

# Infocommunication Radio communication (analog & digital)



Dr. Mohammed Salah Al-Radhi

Dr. Tamás Gábor Csapó

malradhi@tmit.bme.hu



*Andrija Pavlov*  
(1844 - 1863)

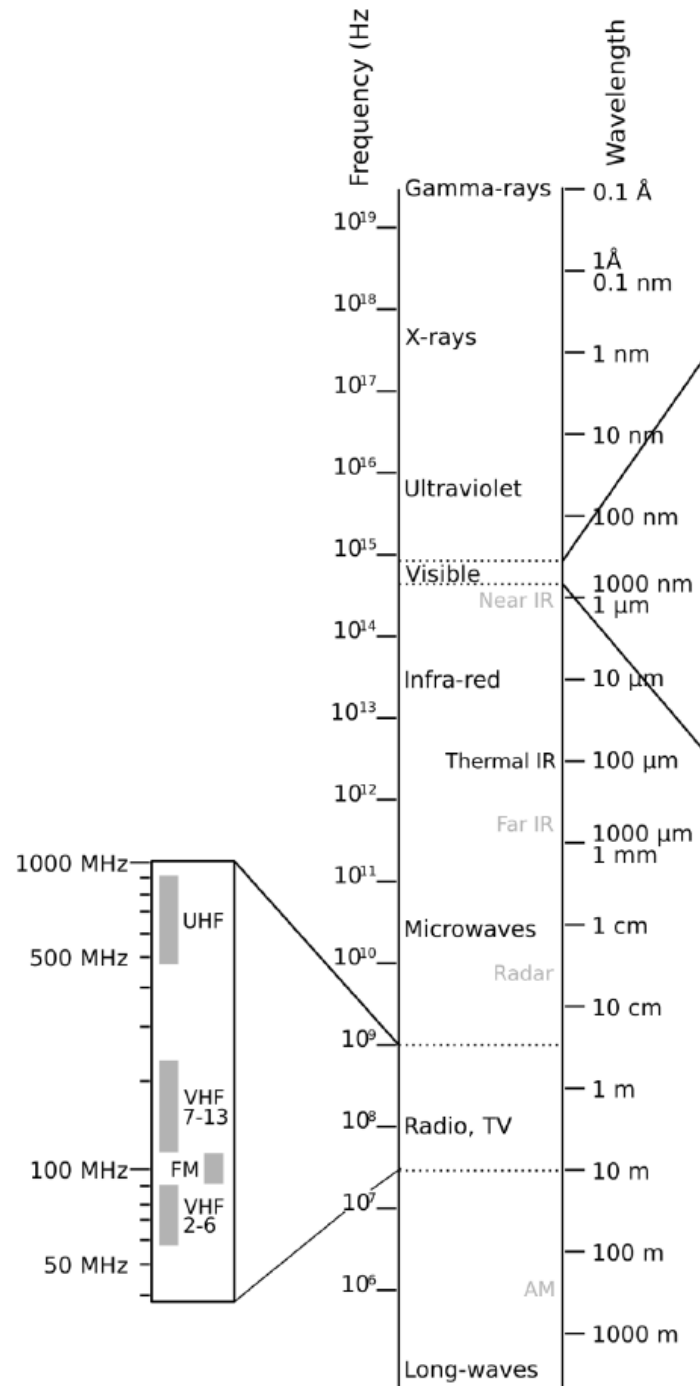
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# Radio communication [Audio broadcasting]

Hearing  $\sim 20 \text{ Hz} - 18 \text{ kHz}$   
Music  $\sim 50 \text{ Hz} - 15 \text{ kHz}$   
Speech  $\sim 100 \text{ Hz} - 5 \text{ kHz}$

# The electromagnetic (EM) spectrum



Source: OP



# MR1-*Kossuth* Radio: The Power of Words



- Lajos *Kossuth* was a Hungarian lawyer, journalist, politician and Regent-President of the Kingdom of Hungary during the revolution of 1848–49. He was widely honored during his lifetime, including in the United Kingdom and the United States, as a freedom fighter and bellwether of democracy in Europe.

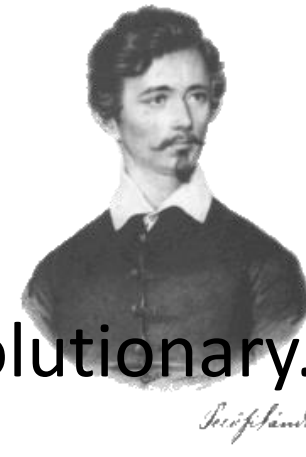
Source: [http://en.wikipedia.org/wiki/Lajos\\_Kossuth](http://en.wikipedia.org/wiki/Lajos_Kossuth)

- MR1-Kossuth Radio is the news-talk station in Hungary with the greatest tradition and with the richest content. Well balanced, authentic news programmes, information in all the important topics, current affairs and national debate.

Source: [http://www.radio.hu/index.php?option=com\\_content&task=blogcategory&id=75&Itemid=117](http://www.radio.hu/index.php?option=com_content&task=blogcategory&id=75&Itemid=117)



# MR2-*Petőfi* Radio: Very music



- Sándor *Petőfi* was a Hungarian poet and liberal revolutionary. He is considered Hungary's national poet, and was one of the key figures of the Hungarian Revolution of 1848. He is the author of the Nemzeti dal (National Song), which is said to have inspired the revolution in the Kingdom of Hungary that grew into a war for independence from the Austrian Empire.

Source: [http://en.wikipedia.org/wiki/Sándor\\_Petőfi](http://en.wikipedia.org/wiki/Sándor_Petőfi)

- The new MR2-Petőfi Radio was launched in 2007. It is now a music station providing a wide selection of the most current and popular European and international music.

Source: [http://www.radio.hu/index.php?option=com\\_content&task=blogcategory&id=75&Itemid=117](http://www.radio.hu/index.php?option=com_content&task=blogcategory&id=75&Itemid=117)



# MR3-*Bartók* Radio:

## The radio of classical music



- Béla ***Bartók*** was a Hungarian composer and pianist. He is considered one of the most important composers of the 20th century; he and Liszt are regarded as Hungary's greatest composers (Gillies 2001). Through his collection and analytical study of folk music, he was one of the founders of comparative musicology, which later became ethnomusicology.

Source: [http://en.wikipedia.org/wiki/Béla\\_Bartók](http://en.wikipedia.org/wiki/Béla_Bartók)

- MR3-Bartók Radio is focusing on classical music and provides music documentaries, jazz, drama and art programmes. Being the classical music station in Hungary, MR3-Bartók Radio is deeply committed to sharing the joy of classical music with listeners, while acknowledging that classical music is an essential source of pleasure of our everyday life.

