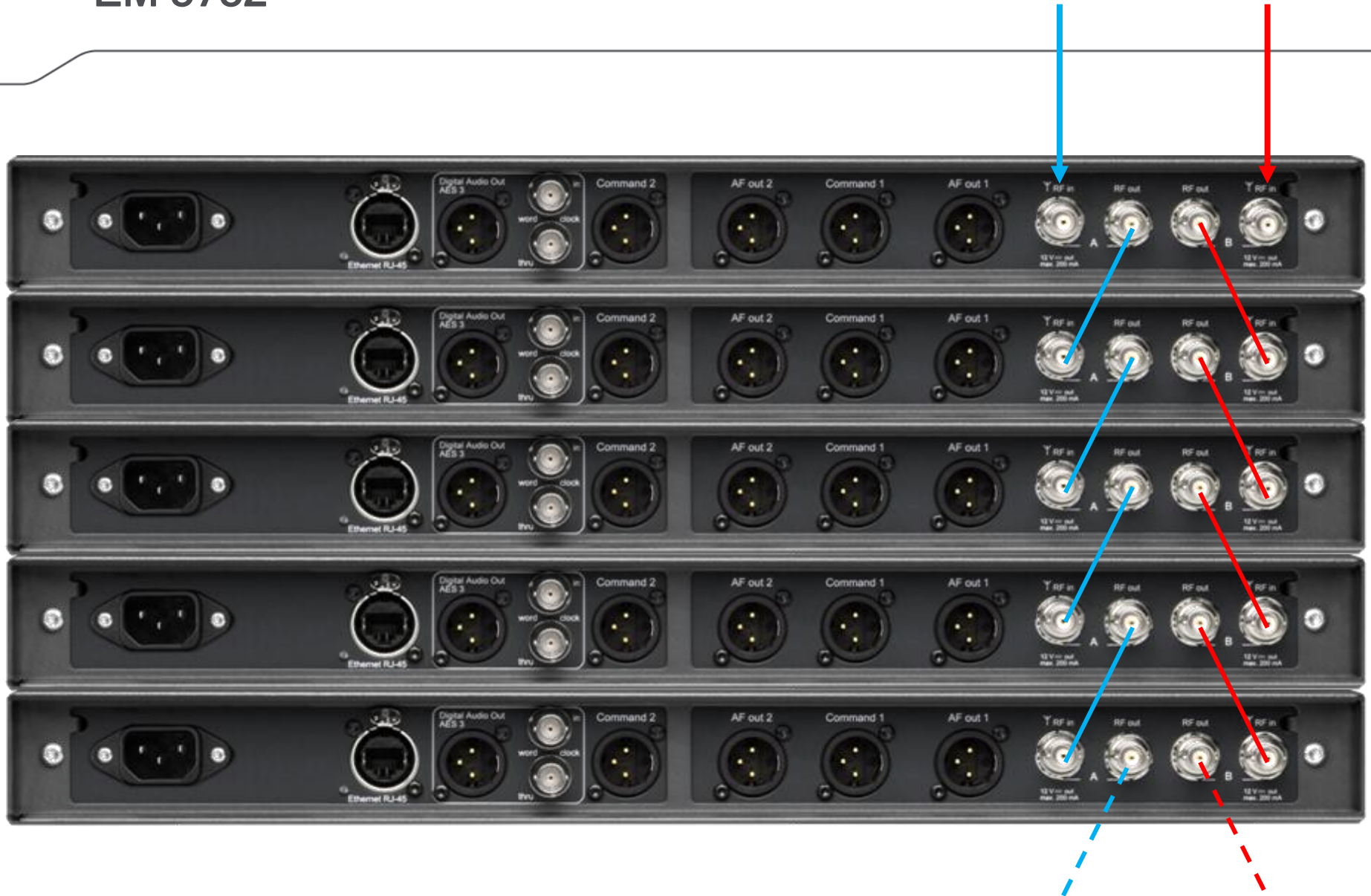
15 Channels



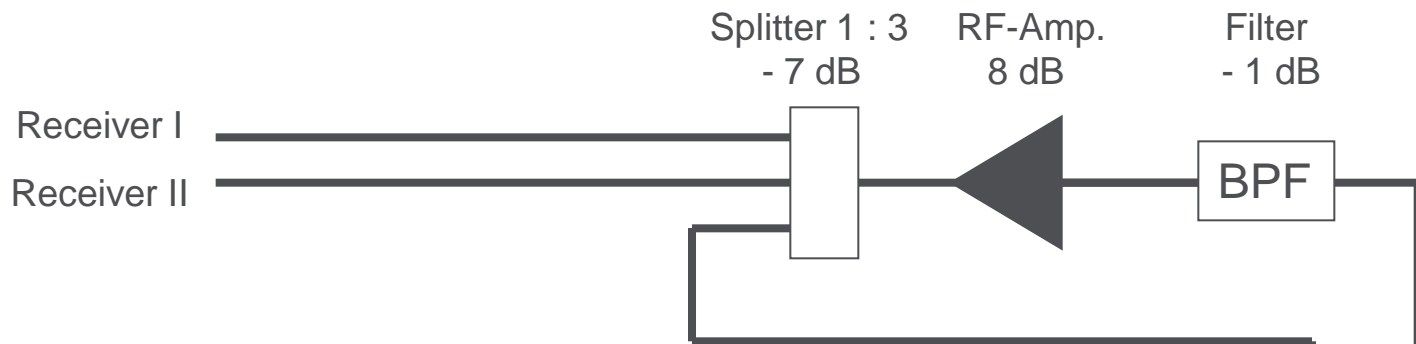
Twin Receivers EM 2050 & EM 3732



EM 3732

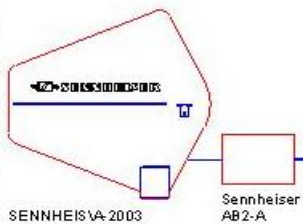
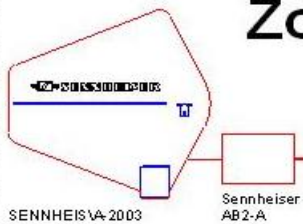


EM 3732



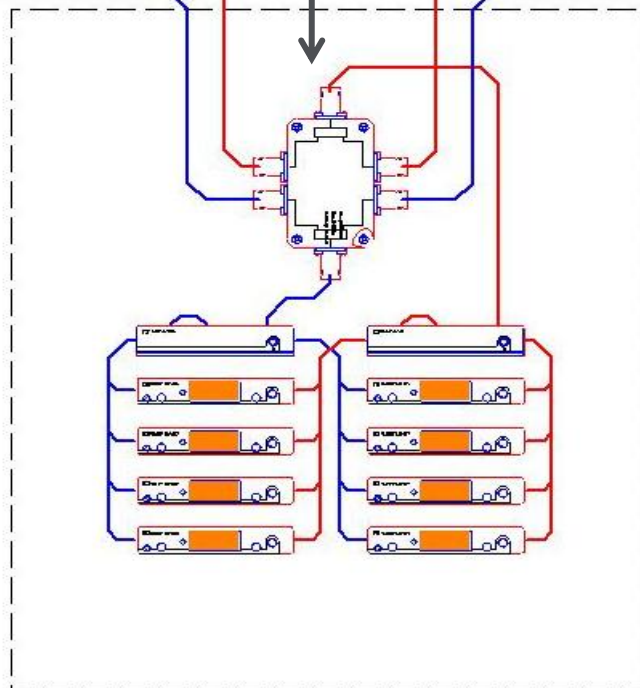
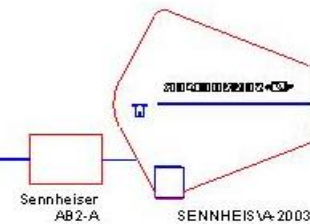
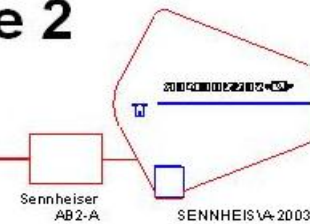
Two zone Antenna Combining

Zone 1



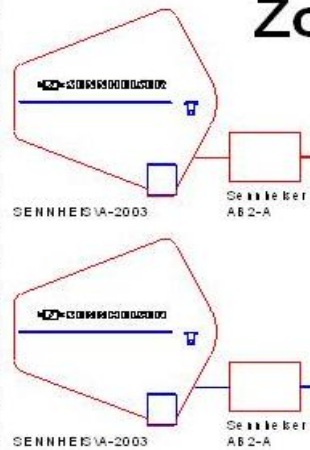
Passive ASP212 = 4dB loss
Booster feed from ASA1 Splitter

Zone 2



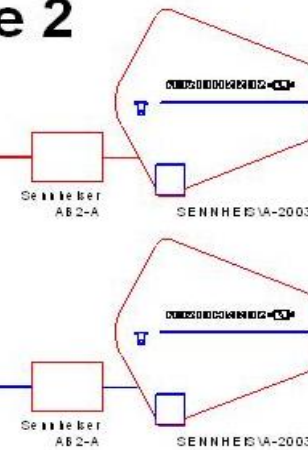
Four zone Antenna Combining

Zone 1

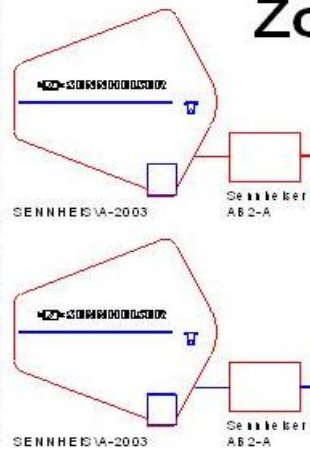


Active AC3 = 0dB loss
Own Booster feed

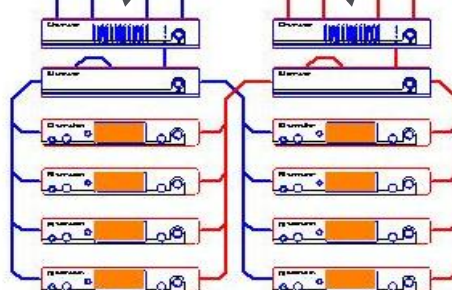
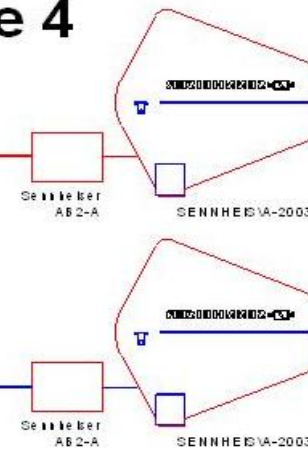
Zone 2



