



Infocommunication Radio communication (analog & digital)

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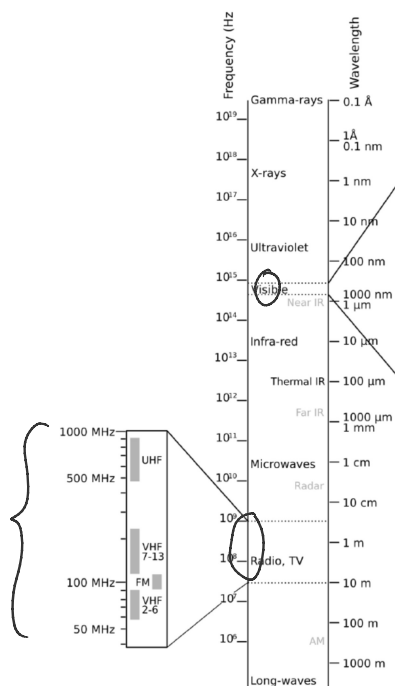
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Radio communication [Audio broadcasting]

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

3



The electromagnetic (EM) spectrum

Source: OP

4



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

- 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

5



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

- 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

6



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

- 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.

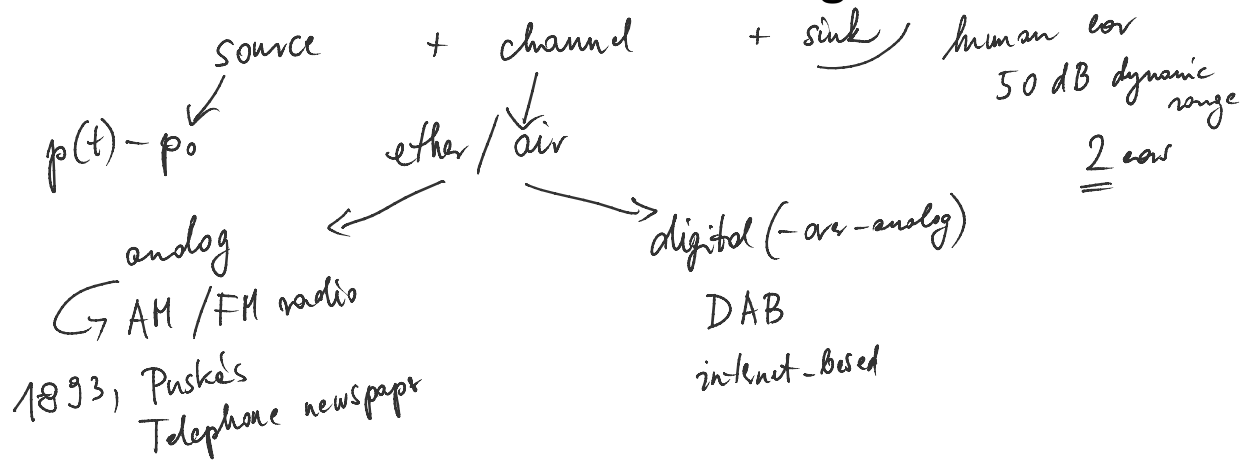
Source: http://www.radio.hu/index.php?option=com_content&task=blogcategory&id=75&Itemid=117

7



8

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
 Kossuth, ⊕ propagation Budapest → Hungary