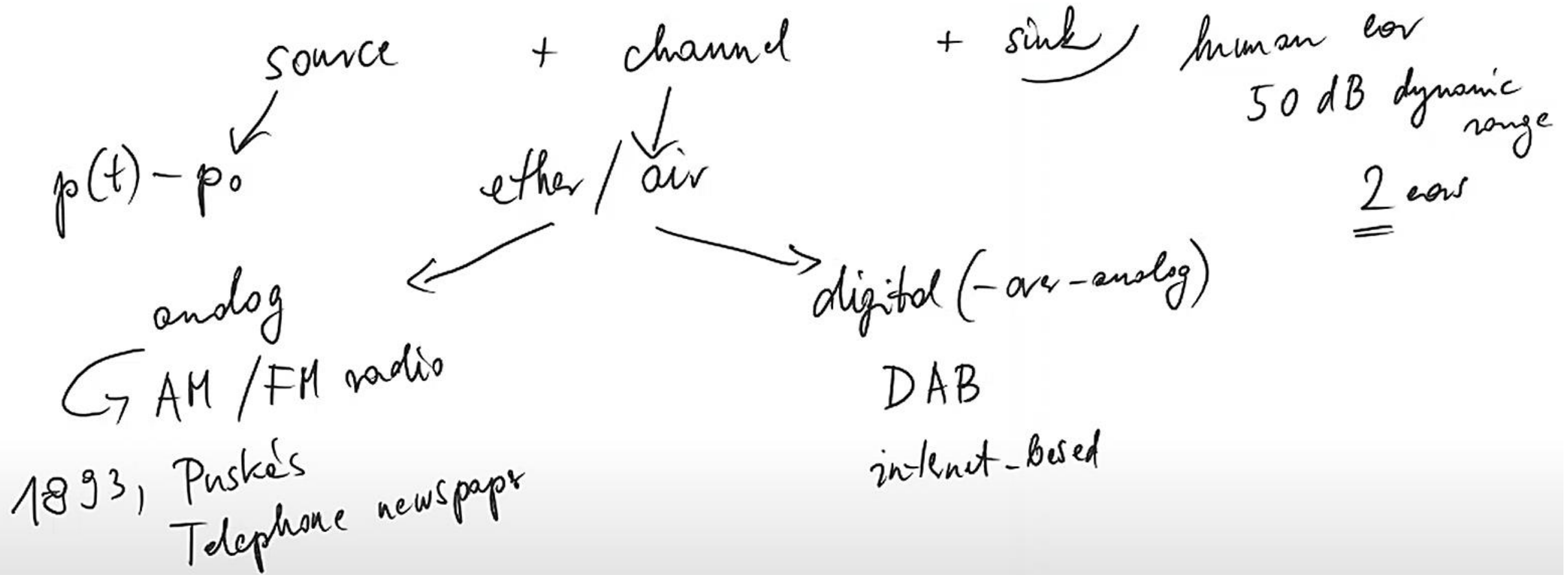
Source: [http://www.radio.hu/index.php?option=com\\_content&task=blogcategory&id=75&Itemid=117](http://www.radio.hu/index.php?option=com_content&task=blogcategory&id=75&Itemid=117)







# Audio broadcasting



# Analog radio

low freq. / long wave LF	middle freq. / middle wave MF	high freq. / short wave HF	very high f. / ultra short wave VHF
$\sim 100 \text{ kHz}$	$\sim 1000 \text{ kHz}$	$\sim 10 \text{ MHz}$	$\sim 100 \text{ MHz}$

LF  
⊕ propagates far away  
⊖ small freq. range  
DCF-77 time signal

MF  
Kosuth, ⊕ propagation

HF  
Radio Free Europe

VHF  
⊖ poor propagation ( $\sim 50-60 \text{ km}$ )

⊕ larger freq. bands

lower / Western : CCIR, 87.5-108 MHz

upper / Eastern : OIRT, 65.8-74 MHz

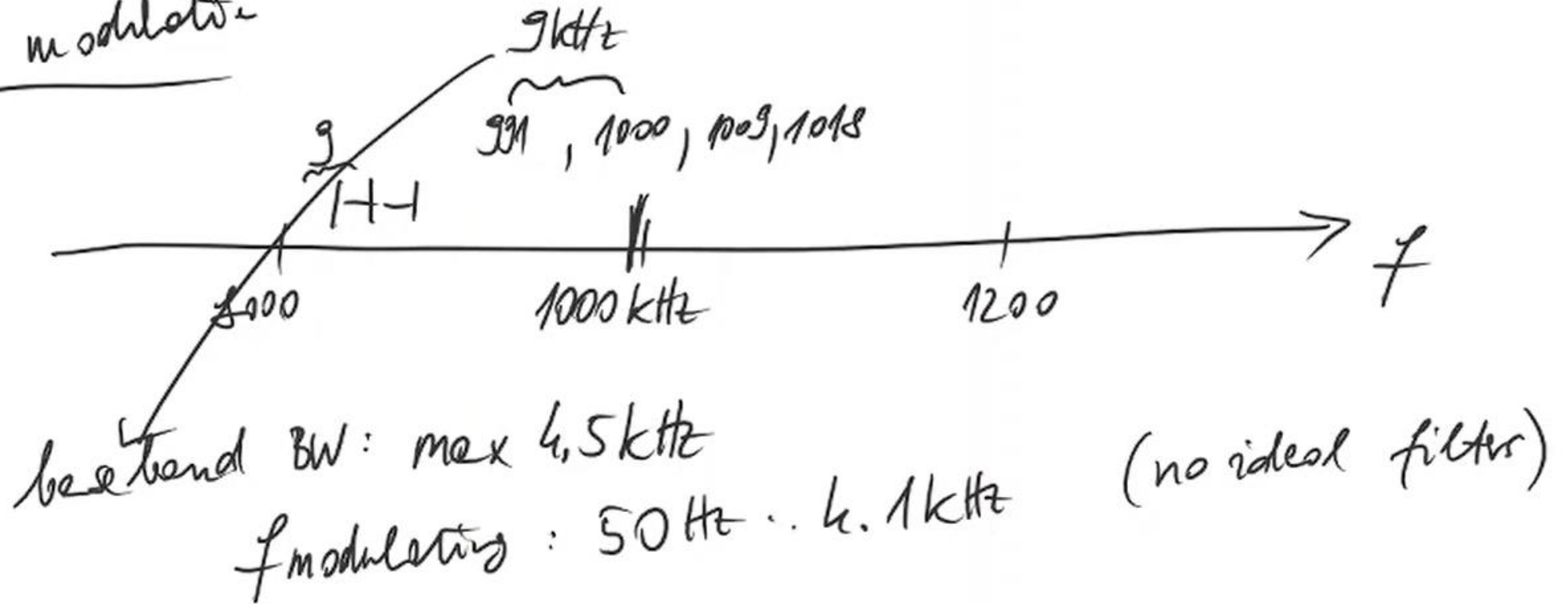
# Modulation

LF MF HF  
AM (Amplitude Modulation)