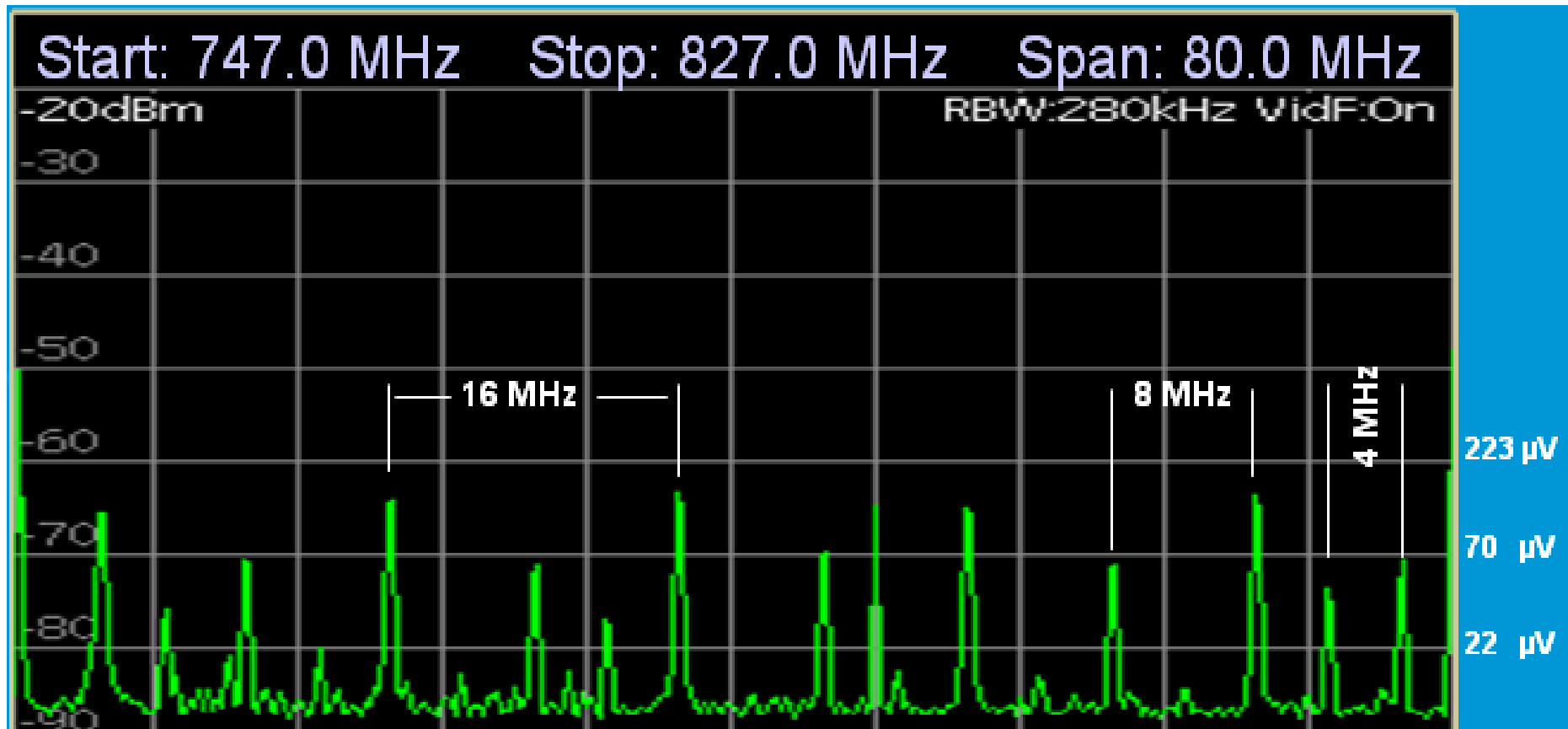
Zone 3



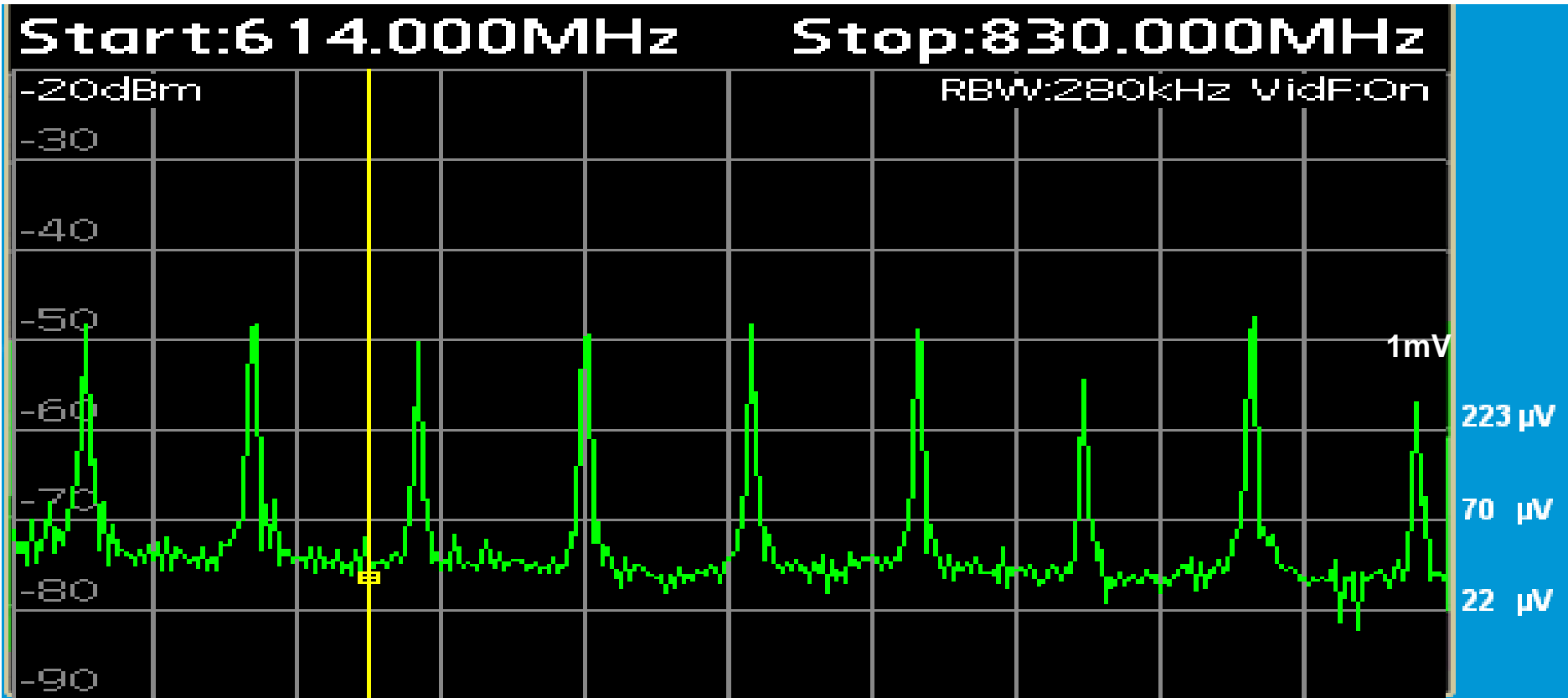
Zone 4



ESC 2007 Barco LED Wall 300M2



ESC 2010 New Dutch Prototype LED Wall 30M2



ESC2010 OSLO



- **1. Are there any existing wireless systems at the installation?**
 - Wireless microphones
 - Wireless intercom
 - Wireless IFB: up to 250mW
 - Video transmitters: up to 250 mW
 - Motorola radios .5 W to 5 W of power

- **Different kind of Intermodulation**
 - Transmitter-Intermodulation
 - Receiver-Intermodulation
 - Intermodulation in any kind of Amplifier

- **and**
 - Blocking

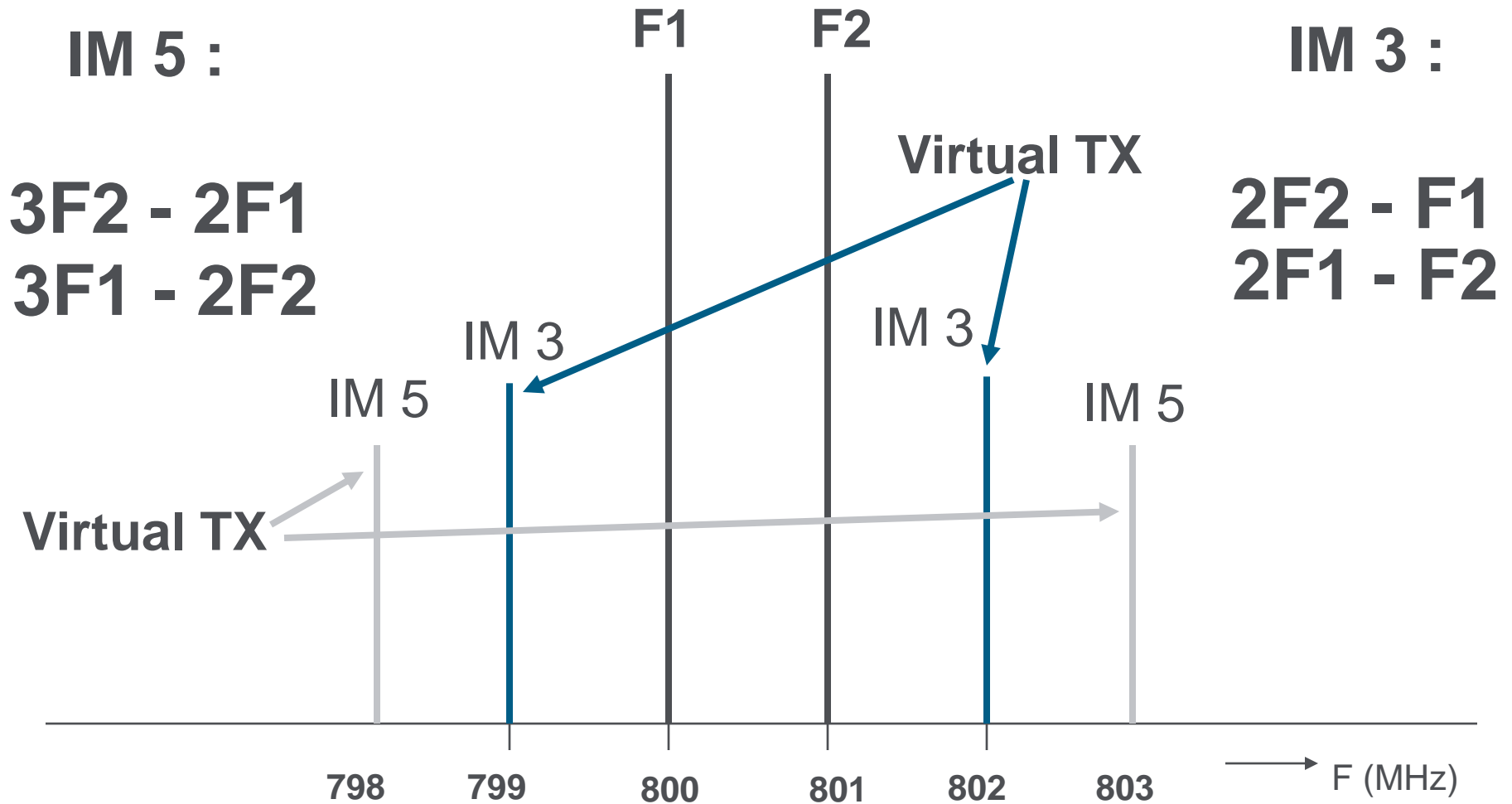
Number of 3rd-Order IM-products generated by multiple channels:

