TERRESTRIAL Broadcast DAB+

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History – First Transmission of Radio service

1924 first ***Radio*** Transmission in Austria

History – First Transmission of TV service

1955 – first Transmission of ***Television*** Service in Austria

History

1972 - Historisches …

- 1923 AM Radio
- 1949 FM Radio, erster europ. FM-Sender: Rohde&Schwarz
- **1982 Compact Disc (CD)**
- 1991 Digital Satellite Radio (DSR)
- 1993 ADR – Astra Digital Radio
- 1989 MUSICAM Audio Encoding
- 1991/93 MPEG-1, MPEG-2 Standard
- **ab 1987 Eureka Projekt 147/DAB** (MUSICAM MPEG-1 Layer II Audio, COFDM)
- seit Anfang der 1990er DAB in Deutschland, teilweise als Versuche, im VHF Band III (Mode I) und teilweise im L-Band (Mode II)
- 1995 als DVB-Standard ETSI EN 300 401 veröffentlicht
- Mitte der 1990er DVB – Digital Video Broadcasting
- 2001 DRM – Digital Radio Mondiale
- 2005…2008 T-DMB – Terrestrial Digital Multimedia Broadcasting
- **2007 DAB+** … neuer Codec MPEG-4 HE AAC und RS-FEC
- **Ende 2010 Deutschland: Entscheidung der KEF für weiteren DAB-Ausbau in DAB+**
- **ab 2011 DAB+ - Ausbau in Deutschland nur noch im VHF-Band III (Mode I)**

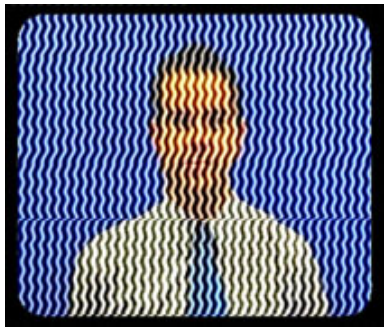
History – Analogue TV

Do you remember?

Ghosting
(Multi path)