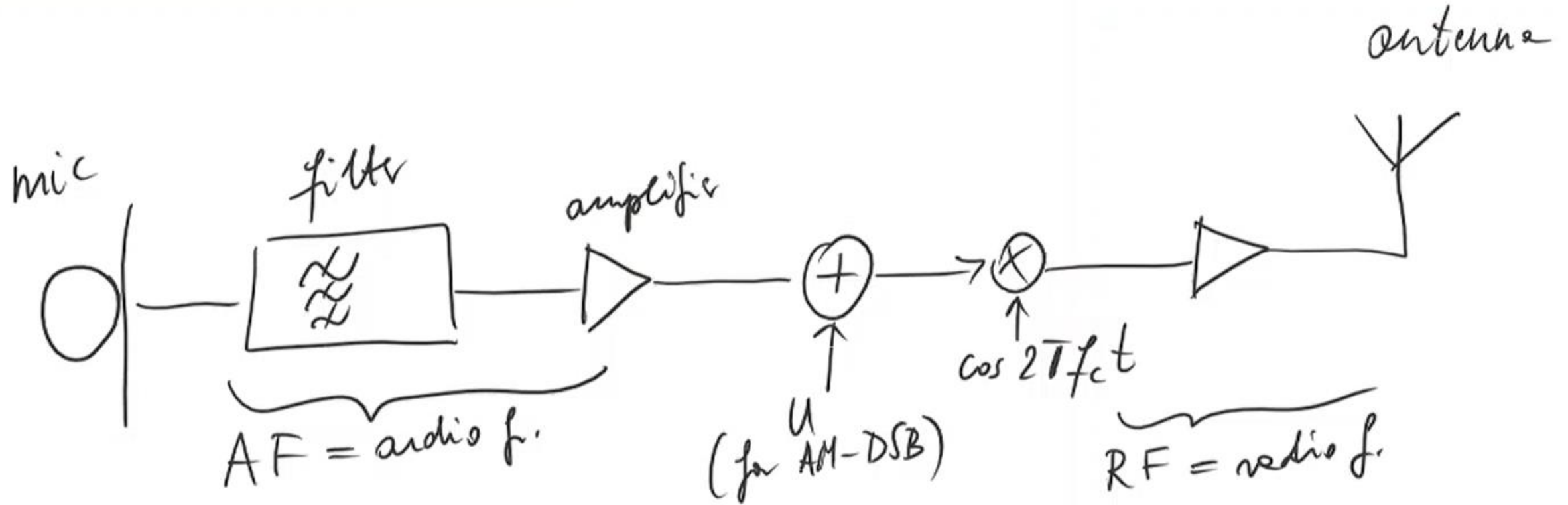
VHF  
FM (Frequency M.)

AM-DSB modulator

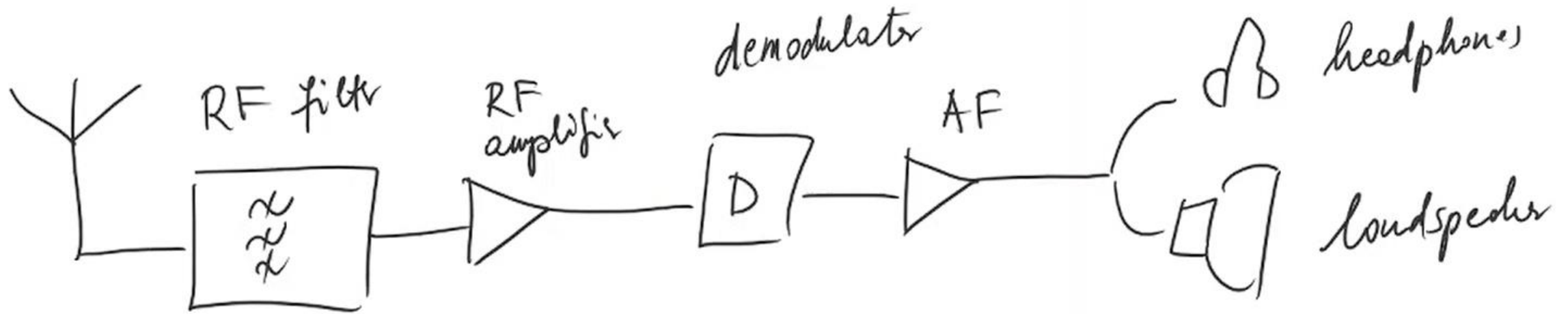
AM



# AM transmitter



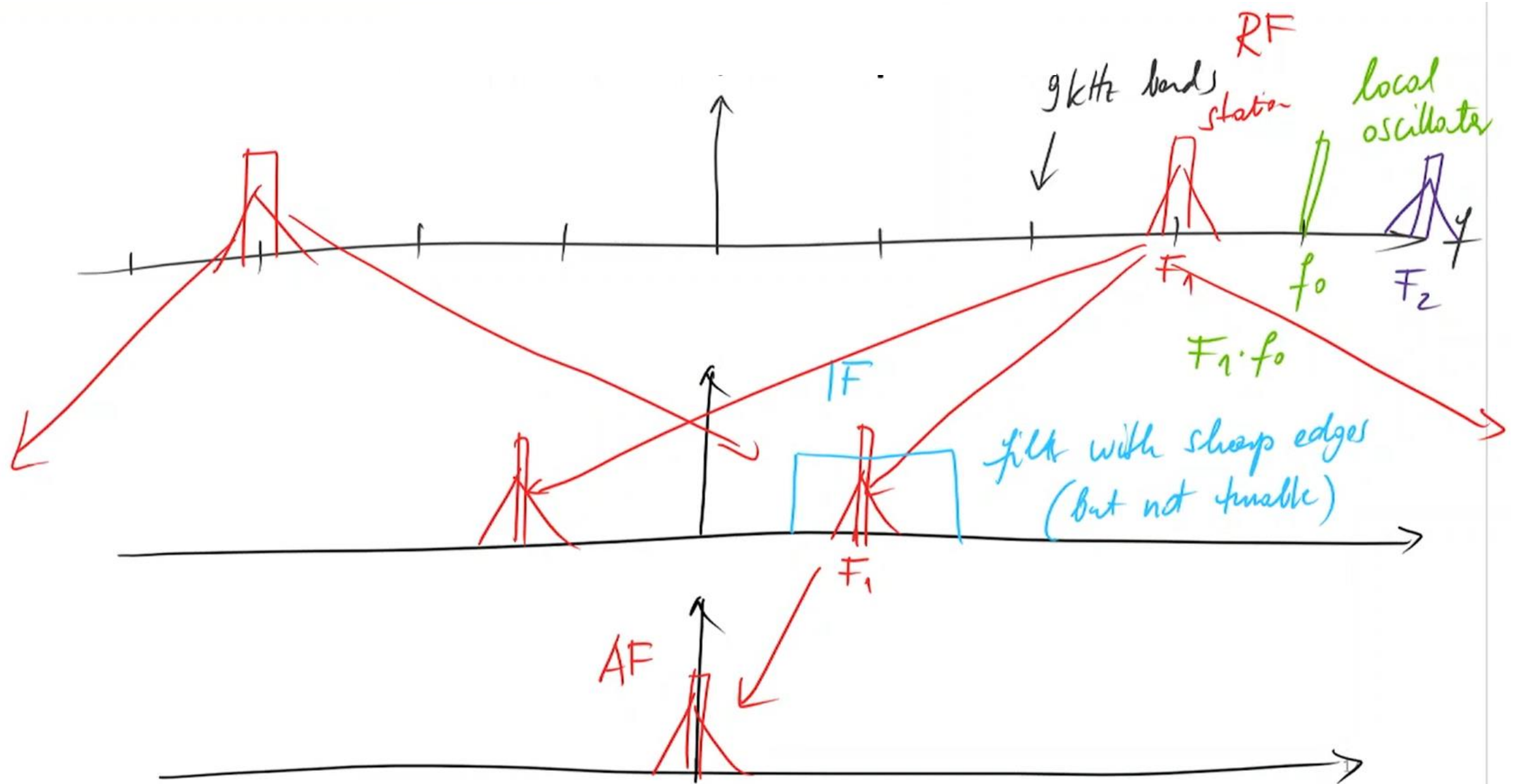
# AM receiver, 1: direct



demodulate ?

a) product demodulator w. coherent carrier } in practice  $\emptyset$   
~ 1000x amplifier