HF
 Radio Free Europe

11

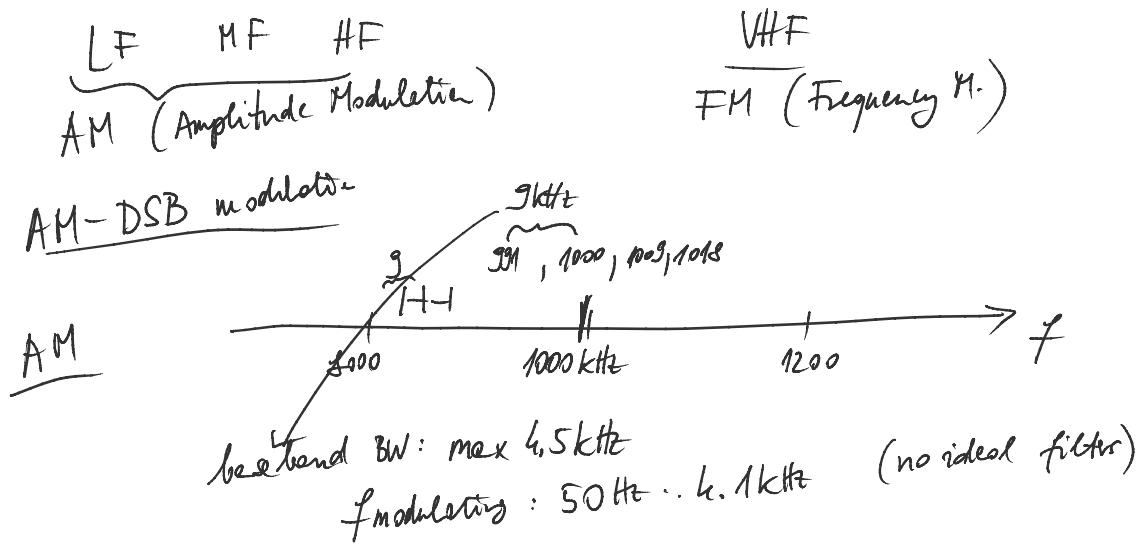
Analog radio

LF	MF	HF	VHF

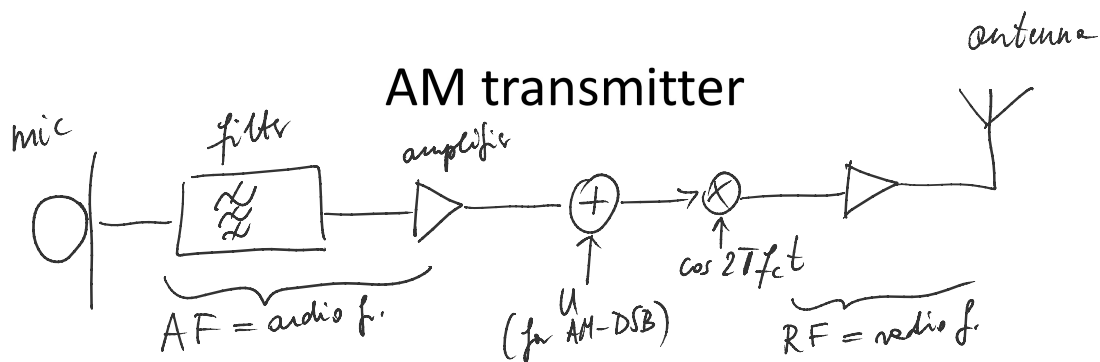
VHF
 ⊖ poor propagation ($\sim 50-60 \text{ km}$)
 ⊕ longer freq. bands
 lower / Western : CCIR, $87.5-108 \text{ MHz}$ $\frac{2}{3}$
 upper / Eastern : OIRT, $65.8-74 \text{ MHz}$

12

Modulation

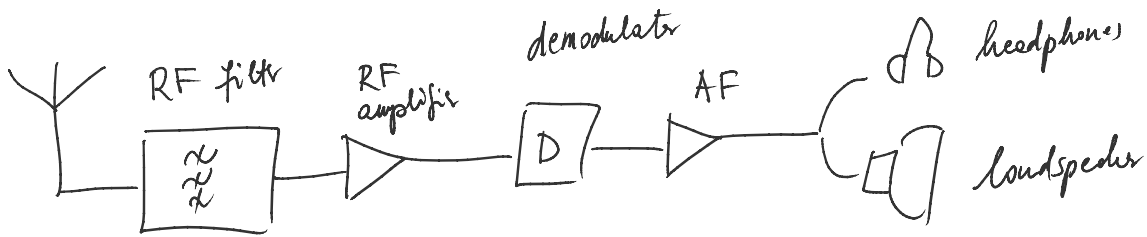


13



14

AM receiver, 1: direct



demodulate?