2 channels	result in 2,
3 channels	result in 9,
4 channels	result in 24,
5 channels	result in 50,
6 channels	result in 90,
7 channels	result in 147,
8 channels	result in 225,

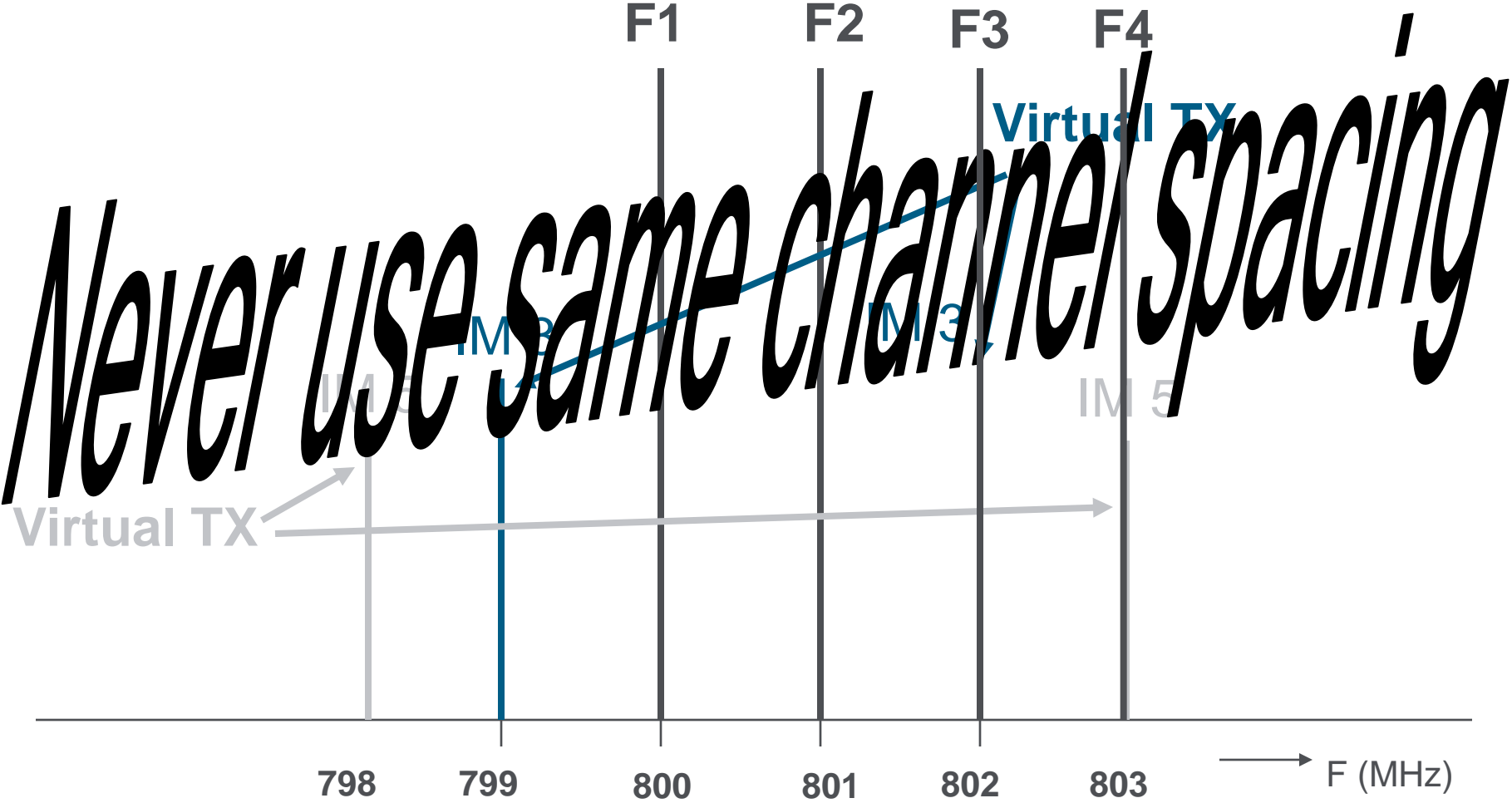
....