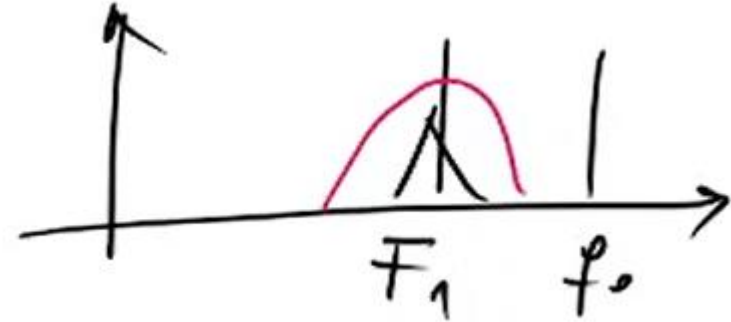
# AM receiver, 2: superhet



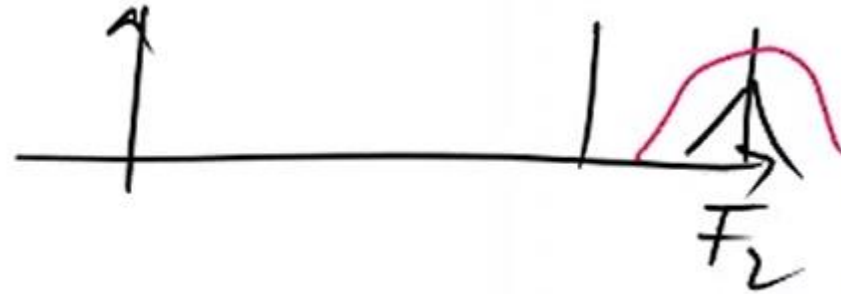


# AM receiver, 2: superhet

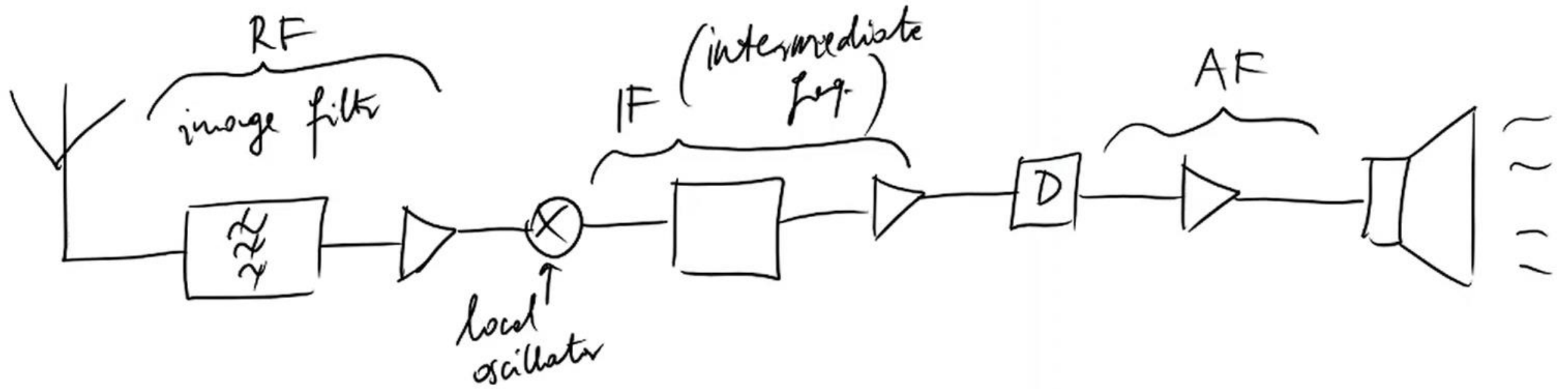
upper band mixing



lower band mixing

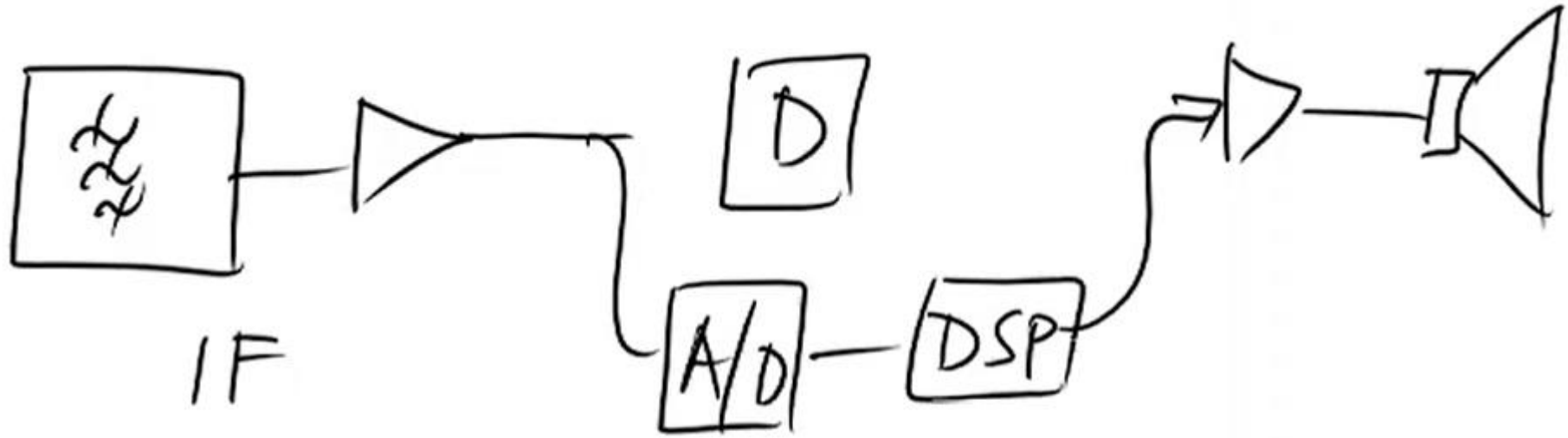


# Supersonic heterodyne receiver



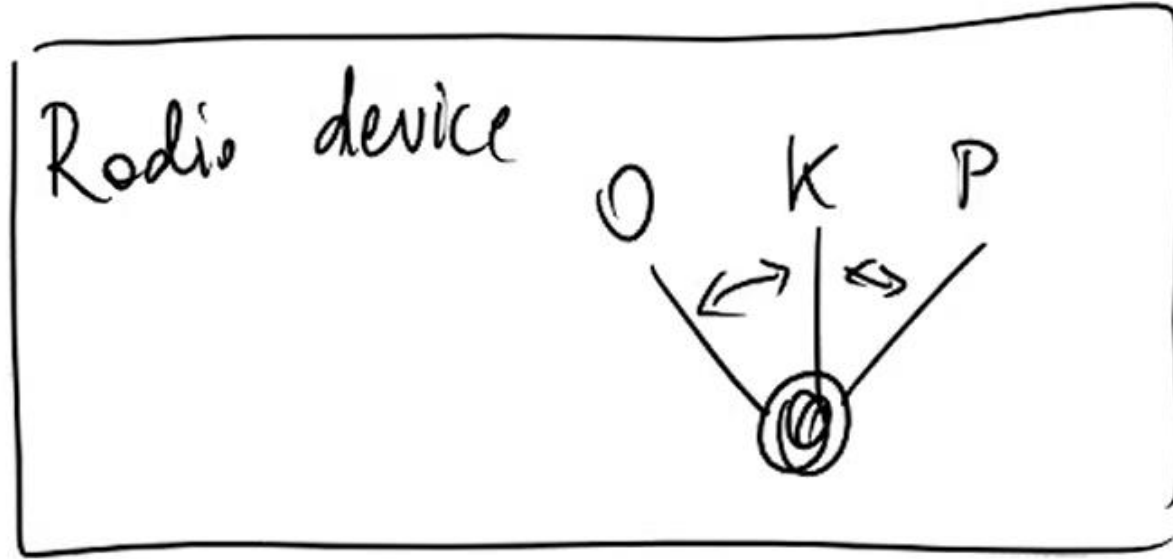
filter {  
RF filter  
IF filter  
} ok!