Weak signal

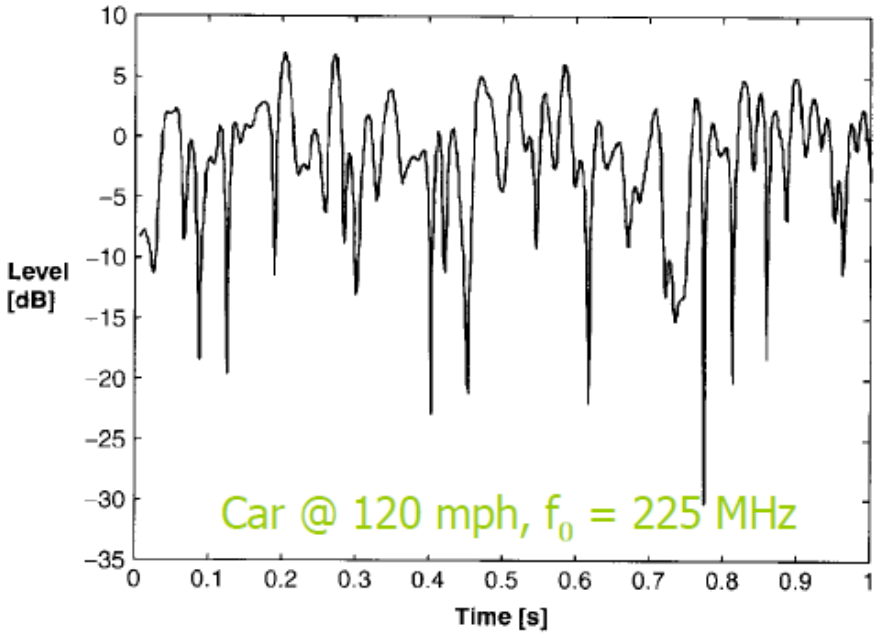
Electrical
Interference

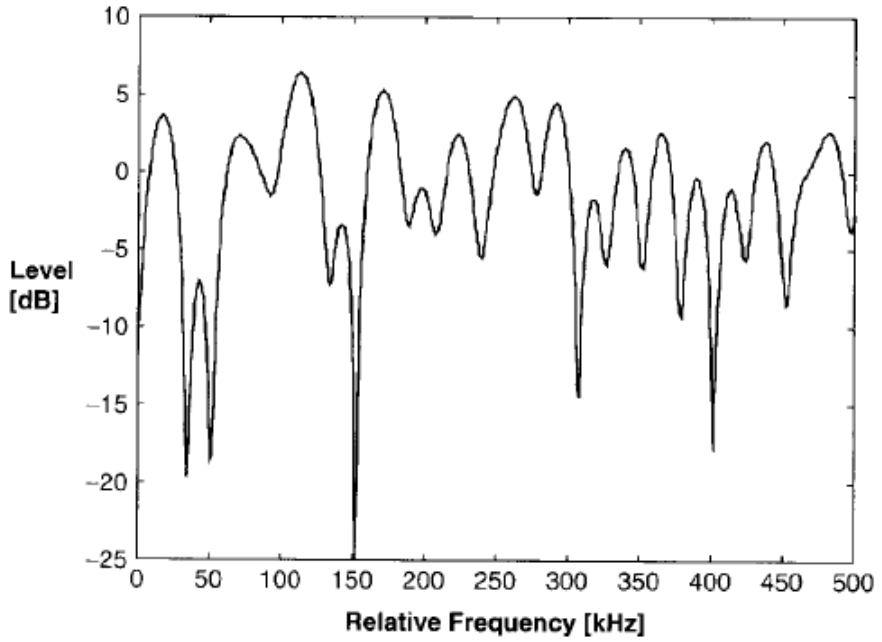


Transmitter
Interference

DAB / DAB+: Challenges in analogue FM

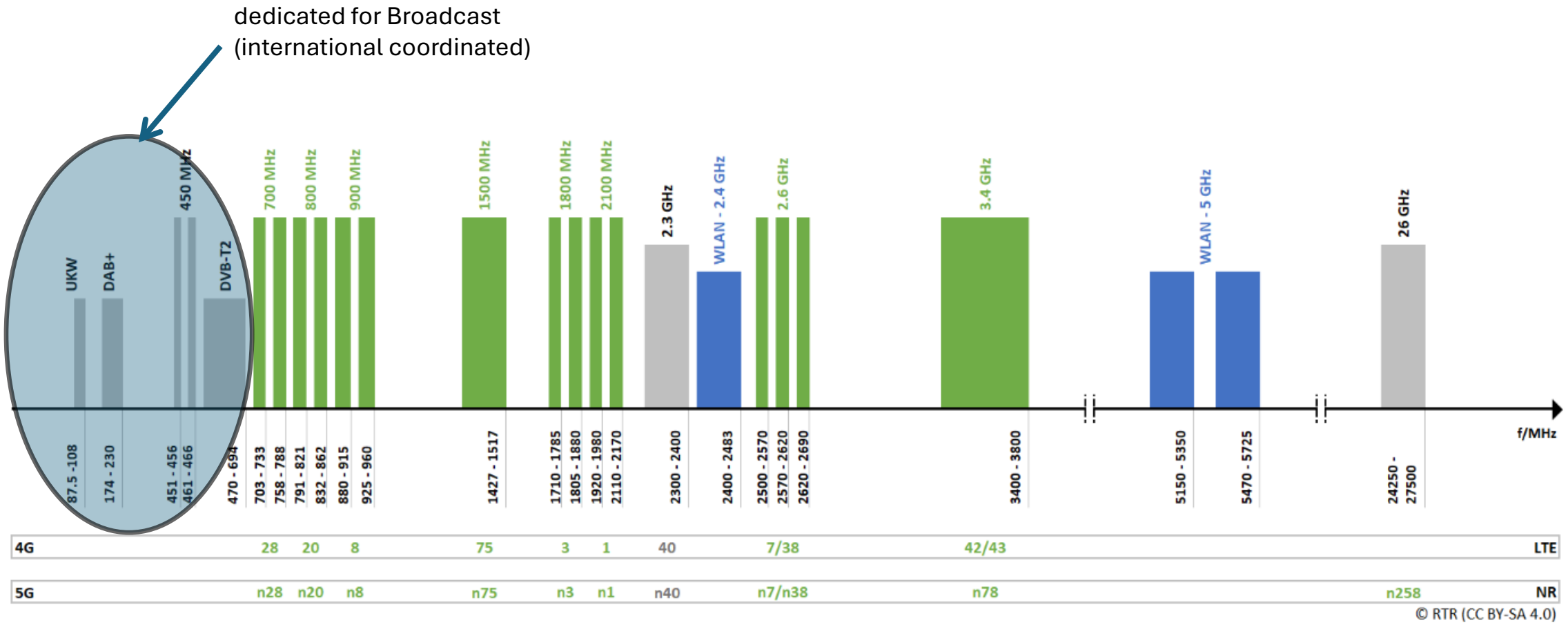
- Multipath fading (reflections from buildings, vehicles)
- Very large variations in signal strength over distances of ~ 1m
- Interference (from equipment, vehicles and other radio stations)