32 channels result in 15,872 3rd-Order IM-products

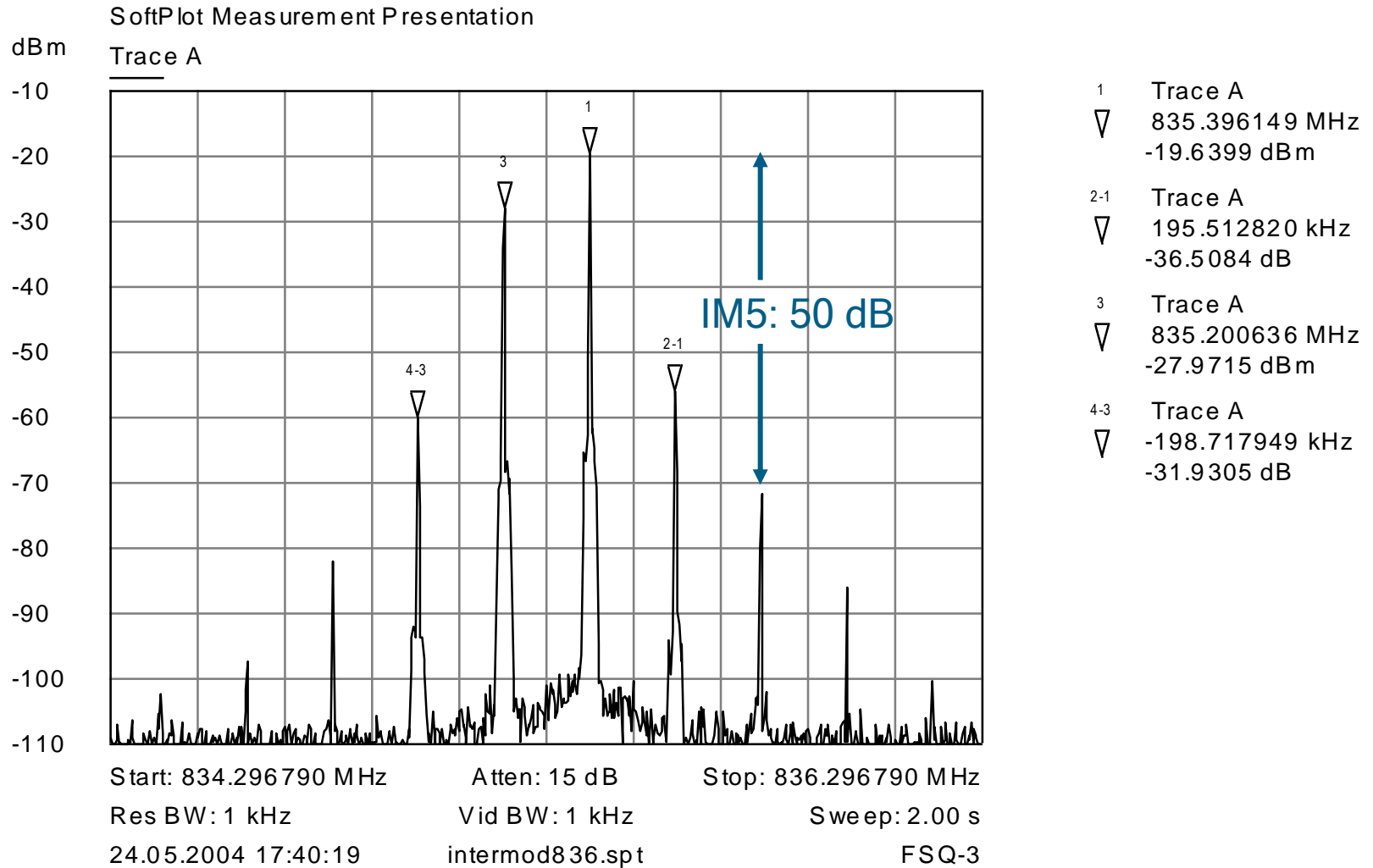
Intermodulation



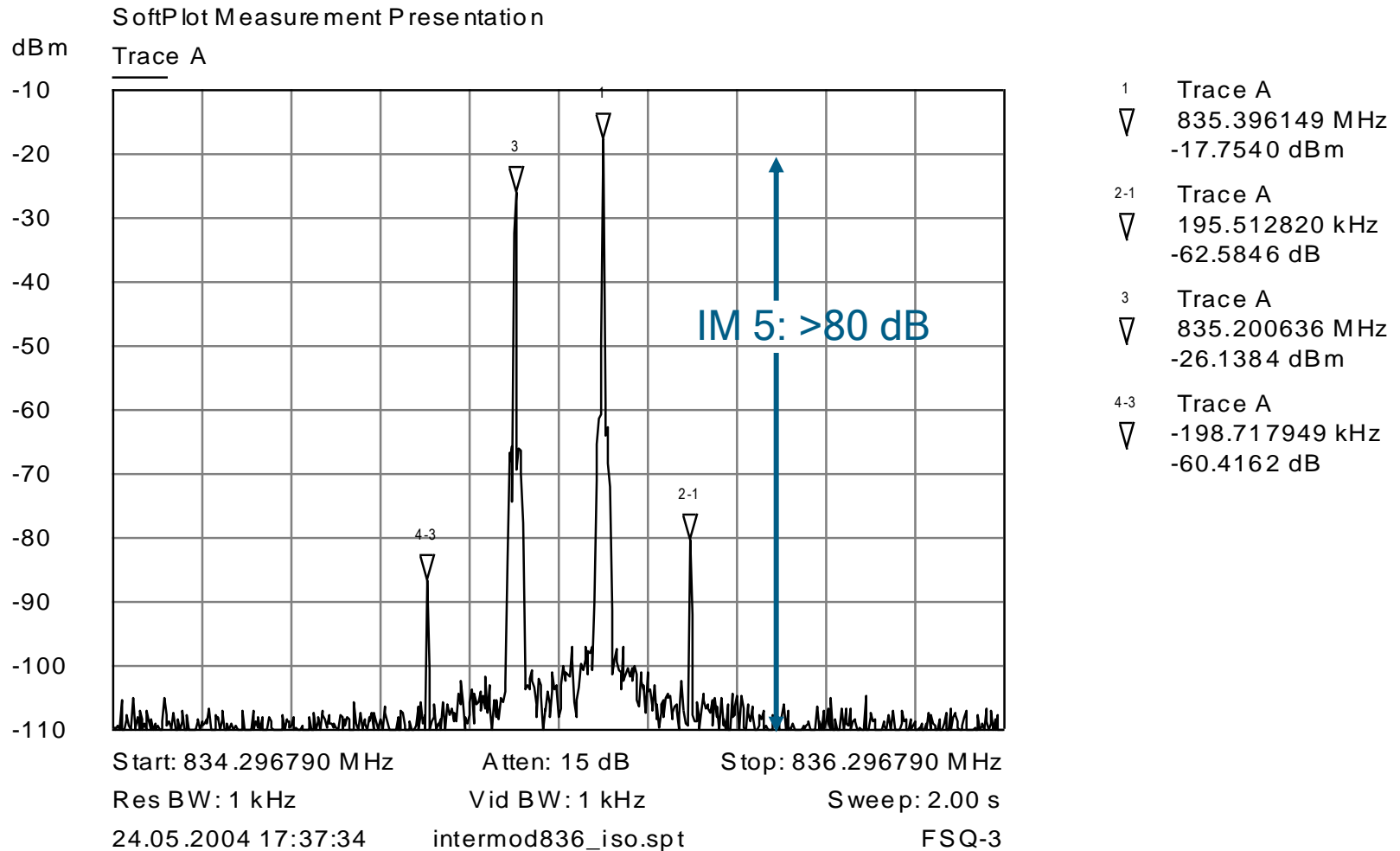
Intermodulation



Transmitter Intermodulation (Normal TX)



Transmitter Intermodulation (New Generation TX)



- **Impact**

- IMD-products can be caused in overloaded antenna boosters, transmitters and receivers.
- The number of IMD products increases exponential with the number of carrier frequencies.
- IM3 products are most critical
- IMD can be predicted/calculated 😊
- Keep min. 375KHz Channel spacing
- Keep min. 075KHz 2TxIM3 spacing

Calculation Software: SIFM Or WSM

SIFM Software 1.2.6
File View Calculate Help

System Editor

Select Channels (13/13)

Sort	Remove	Frq. [MHz]	Label	Co
3		792.375		2
4		793.875		3
5		794.825	EW300IEM G2	
6		796.100		4
7		796.675		5
8		801.100	PSM 400	
9		803.675	AKG	
10		805.050	PSM 400	
11		810.550	PSM 400	
12		811.600	PSM 400	
13		813.600	EW135 G2	
14		0.000		

Shift Presets
Mirror Presets

Choose System

EW G2 Standard

System :

SIFM SENNHEISER

Check For

Spacing #1 2Tx IM(3) #1
Spectrum 2Tx IM(5) 3Tx IM(3)

Find Free Channels

Results to show : Maximum Search
Number of runs :

Add channels : #1
Search step :

Search Spectrum (127)

Sort	Remove	From [MHz]	To [MHz]
1		790.250	790.250
2		791.200	791.200
3		791.900	791.900
4		792.325	792.325
5		792.900	792.900
6		793.725	793.725
7		794.825	794.825
8		795.350	795.350
9		796.100	796.100
10		796.575	796.575
11		798.250	798.250
12		799.200	799.200
13		799.900	799.900

Select TV Channels Presets Range

Possible Channel Setups

Results

Compatible Channels: 13
Compatible Channels: 13
Compatible Channels: 13
Compatible Channels: 13
Compatible Channels: 13
Compatible Channels: 13
Compatible Channels: 13
Compatible Channels: 13
Compatible Channels: 13
Compatible Channels: 13

Compatible Channels

790.250 MHz EW300I
790.700 MHz 1
792.375 MHz 2
793.875 MHz 3
794.825 MHz EW300I
796.100 MHz 4
796.675 MHz 5
801.100 MHz PSM 40
803.675 MHz AKG
805.050 MHz PSM 40
810.550 MHz PSM 40
811.600 MHz PSM 40
813.600 MHz EW135

Use Save
Export Discard

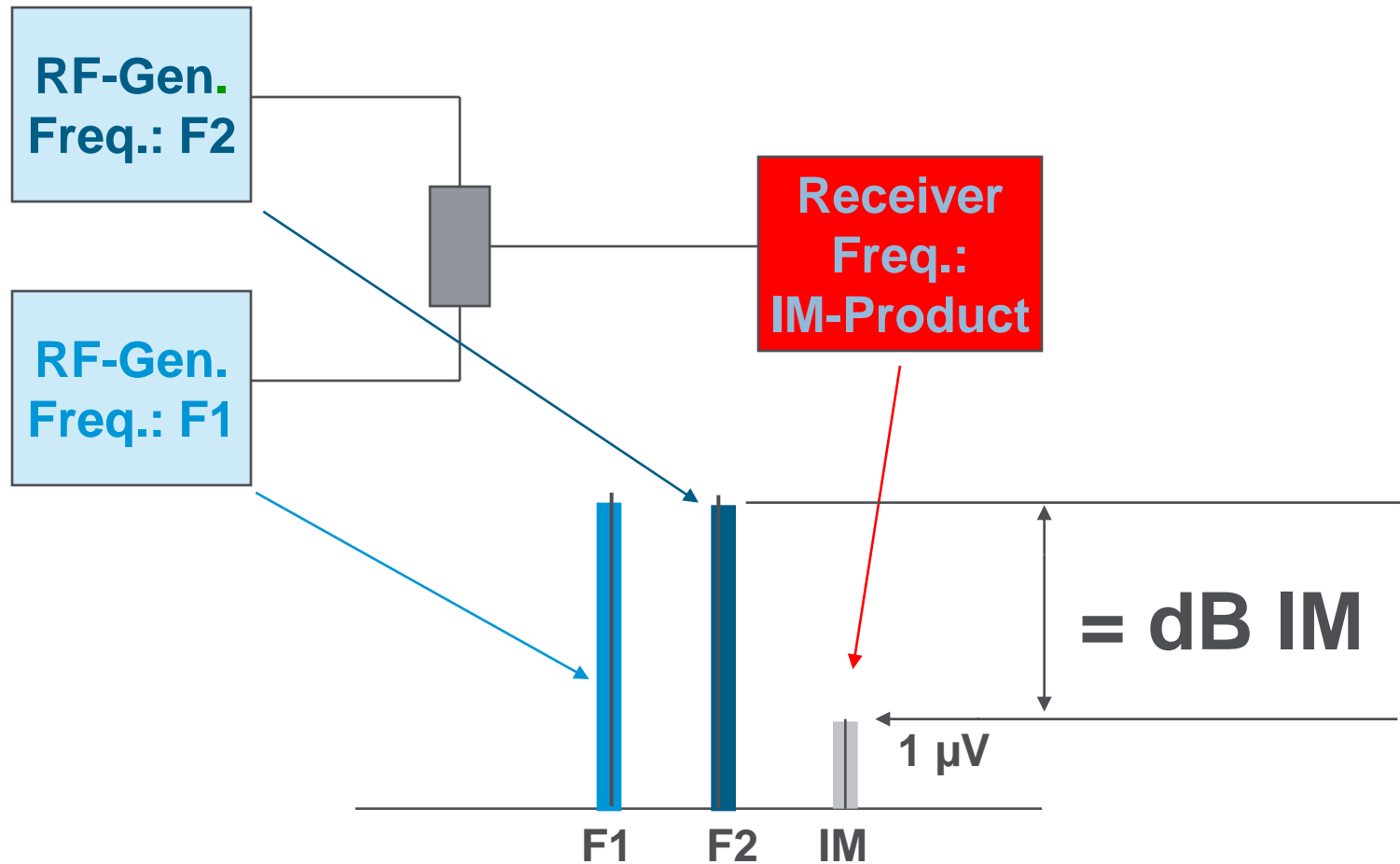
Spectrum Display

Full View

Full Used Channels Search Spectrum Range

789.000 IM Products : Channels : 209 Maximum : 2 Overall : 224 815.000

Receiver Intermodulation



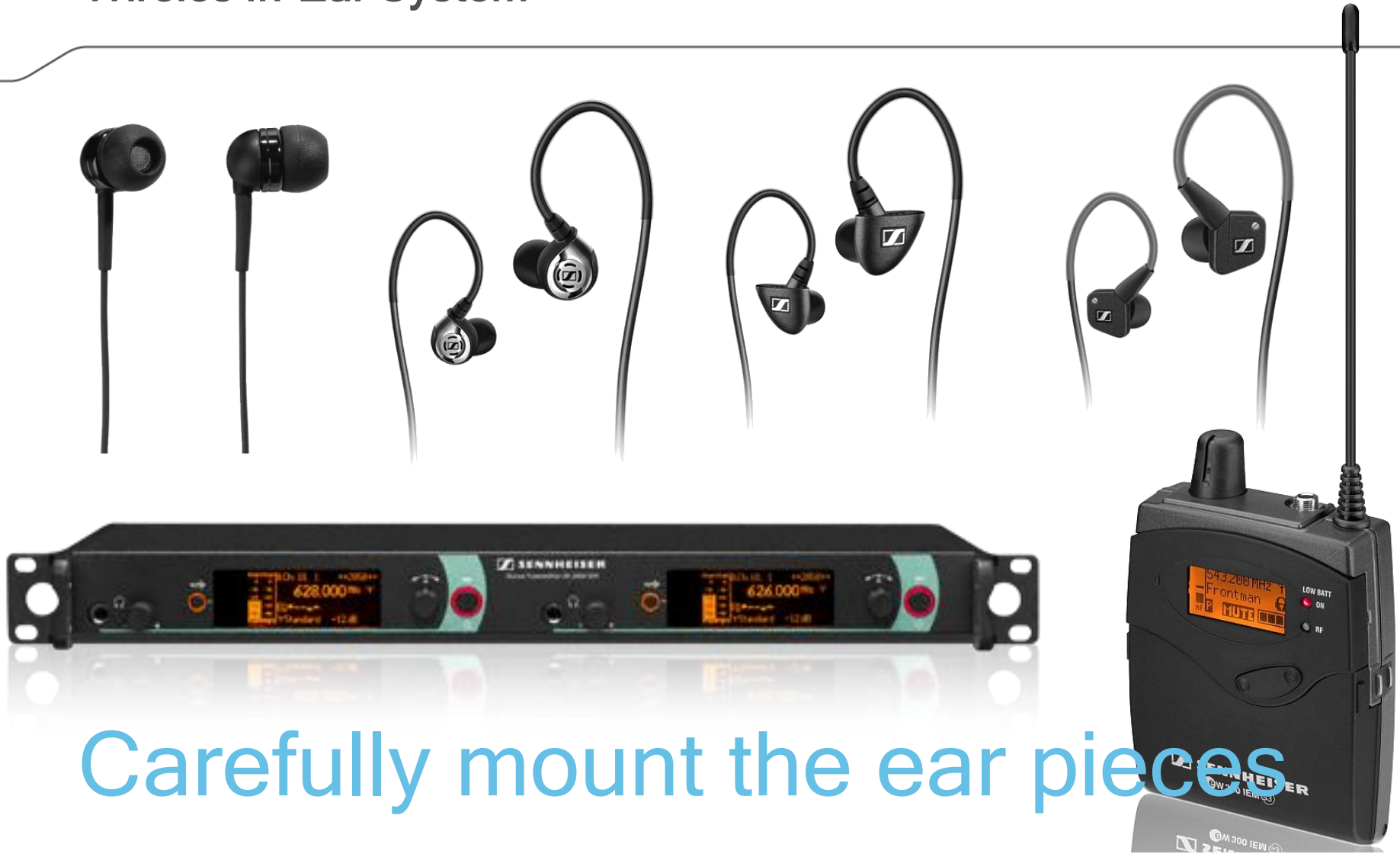
Multichannel Operation Receiver Intermodulation