a) product demodulator w. coherent carrier
~ 1000x amplification

} in practice \emptyset

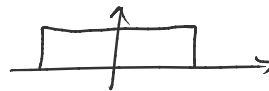
15

AM receiver, 1: direct

b) envelope detector

we need specific filters

sharp edge



instead of

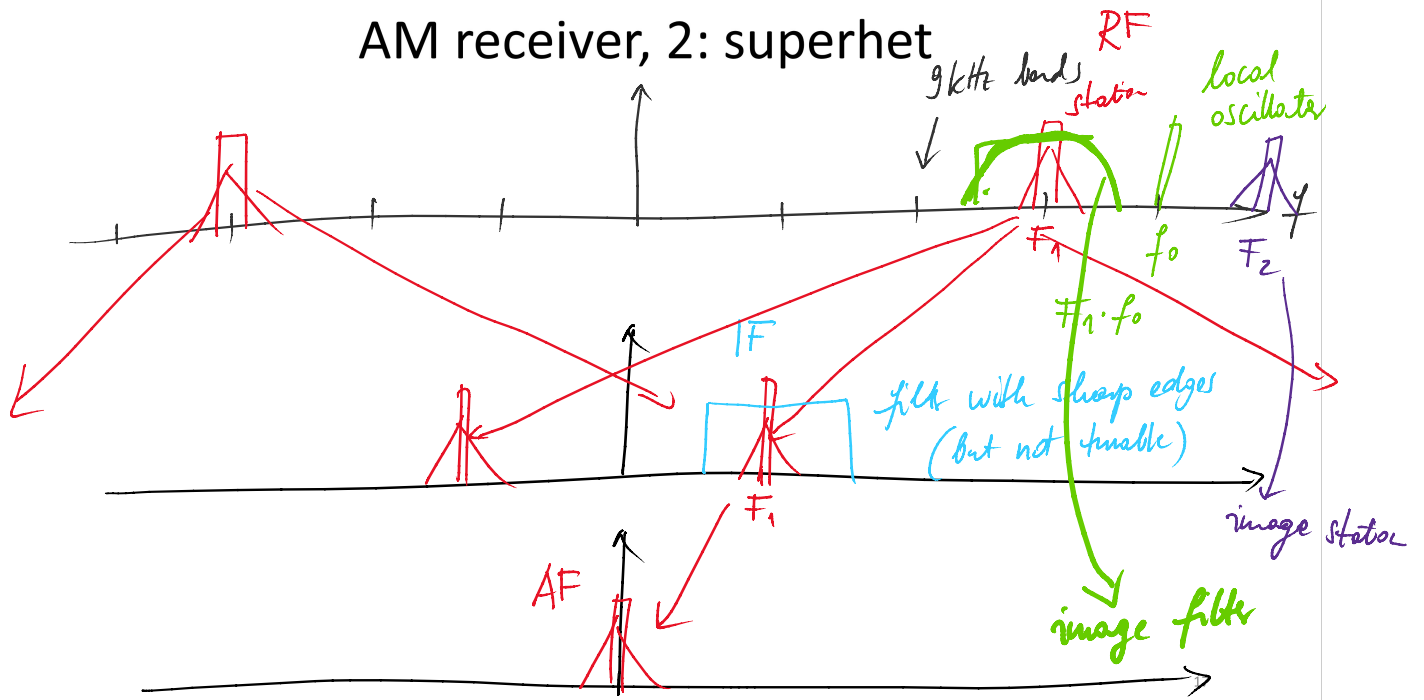


well tunable in full freq. band

direct receiver not used since 1920s

16

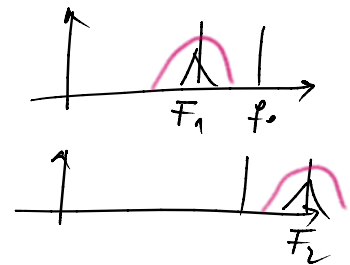
AM receiver, 2: superhet



AM receiver, 2: superhet

upper band mixing

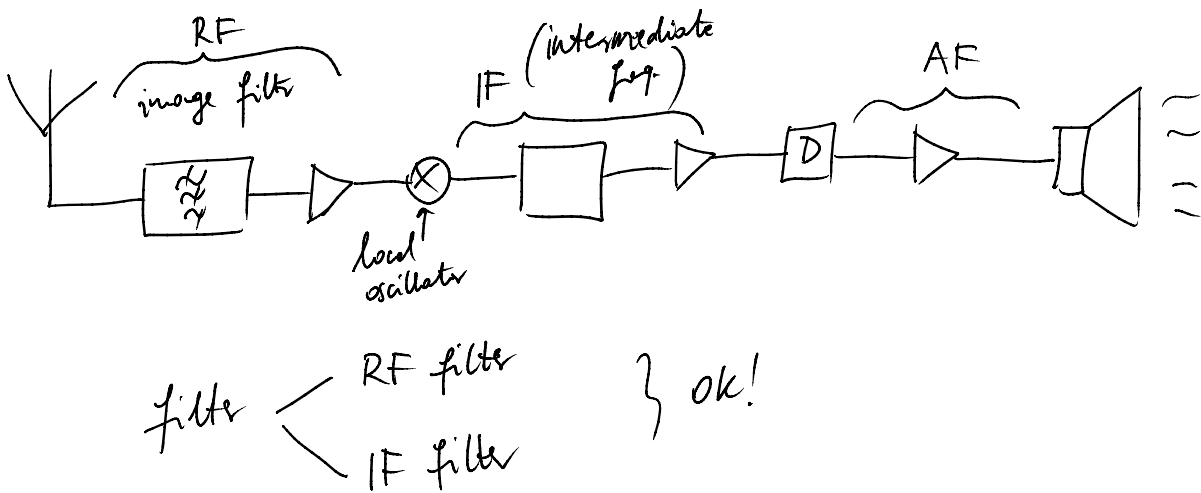