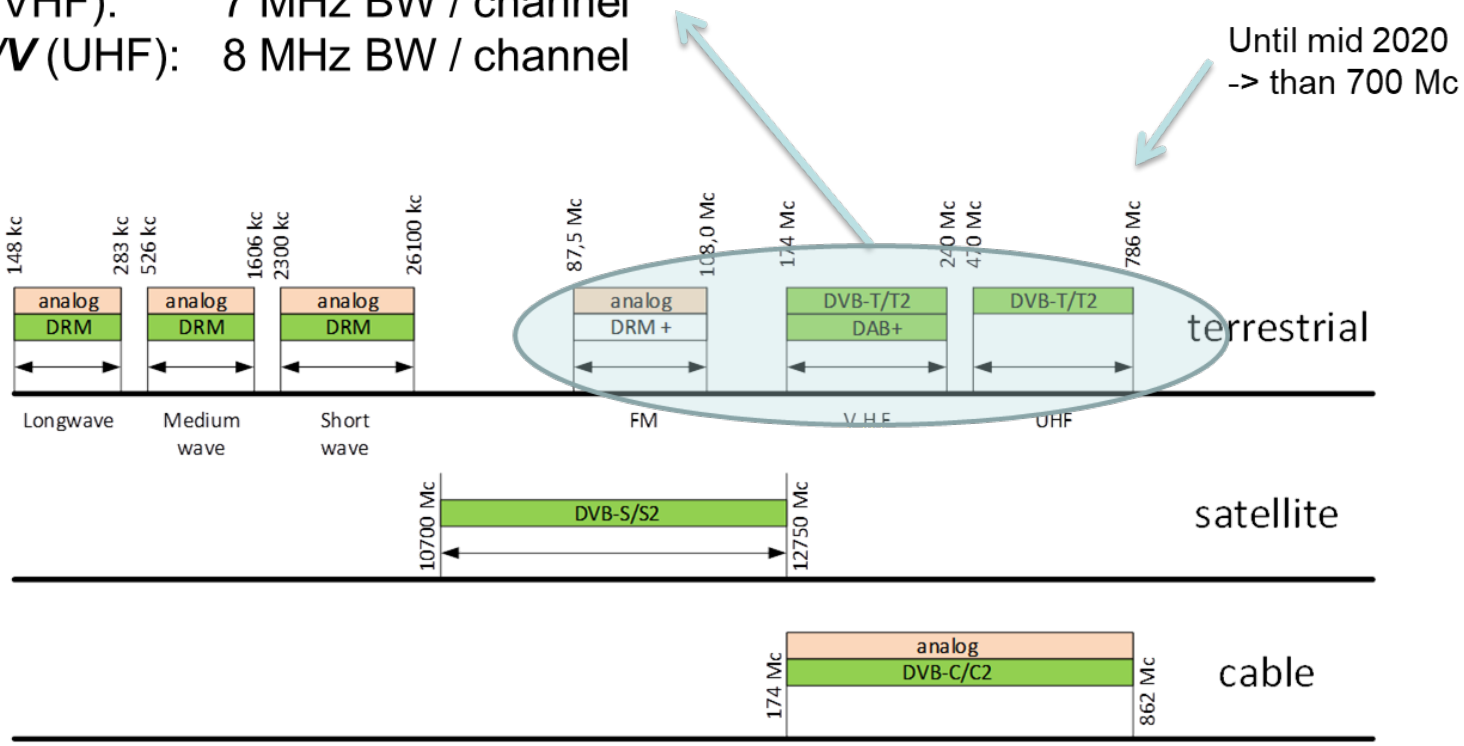
Overview – Frequency Spectrum

Classification

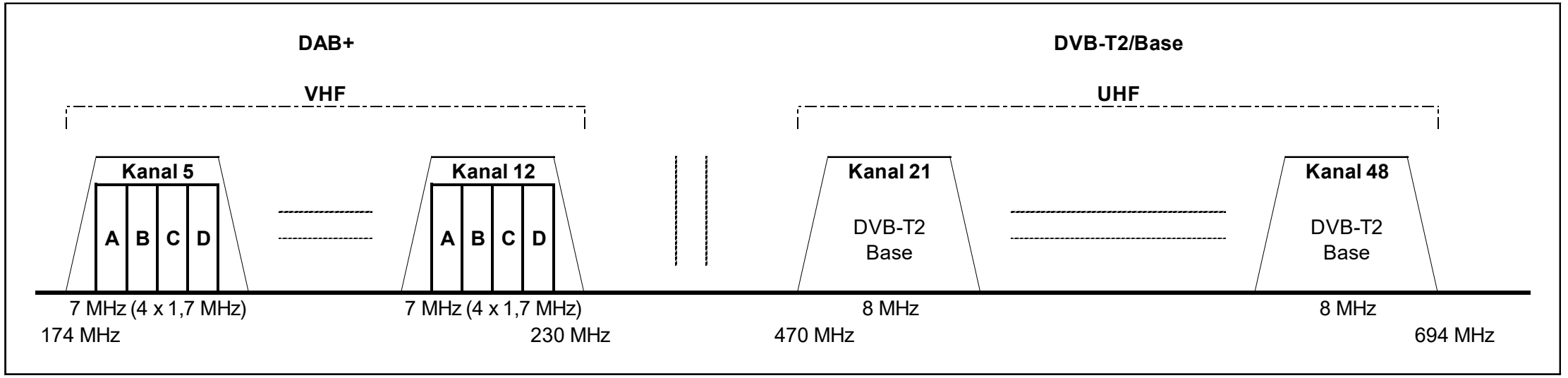