Channels	max. RF-Level (dB)
2	0
3	- 2
4	- 3
5	- 4
6	- 5
8	- 6
10	- 7
12	- 8
16	- 9
24	-11
40	-13

Multichannel IMD - Safety

Channels	EM 3532 (dB)	EM 3732 (dB)
2	70	83
3	68	81
4	67	80
5	66	79
6	65	78
8	64	77
10	63	76
16	61	74
20	60	73
24	59	72
32	58	71
40	57	70

Wireless In-Ear System



Carefully mount the ear pieces

IEM . . . Standard Use . . . In Ear Monitoring

Mono Transmit / Mono Receive



Music



IEM . . . Standard Use . . . In Ear Monitoring

Stereo Transmit / Stereo Receive



Music Left



Music Right



IEM . . . Option . .

In Ear Monitoring

Stereo Transmit / Mono Receive



Music Mix



Click / TB Right



Artist Adjustment with Focus Control . . .

Wearing a monitor receiver

- Take care:
 - If the user is equipped with multiple wireless units

Beltpack
Transmitter



Allow
maximum
space between
the antennas

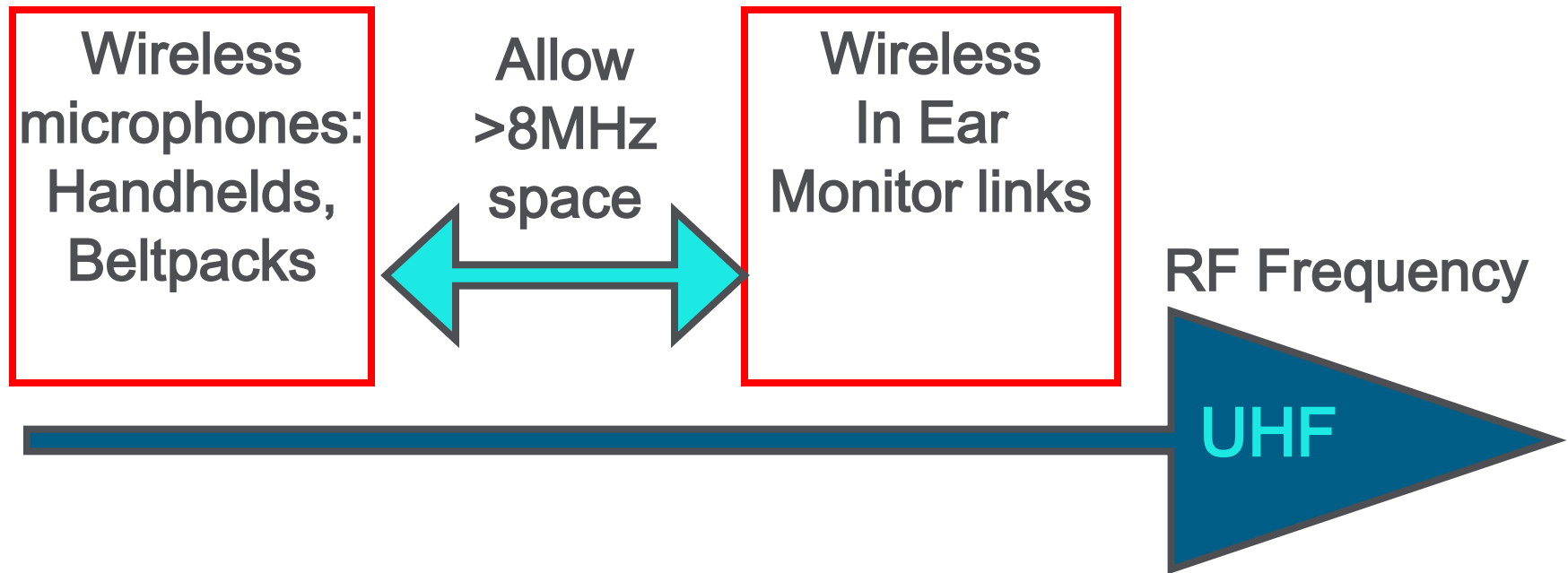


Monitor
Receiver