lower band mixing



AM receiver, 2: superhet

19

Supersonic heterodyne receiver (superhet)

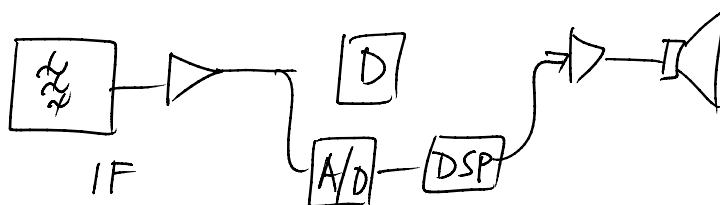


20



21

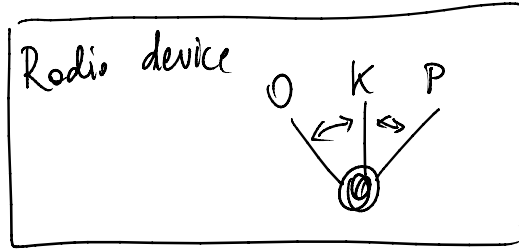
Future



Software defined radio

22

History



O: \emptyset
K: Kossuth
P: Petöfi

AM - main problem: only up to 4.1 kHz $\left\{ \begin{array}{l} \text{OK for speech} \\ \emptyset \text{ for music} \end{array} \right.$

PAUSE

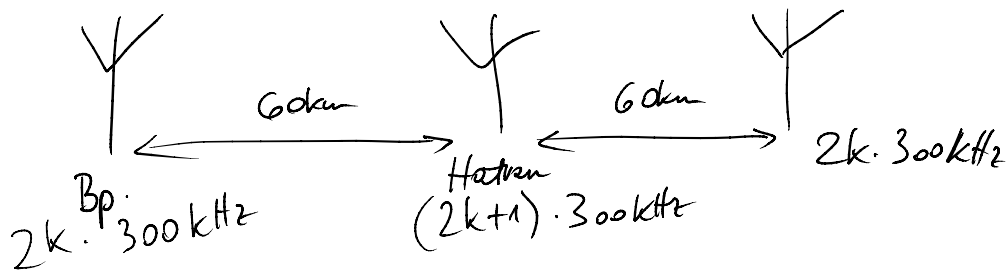
FM (in VHF band $\sim 100\text{ MHz}$)