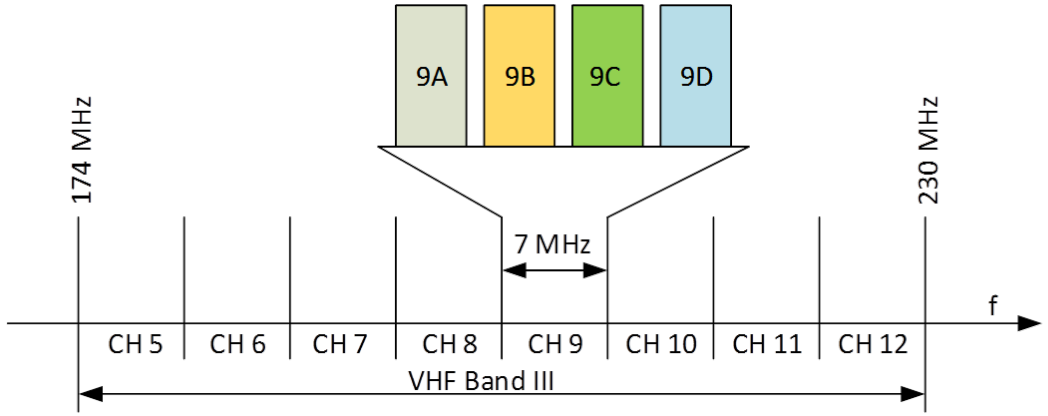
Overview - Digitalization

Bd. II (FM): 150 kHz / channel
Bd.III (VHF): 7 MHz BW / channel
Bd. IV/V (UHF): 8 MHz BW / channel