# FUTURE



*Software defined radio*

# HISTORY



O:  $\emptyset$   
K: Kossuth  
P: Petőfi

AM

— main problem: only up to 4.1 kHz

- dc for speech
- $\emptyset$  for music

# FM

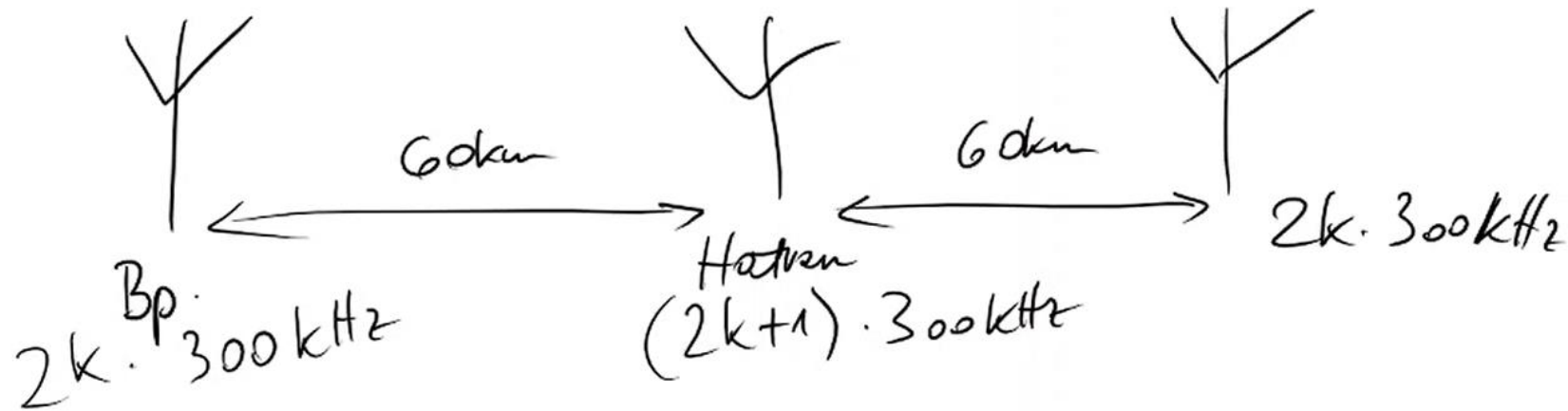
(in VHF band  $\sim 100\text{MHz}$ )

WB FM (Wideband FM)

$$f_D = 75\text{ kHz}$$

$f_{\text{modulating}} : 5\text{ Hz} \dots 15\text{ kHz} \rightarrow \text{h.g. music}$

rate :  $300\text{ kHz}$  (vs. AM:  $9\text{ kHz}$ )



# FM stereo

first: mono

last: stereo,

L+R channel

Solution

$$M \text{ (mid)} : \frac{L+R}{2}$$

$\rightarrow$  as mono

$$S \text{ (side)} : \frac{L-R}{2}$$

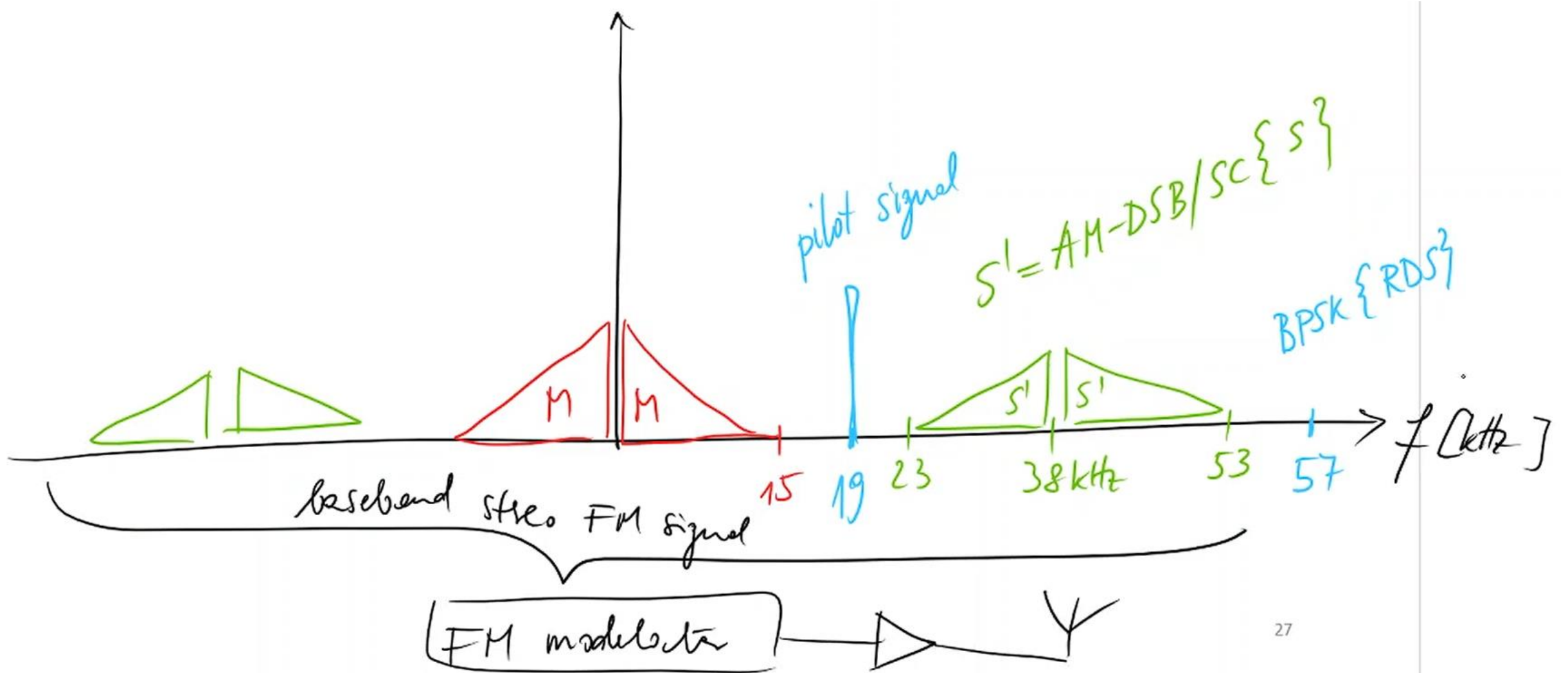
$\rightarrow$  transpose by modulation  
AM-DSB/SC, 38kHz

Mono receiver : M

Stereo receive :  $M+S=L$   
 $M-S=R$



# FM stereo



27

# AM-DSB/SC demodulation

product demodulator w. coh. carrier

Carrier: 19 kHz pilot

- if signal at 19 kHz  $\rightarrow$  S band available  $\rightarrow$  stereo
- if no  $\rightarrow$  S not avail.  $\rightarrow$  mono