WB FM (Wideband FM)

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

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

master: 300 kHz (vs. AM: 9 kHz)



25

FM stereo

first: mono

later: stereo, $L+R$ channel

Solution

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

\rightarrow as mono

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

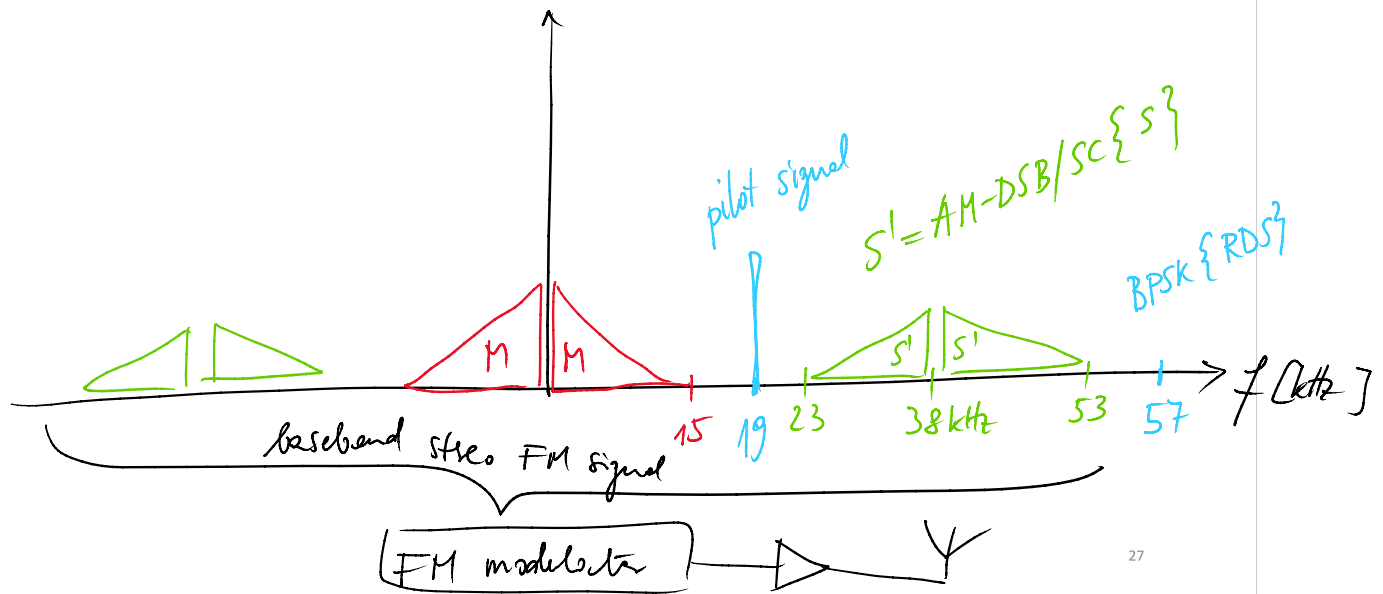
\rightarrow transpose by modulation
AM-DSB/SC, 38 kHz