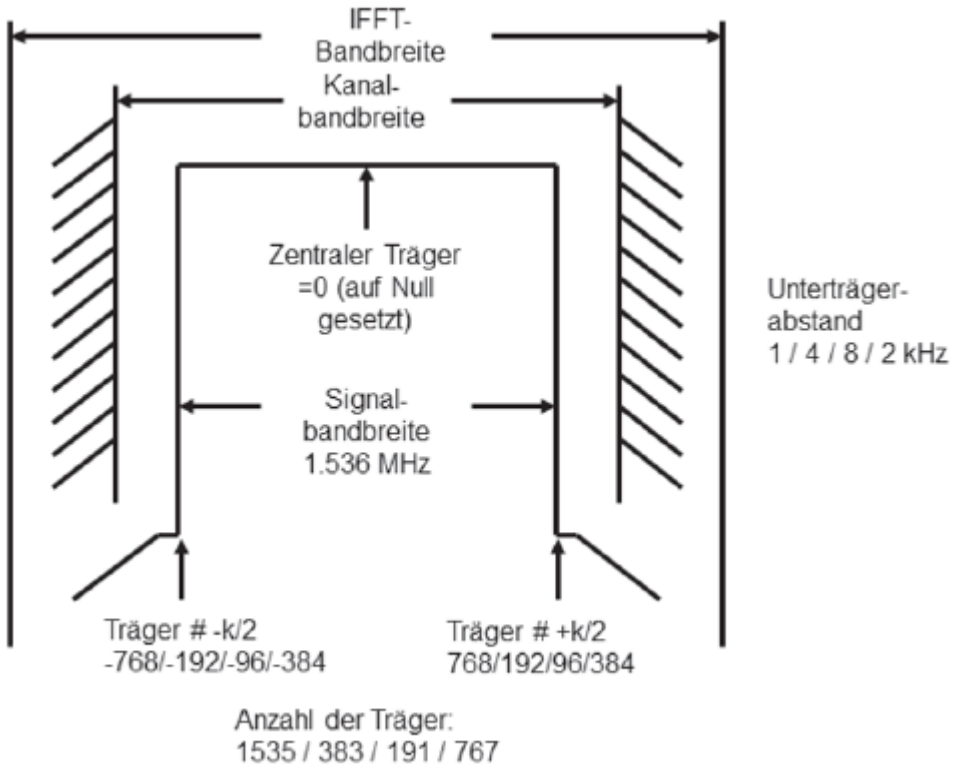


DAB / DAB+: frequency spectrum





DAB / DAB+: channel spectrum

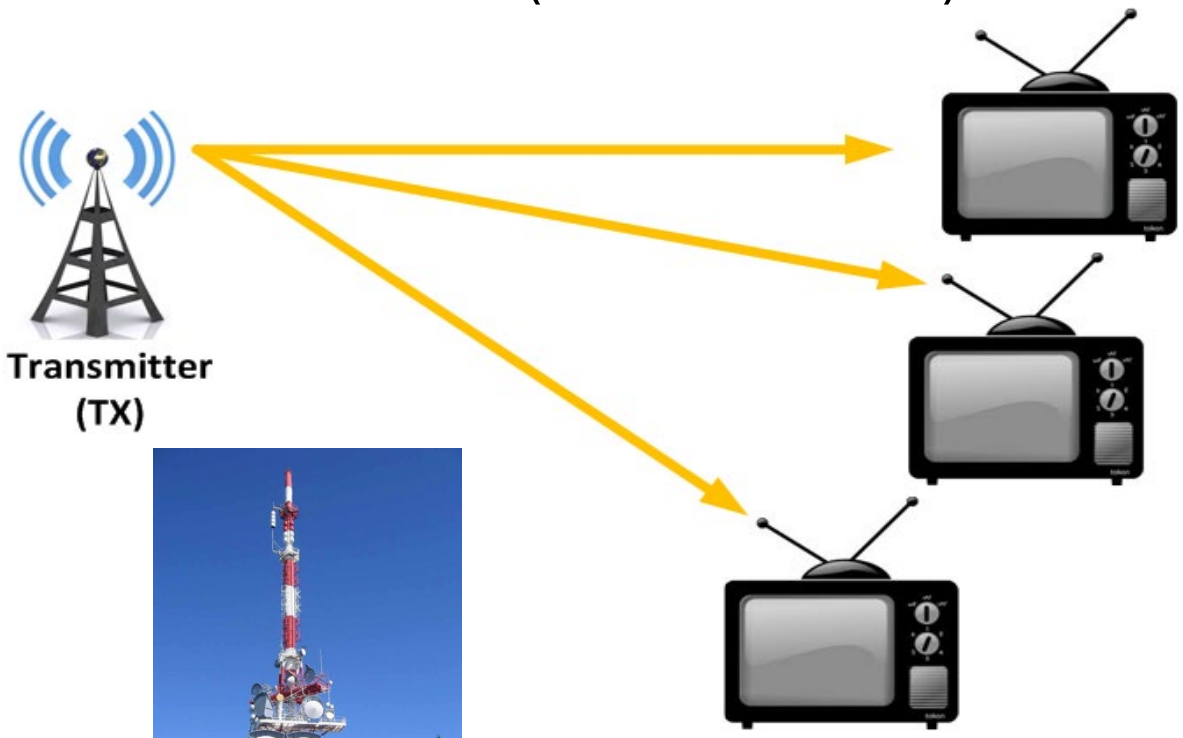


Source: W. Fischer

Differences – Mobile Communication vs. Broadcast