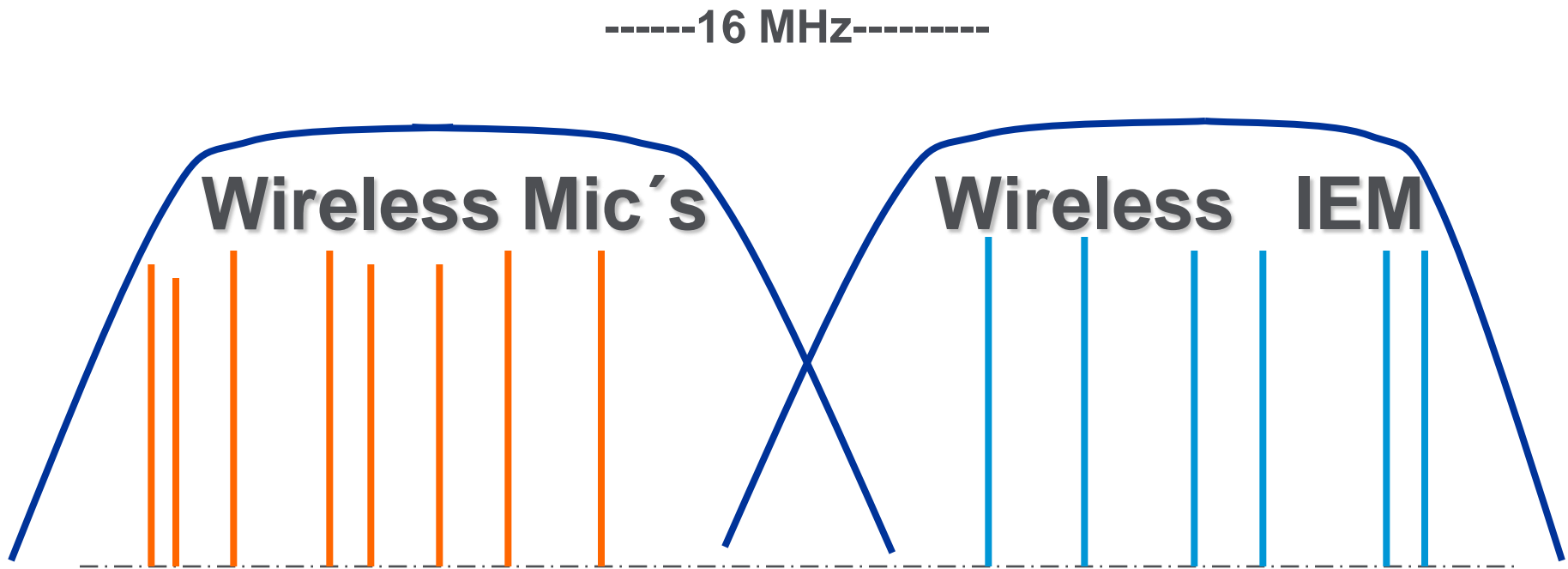
Frequency allocation Of In-Ear Monitors

For save and reliable operation

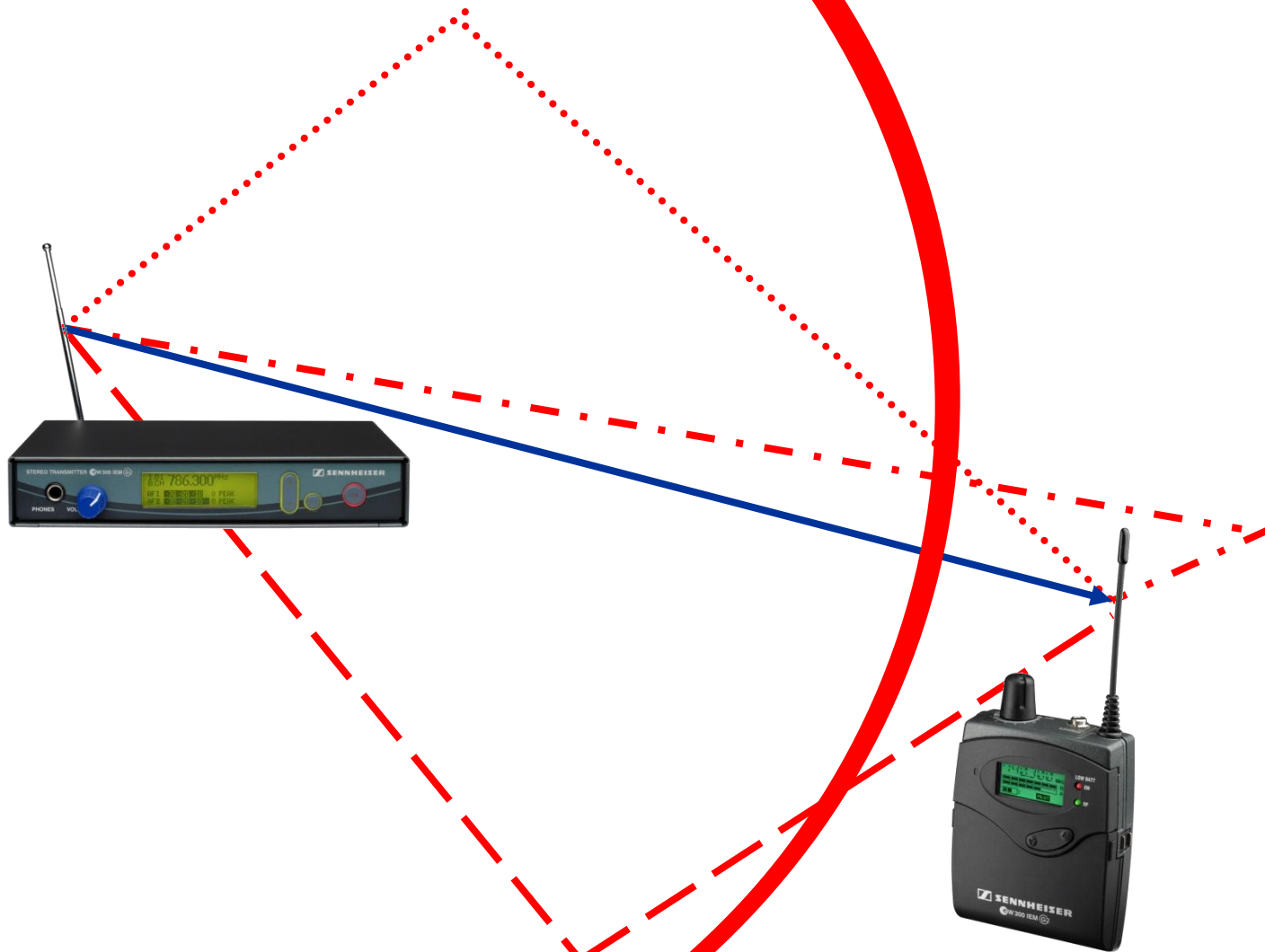


Frequency Configuration

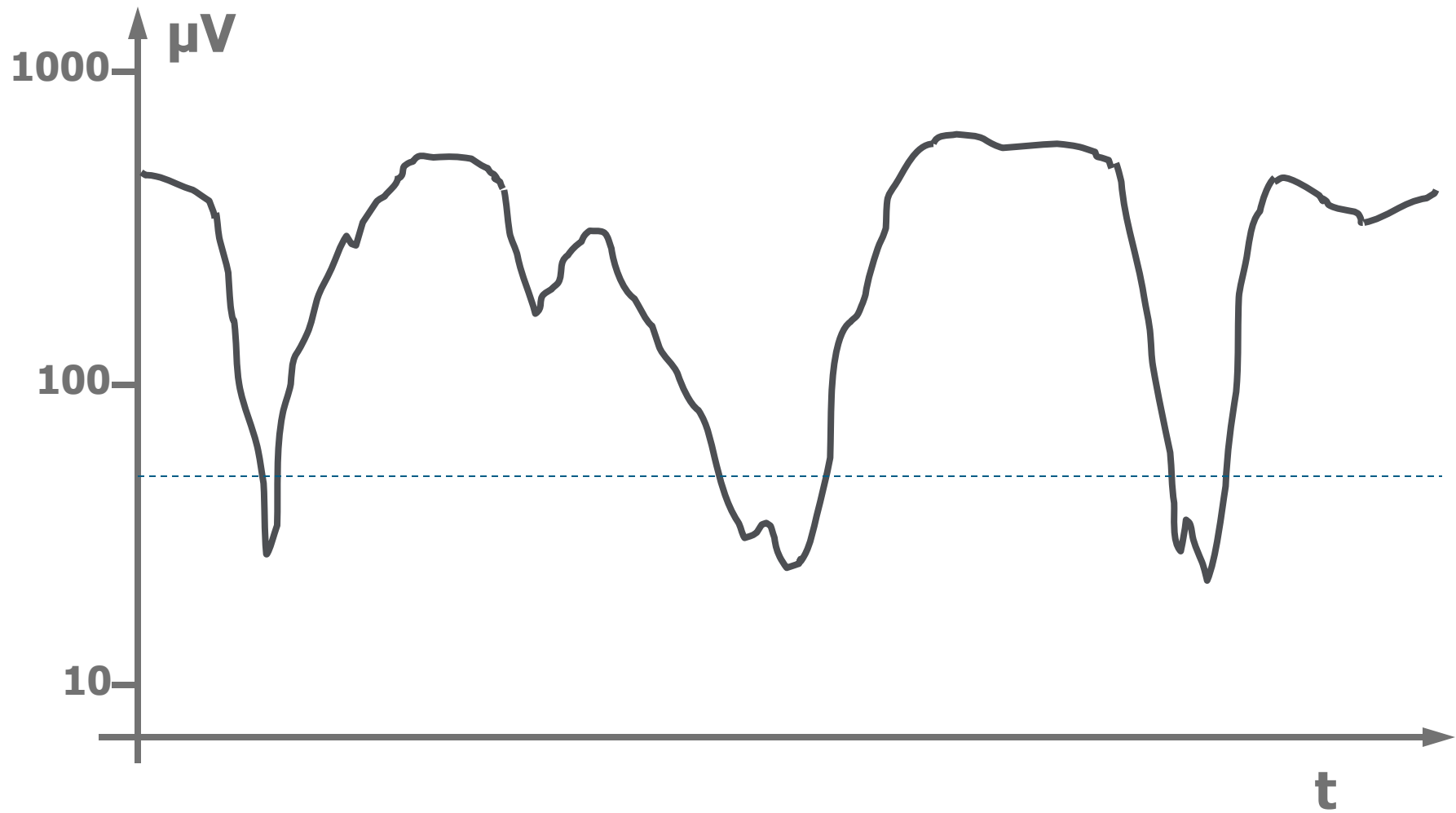
- Optimum: two different ranges for wireless microphones and IEM (e.g. microphones in G, IEM in B range).



RF Reflects Via Many Ways



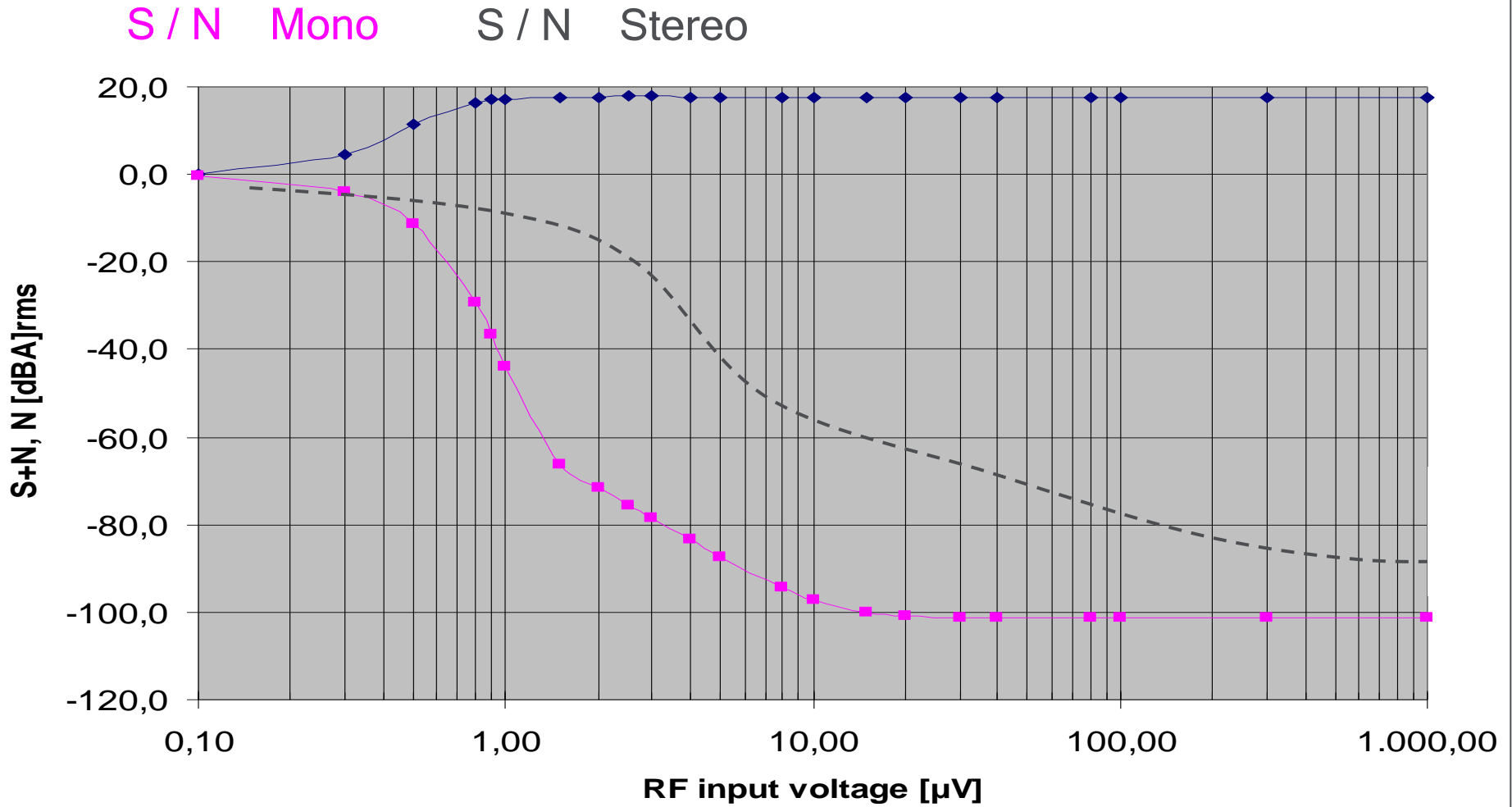
Antenna Level IEM Receiver



Antenna Level With Circular Polatisation



EK300 IEM S/N

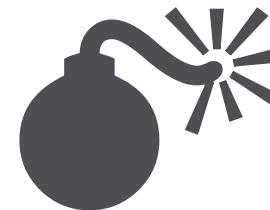


Use of wireless Microphones and IEM

- Use directional circular antennas.
Minimum distance between antennas: 4m
- IM3 tolerance between Stereo IEMs : 200 kHz
- Check performance area under worst case conditions
- Avoid possible dropouts with antenna placement
- Use Short low loss cables
- Teach the artist correct handling of the beltpack and earpieces