Mono receive: M

$$\begin{aligned} \text{Stereo receive: } M+S &= L \\ M-S &= R \end{aligned}$$

26

FM stereo



27

AM-DSB/SC demodulation

product demodulator w. coh. carrier

Carrier: 19 kHz pilot

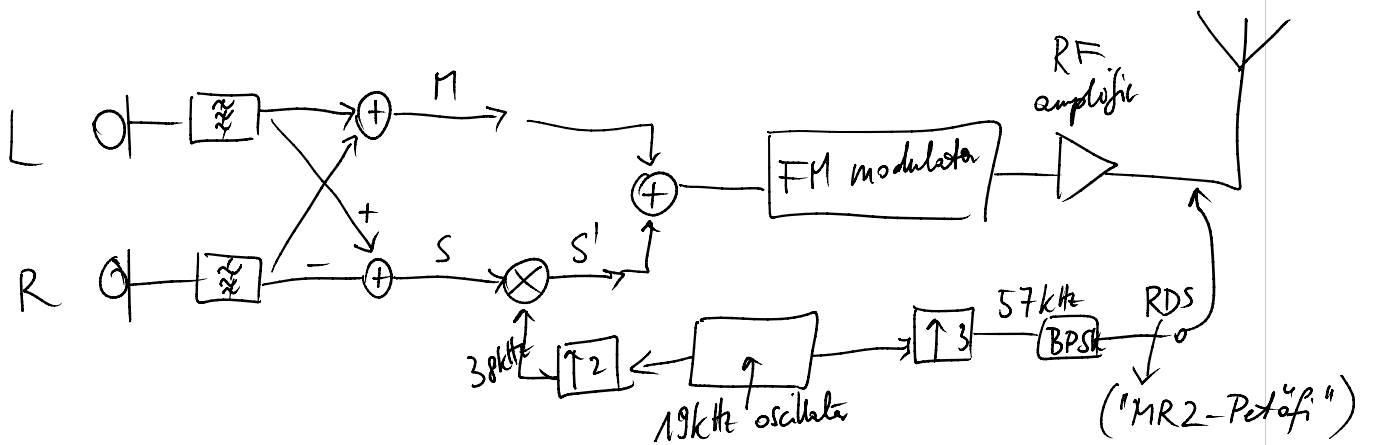
- if signal at 19 kHz \rightarrow S band available \rightarrow stereo
- if no \rightarrow S not avail. \rightarrow mono

Carson rule

$$B = 2 \cdot \left(\underset{\substack{\uparrow \\ 57 \text{ kHz} \\ \text{(RDS)}}}{f_{\max}} + \underset{\substack{\uparrow \\ 75 \text{ kHz}}}{f_D} \right) \approx 270 \text{ kHz} \Rightarrow 300 \text{ kHz} \text{ raster in VHF band}$$