Broadcast – point to multipoint system

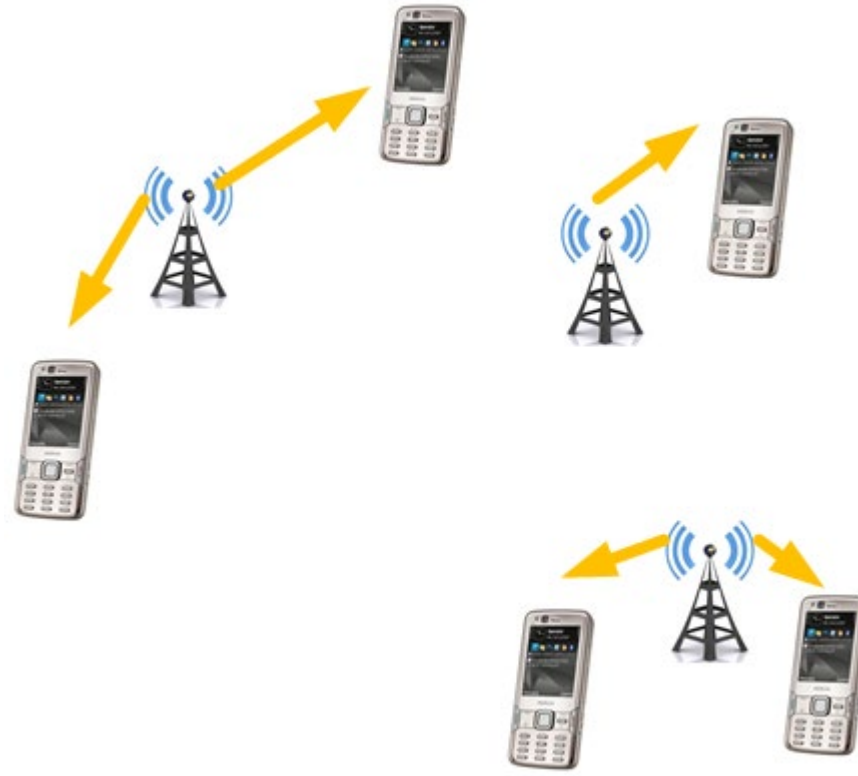
- *Error correction* in advance necessary
- No communication between TX – RX (radius < 64 km)
- HTHP