Carson rule

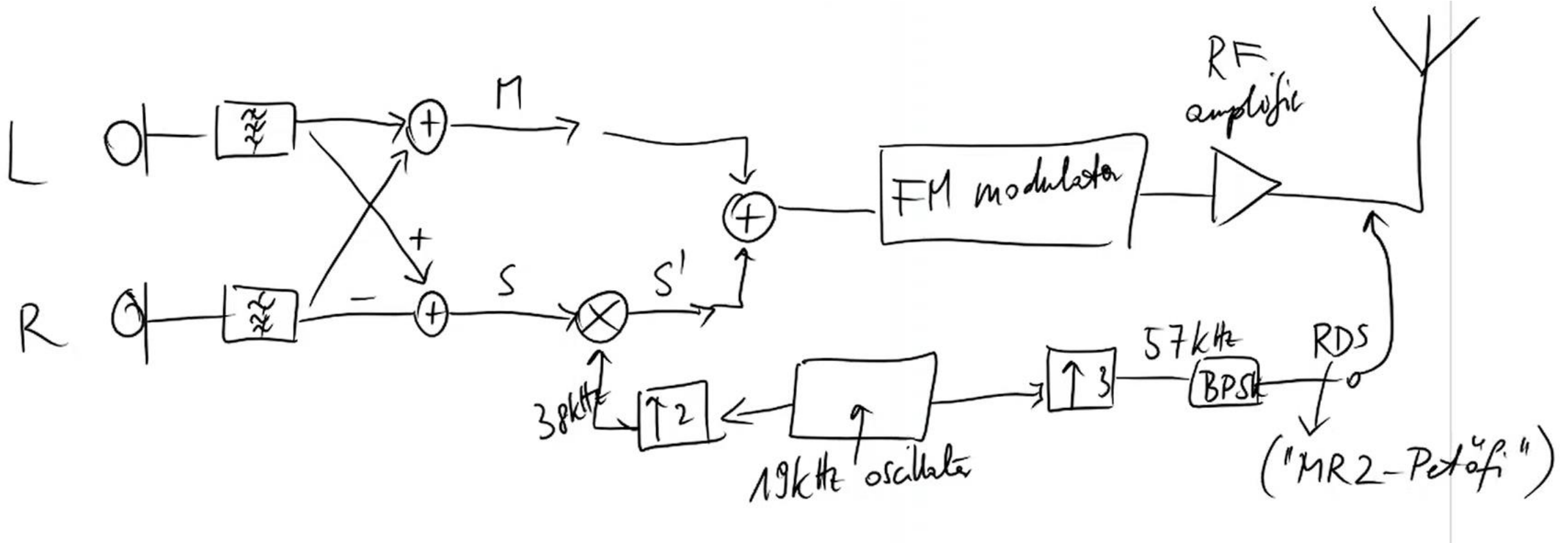
$$B = 2 \cdot (f_{\max} + f_D) \approx 270 \text{ kHz} \Rightarrow 300 \text{ kHz}$$