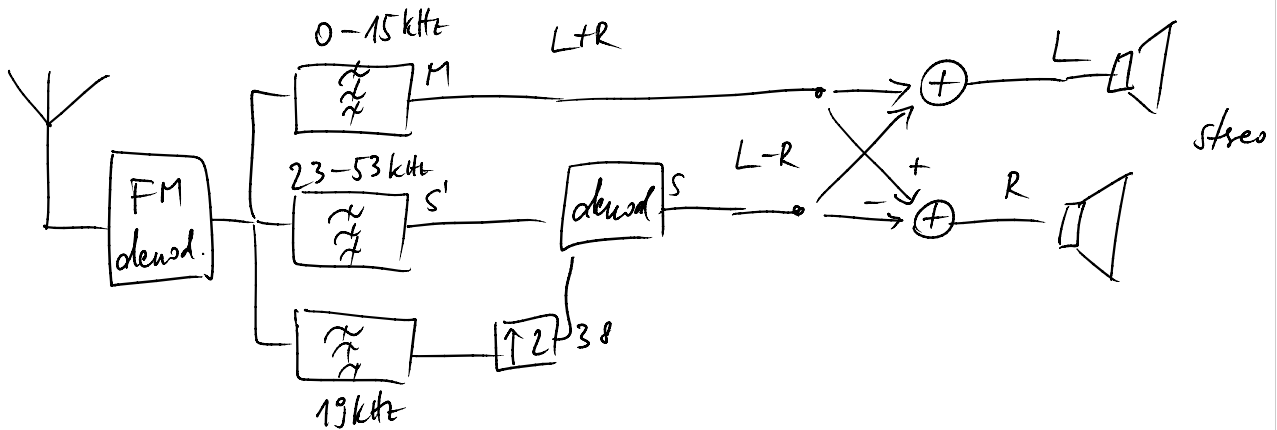
28

FM transmitter



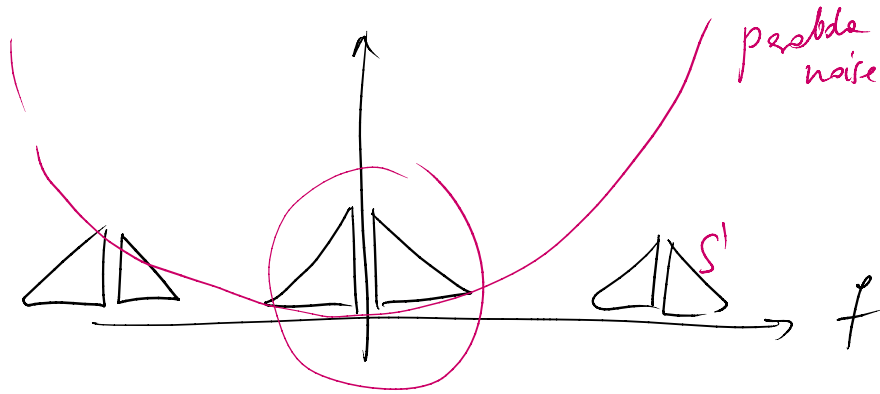
29

FM receiver



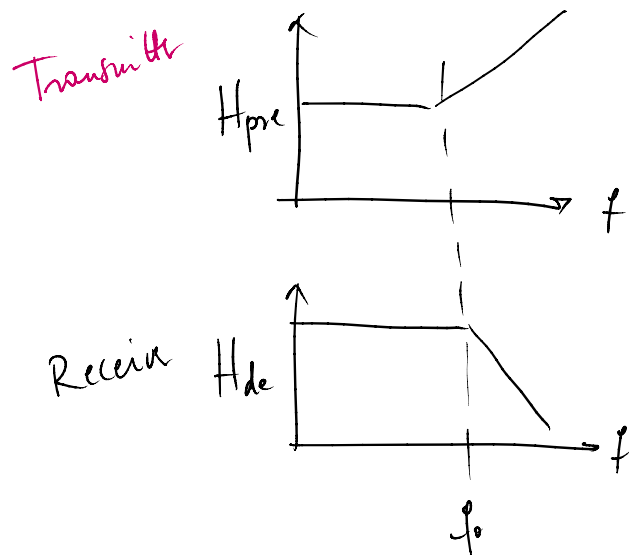
30

Noise in FM transmission



31

Noise reduction



32

Noise reduction

+ Quadro transmission
↳ 4 channels

33

RDS = Radio (Broadcast) Data System

signal at 57 kHz
symbol rate: 1187.5 bps ($\frac{1}{48}$ of 57 kHz)
C(26,16) error control code
16 bit data + 10 bit e.c.

net bitrate $\frac{16}{26} \cdot 1187.5 \text{ bps} \approx 100 \text{ char./sec}$

→ digital info in analog radio

34

RDS = Radio (Broadcast) Data System

- Program Service — "BARTók"
- Program Identification ID — help for switching
- Alternative Frequencies
- Program Type
- Radio Text ABBA
- Traffic Announcement
- Traffic Program
- Traffic Message Channel
- Clock Time ~ 100ms error

35

PAUSE

36



37

Radio communication, digital (-over-analog)

- What is needed for digital transmission?

- Good A/D converter
- Good D/A converter
- Good source coding
- Good error control coding
- Good modulation

} MPEG = Moving Picture Expert Group
MP3

38

Modulation

ISI

Solution: large symbol time

$T: \nearrow \quad 2 \cdot \frac{1}{T} \searrow$, small BW

FDM, Freq. Division Mpx

e.g. 1 transmit, 1MHz, $1000 \times 1\text{kHz}$ bands

↓
OFDM = Orthogonal

39

Orthogonal FDM (OFDM)