Multichannel IEM

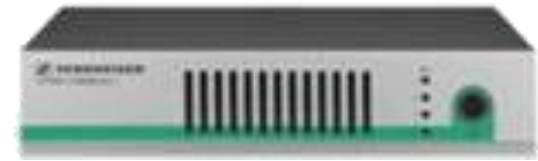


Transmitter Antenna Combiner

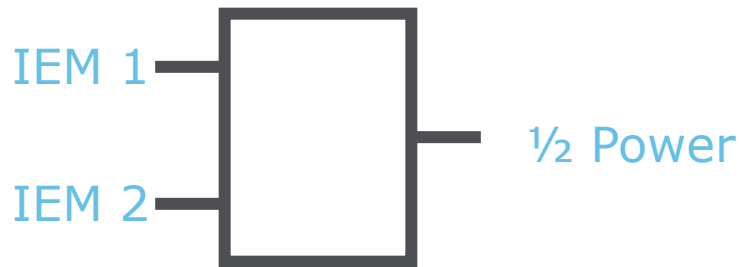
AC 3200 - 8 in / 1 out



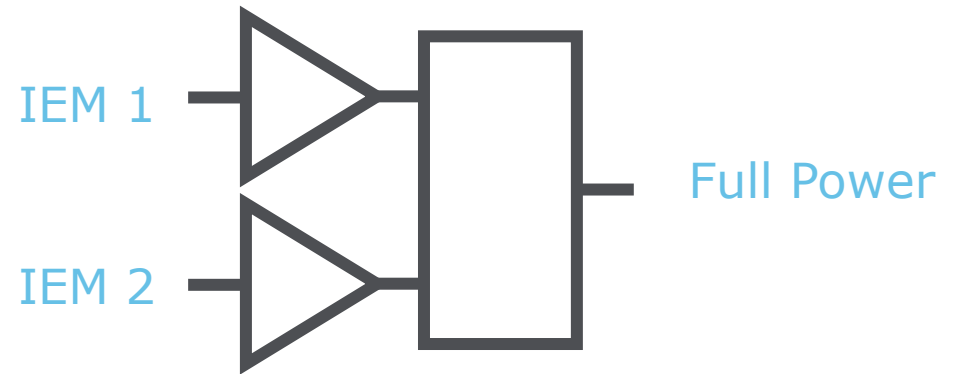
AC 3 - 4 in / 1 out



Passive Combiner

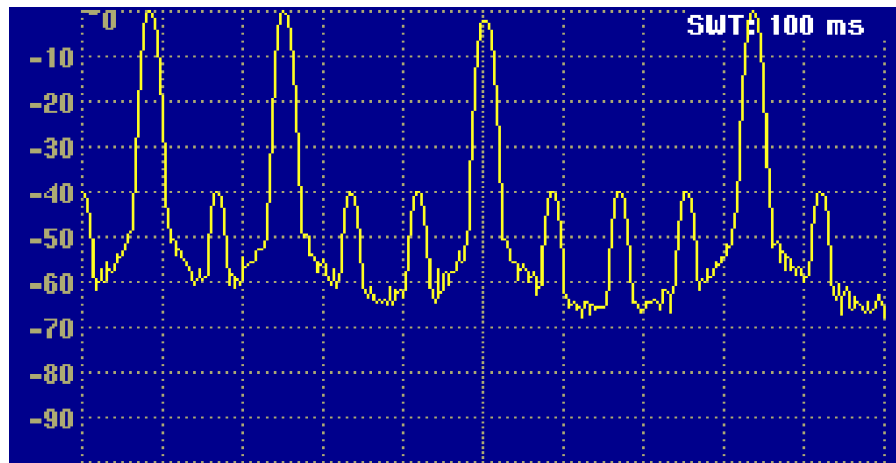


Active Combiner

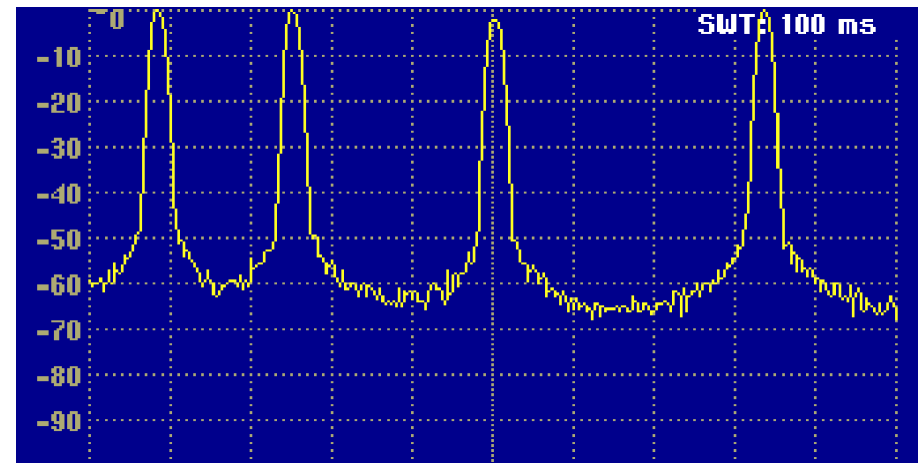


Why antenna combiner?

- For more than 2 Tx: apply Antenna Combiner
IM-interference will be prevented effectively