$\downarrow$   $\downarrow$

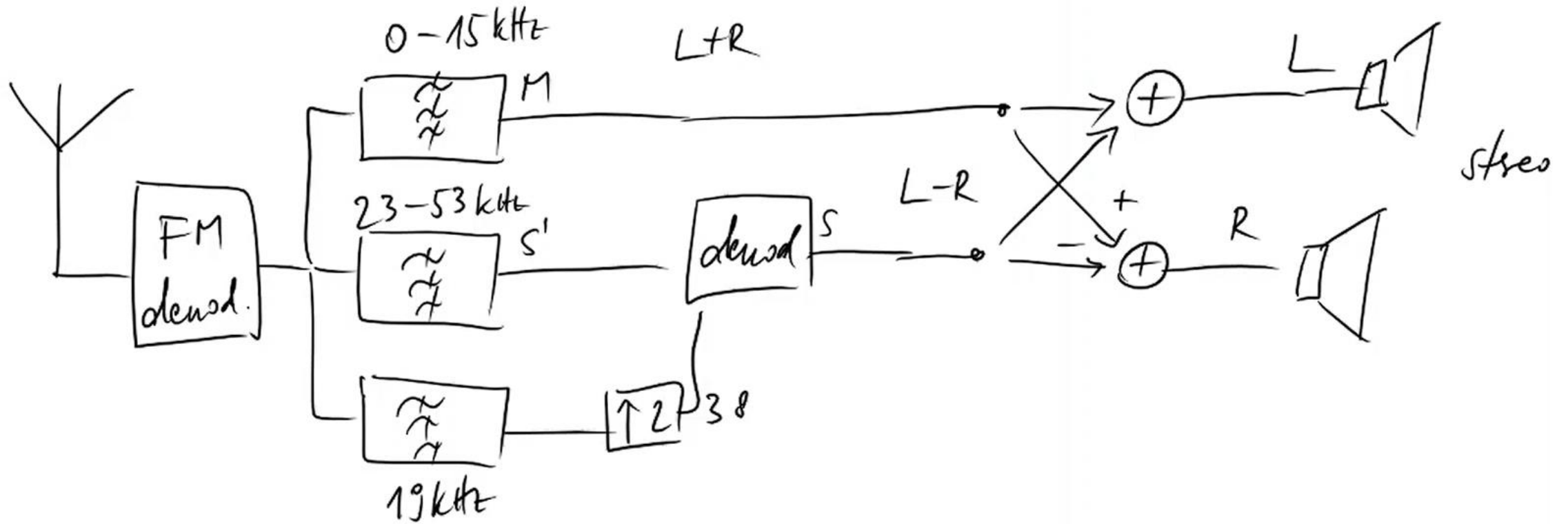
57 kHz (RDS)      75 kHz

rate  
in VHF band

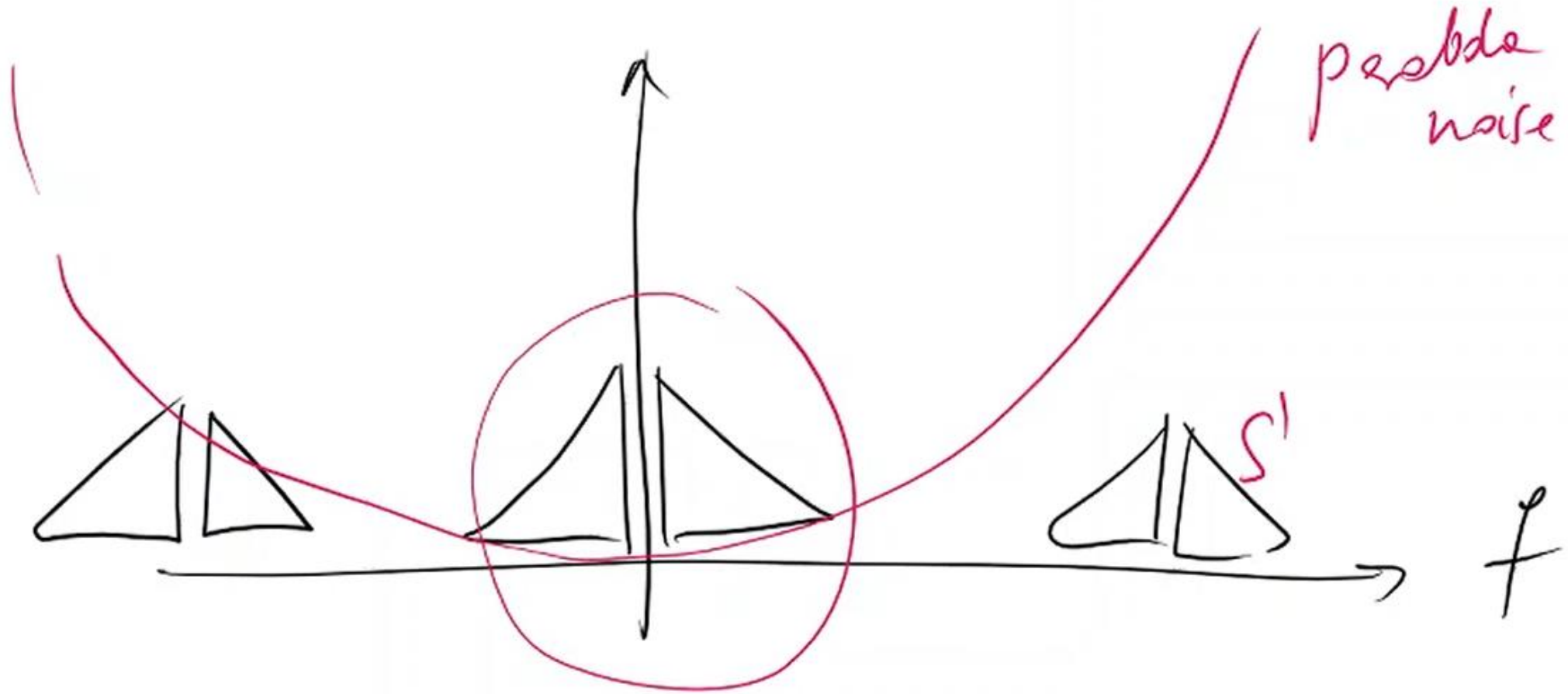
# FM transmitter



# FM receiver



# Noise in FM transmission



# RDS = Radio (Broadcast) Data System

- Digital information in analog radio
- Signal at 57 kHz
- Symbol rate: 1187.5 bps (1/48 of 57 kHz)
- BPSK modulation
- C(26,16) error control code: 16 bit data + 10 bit error control
- Net bitrate:  $16/26 * 1187.5 \text{ bps} \sim 100 \text{ characters/sec}$



# RDS = Radio (Broadcast) Data System

- Program Service – e.g. „Bartók”
- Program Identification – ID of station (can be used for AF switch)
- Alternative Frequencies
- Program Type – e.g. „country music”
- Radio Text – title of current song, e.g. „Metallica – Sad but True”
- Traffic Announcement – 1 bit, if traffic news -> automatic change
- Traffic Program
- Traffic Message Channel (TMC) – help for GPS navigation
- Clock Time – exact time, ~100ms accuracy



# Radio communication, digital (-over-analog)

- What is needed for digital transmission?
  - Good A/D converter (transmitter)
  - Good D/A converter (receiver)
  - Good source coding (MPEG, MP3)
  - Good error control coding (MPEG, MP3)
  - Good modulation
  
  - MPEG = Moving Pictures Expert Group -> also audio

# Modulation

- Problem:  
if symbols are too dense -> inter symbol interference (ISI)
- Solution:  
large symbol time (but: practical bandwidth decreases)
- FDM = Frequency Division Multiplexing  
(lots of narrowband signals near each other)  
e.g. 1 transmitter, 1 MHz = 1000 x 1 kHz bands

# Digital Audio Broadcasting (DAB)

- First: Norway, 1995
- Hungary: since 1997, DAB+ test bitrates: 48-128 kbps
- USA: HD-Radio



# Digital Audio Broadcasting (DAB)



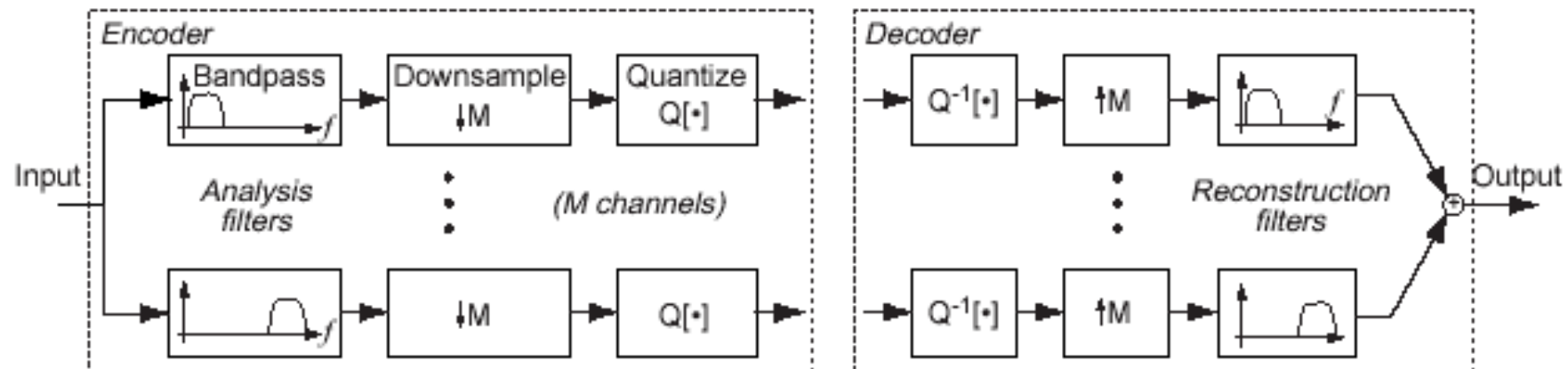
- VHF/Band III: 174-240 MHz  
UHF/L-band: 1452-1492 MHz
- Modulation: OFDM + DQ-PSK:
  - 1536 sub-carriers, 1 kHz „distance”
  - 1537 kHz bandwidth
- MPEG-1 / Layer II Audio
- Sampling frequency: 48 kHz
- Quantization: 16 bits
  
- DAB+: MPEG-4/AAC+ (no demand) →  
20 channels, 96-128 kbps (PCM would be 1.5 Mbps)

# Perceptual coding

- Goal: compress audio (e.g. music) without quality loss
- Use properties of hearing
  - Critical bands
  - Hearing limitations
  - Masking
    - Time domain
    - Frequency domain

# Subband coding

- Analysis filter bank,  $M$  bandpass filters
- Quantize separately in different bands
  - quantization noise stay within band; gets masked