ISI - free data transmission

SFN = Single Frequency Network

40

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)

first: Norway 1995
Hungary: since 1997

41

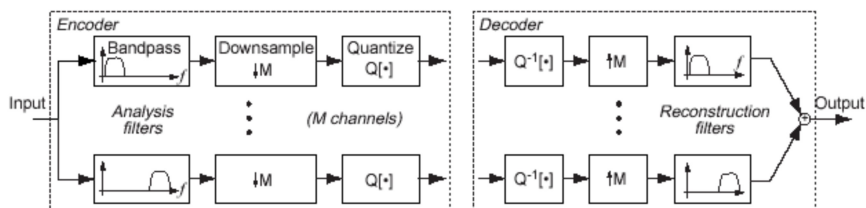
Perceptual coding

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

42

Subband coding

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



Source: <http://www.aiv.it/AISVScuolaEstiva2008/materials/N.Orio/Compressione-MP3.ppt>

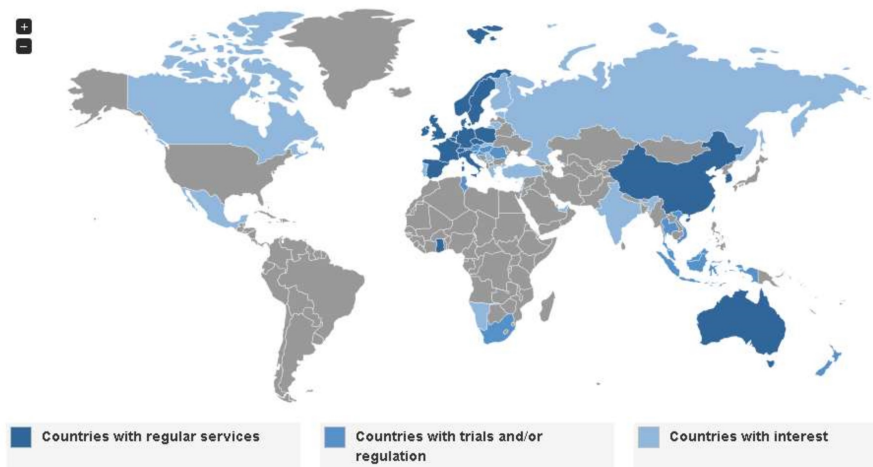
43

Digital Radio Mondiale (DRM)

- MF and HF, 9 kHz raster
 - Modulation: OFDM + N-QAM
 - Codec: MPEG-4
 - (theoretically) high quality, long range
 - Sensitive to the Doppler effect
- (~ AM radio 1000kHz band)*

44

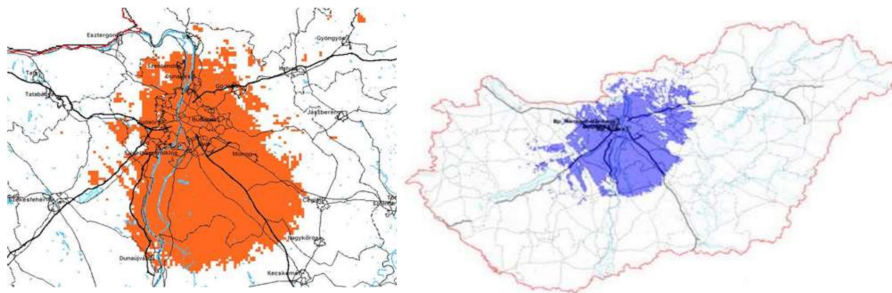
Coverage of DAB/DAB+/...



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

45

Coverage of DAB+ (Hungary)



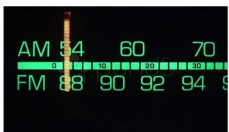
Source:
<https://www.ahrt.hu/hu/digitalis-radio-magyarorszagon>

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

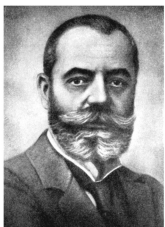
46



x



Infocommunication Radio communication (analog & digital) The END



Ányos Károly
1861-1912

Tamás Csapó
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x



x



x



x