Differences – Mobile Communication vs. Broadcast

Mobile Communication (Unicast) – point to point

- Communication between TX/RX – RX/TX
- Cellular network (raduis < 5 km)
- LTLP

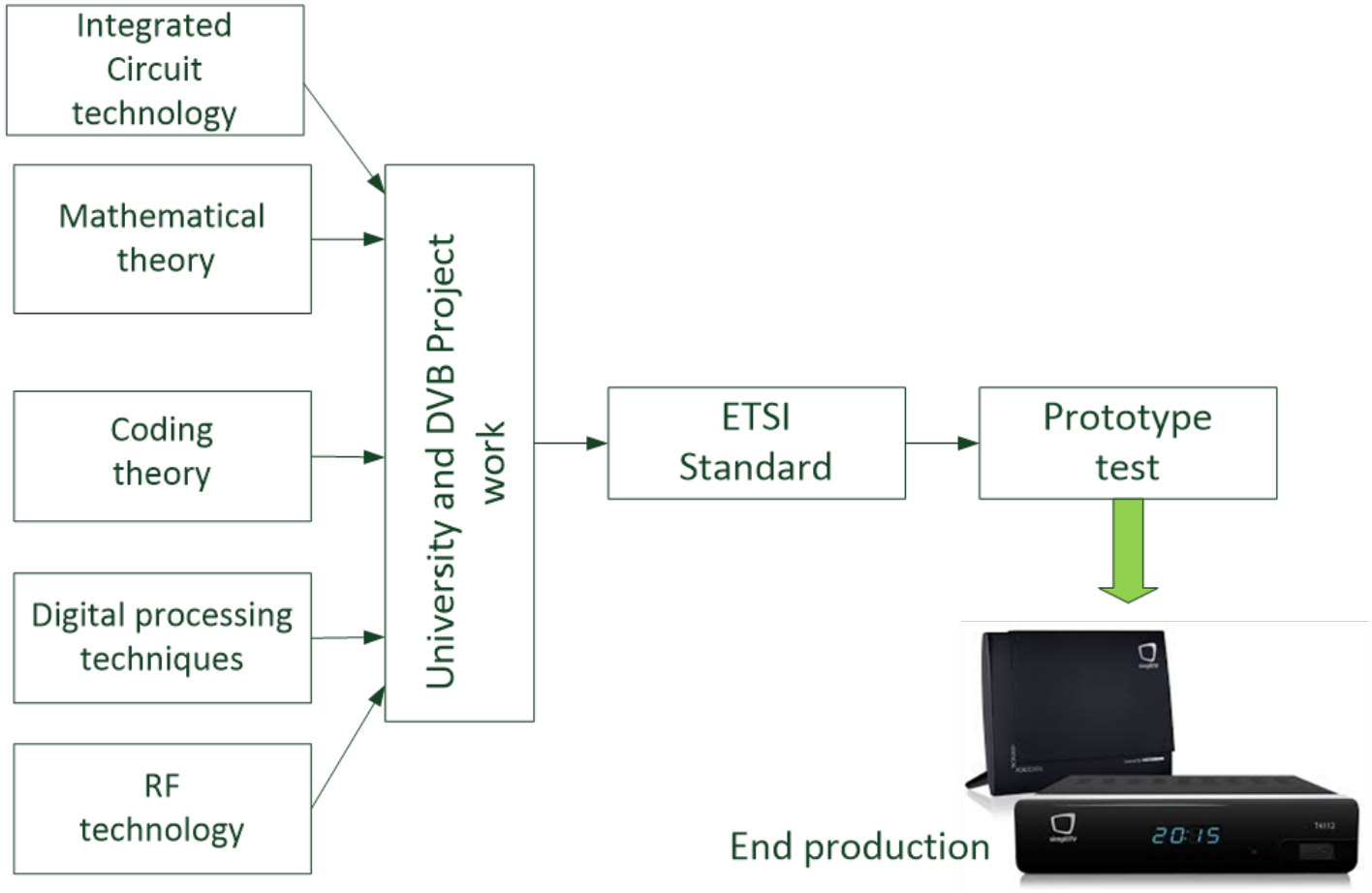


DAB / DAB+: Benefits of DAB/DAB+ compared to FM

- *Improved features for end consumer*
  - similar to RDS (FM) – Dynamic Label Segment - Journals
- *Efficient use of VHF channels*
  - more programs available instead of FM
  - 7 MHz channel / subdivided in e.g. 5A, 5B, 5C, 5D
- *Reception quality*
  - robustness concerning multipath fading / noise
- *Variable bandwidth*
  - dependent on content type – speech, talk, music
  - forward error correction
- *Transmission power*
  - compared to FM equipment approx. 25%