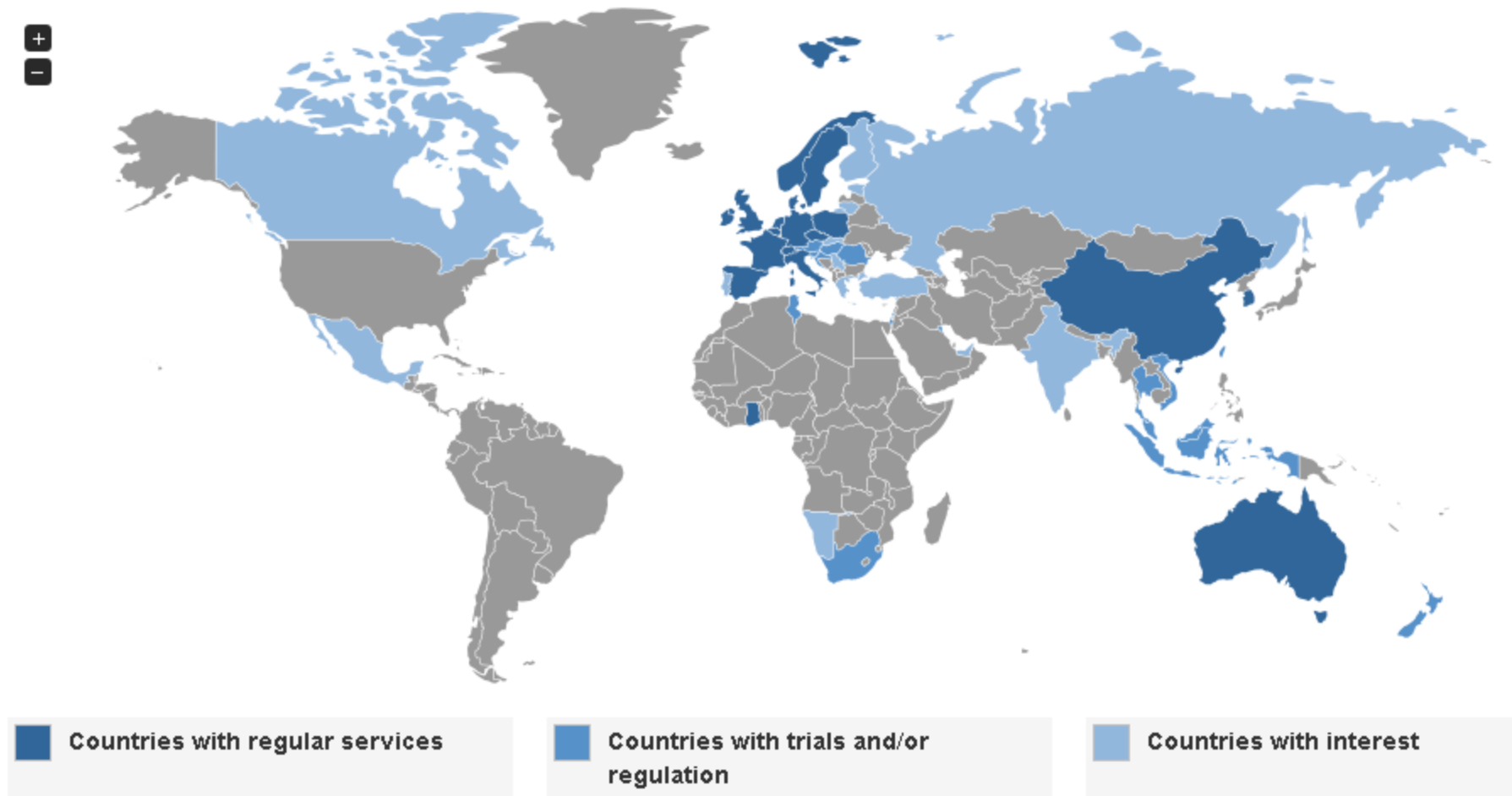


# Digital Radio Mondiale (DRM)

- MF and HF, 9 kHz raster
- ~ FM quality, but better spectral efficiency
- Modulation: OFDM + N-QAM
- Codec: MPEG-4
- Good propagation, long range
- Sensitive to the Doppler effect

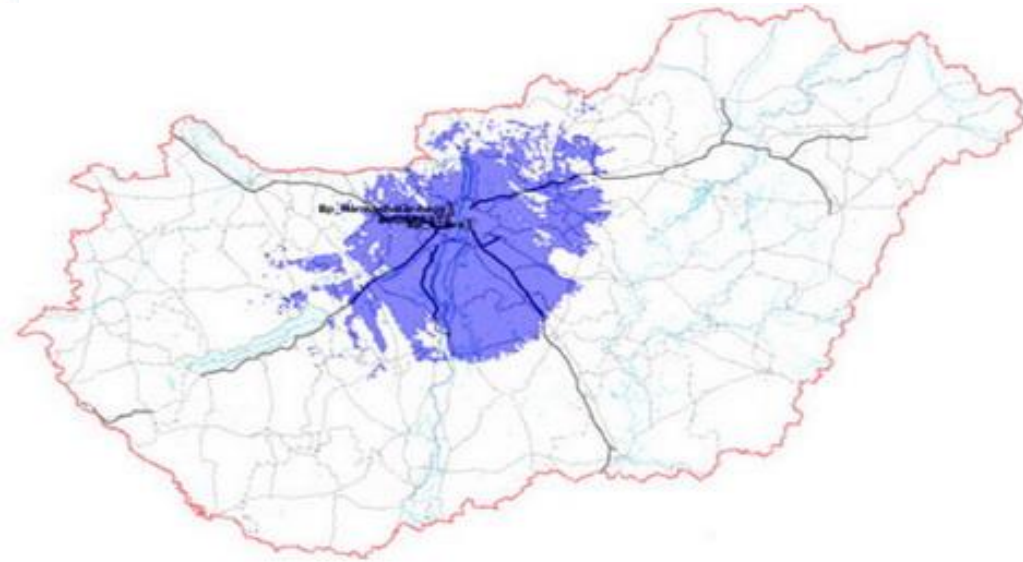
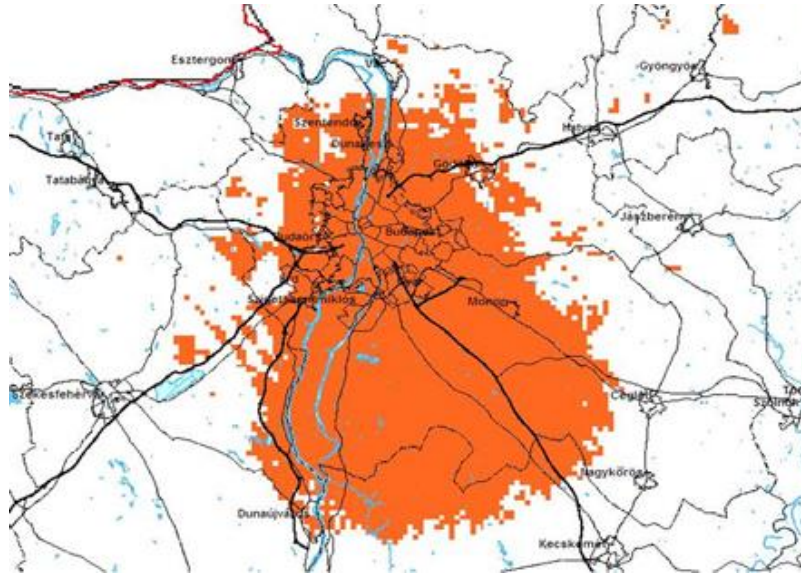


# Coverage of DAB/DAB+/-...



Source: <http://www.worlddab.org/country-information>

# Coverage of DAB+ (Hungary)




Source:  
<https://www.ahrt.hu/hu/digitalis-radio-magyarorszagon>

Source:  
<http://www.frekvencia.hu/t-dab-hng.htm>

# FM switch-off

- Norway has 99.5% DAB coverage
- FM switched off in 2017
  - (around two-thirds of people opposed the switch...)
  - X

Norway reports stable listening figures following DSO

10.04.2018 - Norway - 

The proportion of daily listeners on national channels has increased from 56.9 per cent in January 2018 to 57.4 per cent in March. The total listening time has increased over the same period from 71 to 74 minutes. "It has always been expected that radio broadcasting will stabilise from 2018. We can probably expect more stable listening figures in the future," says Director of Media Authority Mari Velsand.

*From Medietilsynet:*

[Read more...](#) 

- (in other countries: 2022-...)

# ~~FM switch-off~~

- Hungary: DAB switched off in 2020

<https://www.vik.bme.hu/hir/2705-kiserleti-digitalis-radioadas-vik-kozremukodessel>



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The END

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*Andrija Papić*  
(1844 - 1863)