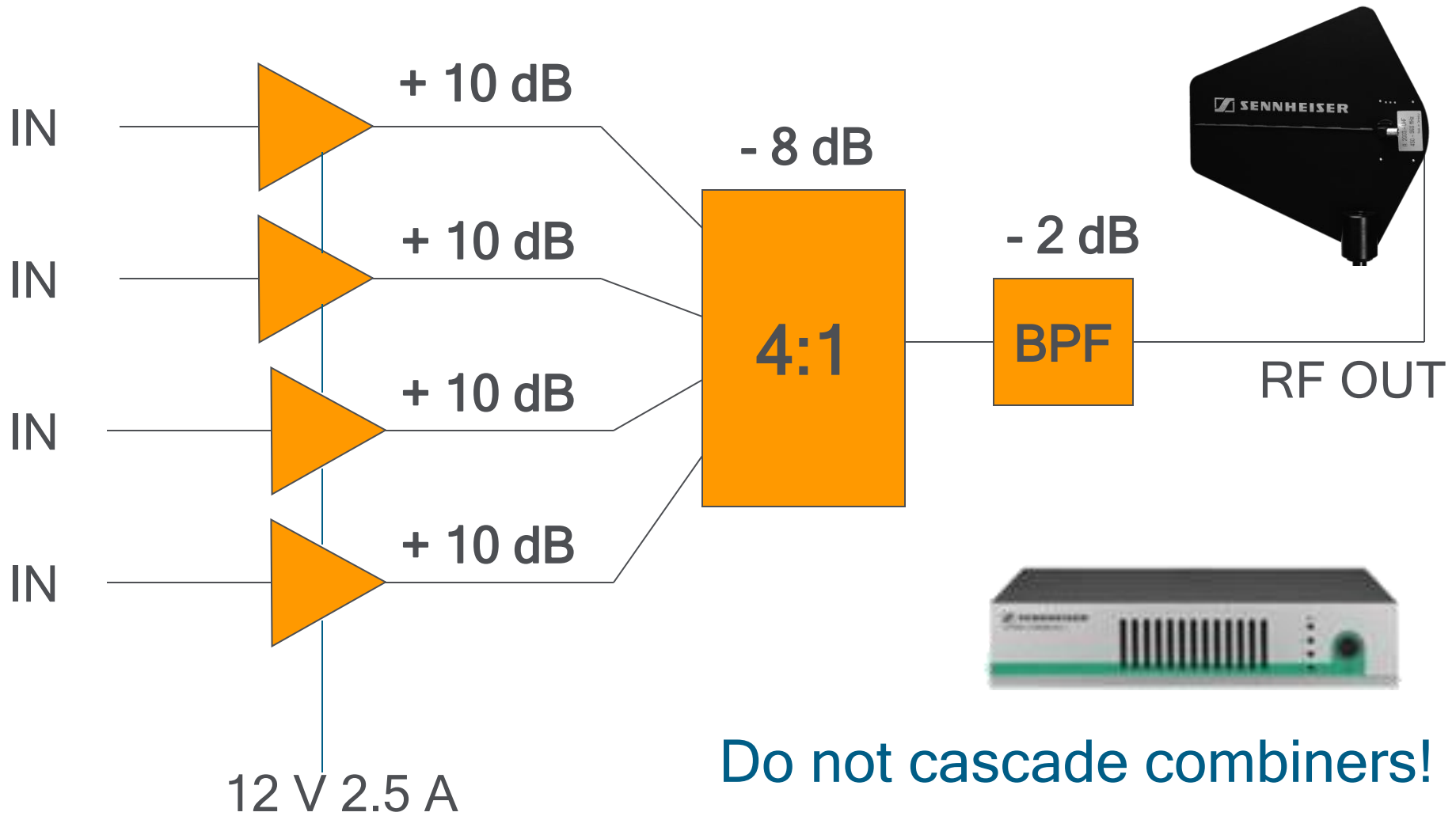


without AC, antennas rear mounted



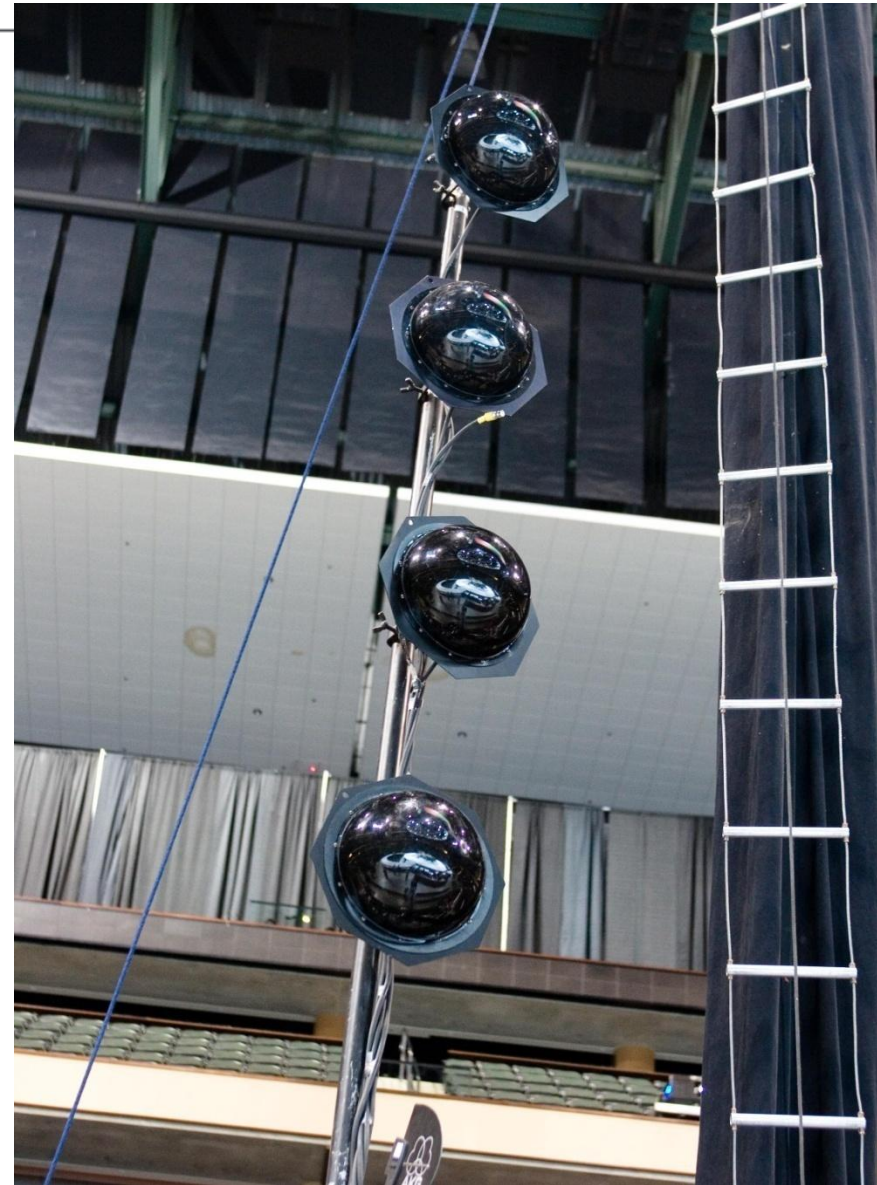
with AC

Transmitter Combiner AC3

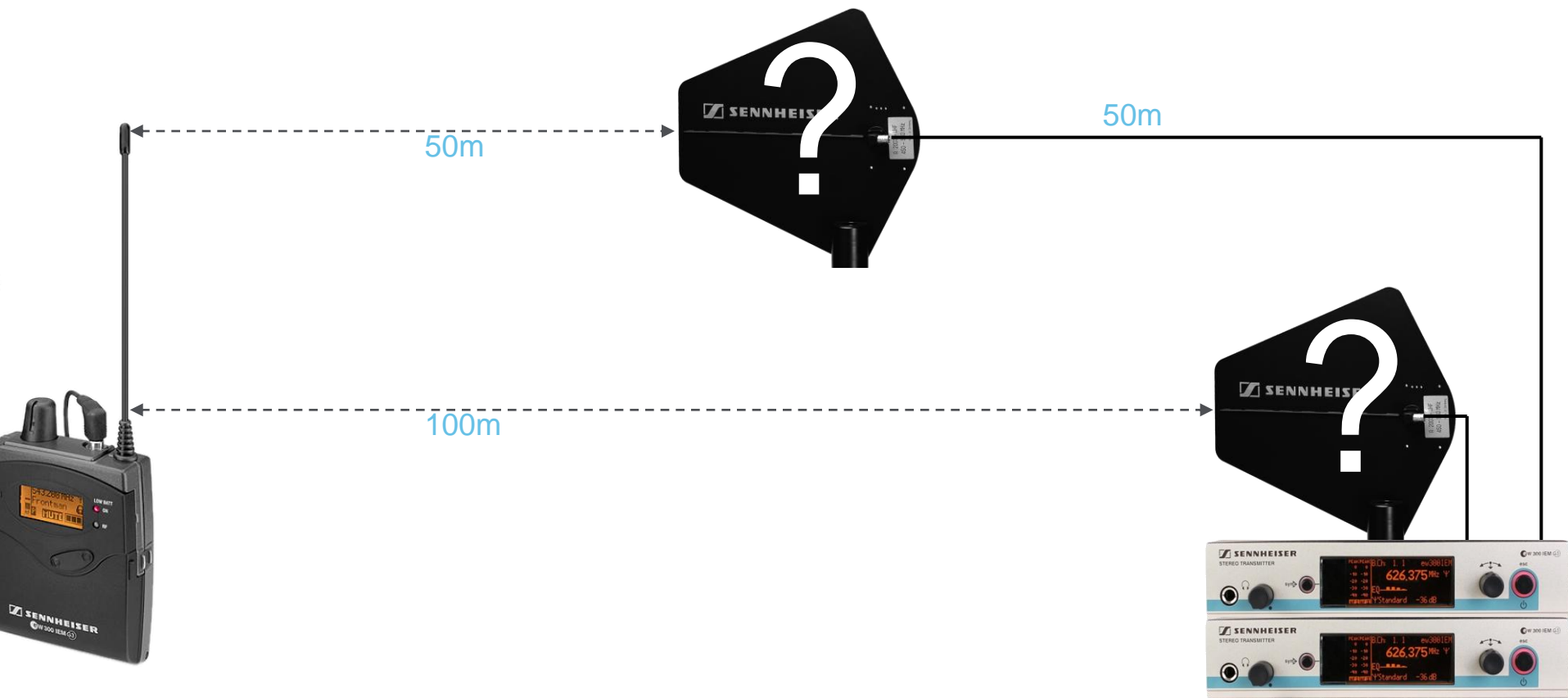


Do not cascade combiners!

More Channels ?

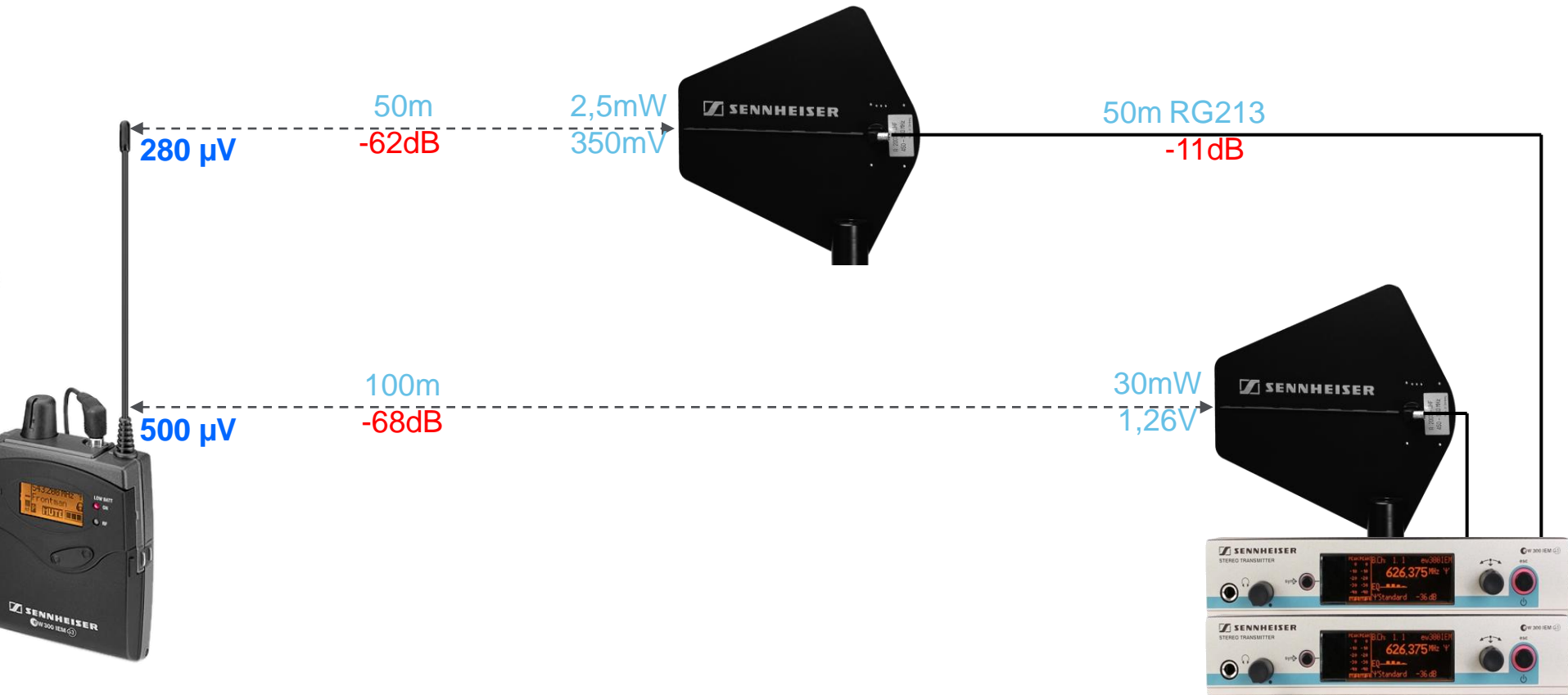


IEM Antenna placement



IEM Antenna placement

Gain structure



IEM ESC 2010 OSLO



Digital Audio Transmission

ERC Report 42 Quote

„The reasons stated for using digital modulation for transmitting an audio signal are to provide better spectrum efficiency and better transmission quality. For the foreseeable future these are mutually exclusive aims for radio microphones, in practice either higher quality or spectrum efficiency is achieved.“

Expect the unexpected

German Soccer Team after European Championship



...our microphone

Operation: Okay

Rules Of Thumb - Mic

Apply new batteries properly
Adjust the input sensitivity at the transmitter
Switch on the receivers first!!

Never operate two transmitters at the same frequency!!
Adjust antennas properly !
Keep a distance of app. 1cm between body and transmitter antenna
Distance between transmitters and receiver antennas should not fall below 4m
Equal antenna polarisation gives best levels
Length of antenna cables should not exceed 10m
Safe operation needs average antenna levels above 100 μ V
Diversity switching must operate frequently I/II
Never apply equal frequency spacings for multichannel use!

Prepare spare systems

Rules Of Thumb - IEM

Minimum spacing between radio microphones and radio monitors: >8 MHz

Use different frequency bands if possible

Allow a minimum distance of 4m between IEM and microphones antennas

Apply active antenna combiners for multichannel ear monitoring

Apply directional circular polarized antennas for IEM transmitters!

Do not overload the combiner

Do not cascade combiners

Use the correct frequency presets

Mono mode for critical IEM conditions (wide range)

Mount the earpieces carefully !

Take care og high AF level with limiters

Prepare spare systems

Danke
Thank you Dank u
Gracias Grazie شكراً
Merci Obrigado
Nandri Tack Go raibh maith agat
Salamat Mulțumesc 謝
Termia Kaseh Ευχαριστώ
СПАСИБО ありがとう Gam-sa hapnida
Köszönöm ขอบคุณ Děkuji