DAB Project

Workflow



DAB / DAB+: History

Digital radio is one of the 'oldest' form of new digital media

Research **Project Eureka-147** (1987-1991) Digital Audio Broadcasting (DAB)

DL: AEG, Bosch-Blaupunkt, Fraunhofer, Grundig, Intermetall, IRT, Thomson

Frankreich: CCETT

Holland: Philips

GB: BBC

- The ***MPEG-1 Audio Layer II ("MP2") codec*** was created as part of the EU147 project
- DAB was the first standard based on ***orthogonal frequency division multiplexing (OFDM) modulation*** technique, which has become one of the most popular transmission schemes for modern wideband digital communication systems (e.g. LTE, DVB-T/T2, …)
- First DAB digital radio broadcasts were launched in September 1995 (BBC, NRK).

DAB / DAB+: History

The ***Eureka 147*** system includes ***three main elements***

- **Source Coding:** MUSICAM Audio Coding = **MP2** (by Philips, IRT, CCETT)

  Masking Pattern **U**niversal **S**ub-band **I**ntegrated **C**oding **A**nd **M**ultiplexing

  Since 2011 DAB+ with a new audio compression format: **HE AAC+ V2**
- Transmission coding & multiplexing

  Channel Coding: Convolution, Puncturing, Freq. & Time interleaving
- **COFDM** Modulation

DAB: Source Coding

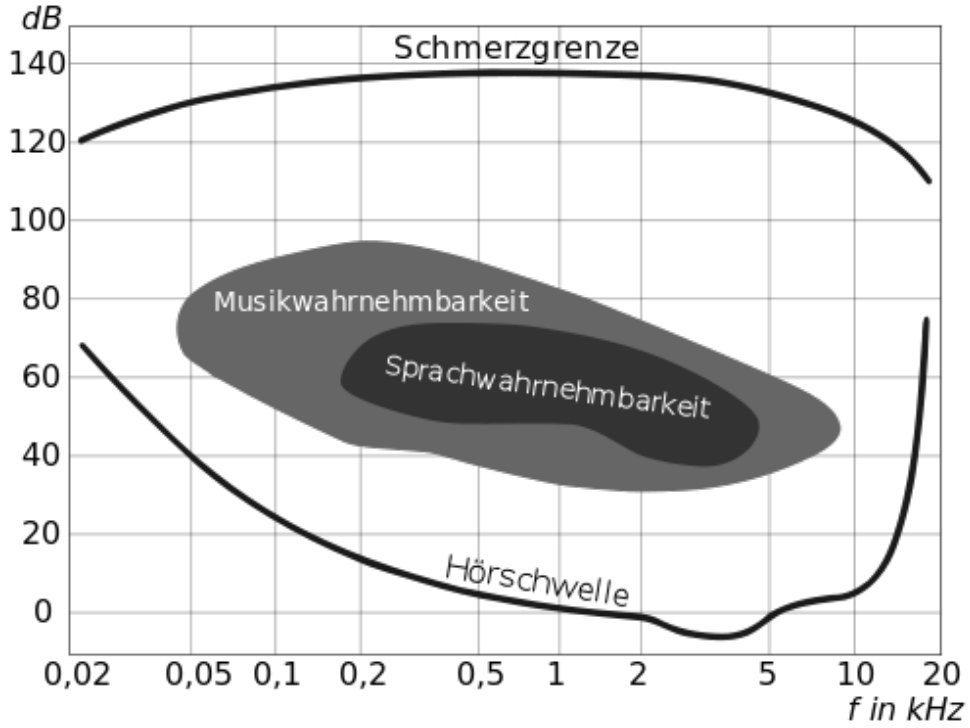
Concept to skip irrelevant Information

MPEG-2 Audio compression (Encoding):

- Audio compression by using ***Psycho Acoustic Model of Human Ear***
- ***Perceptual Coding = Irrelevancy Reduction + Redundancy Reduction***

It is found that the ear has a certain threshold of hearing.

Below this the signals are inaudible.



Source: Wikipedia

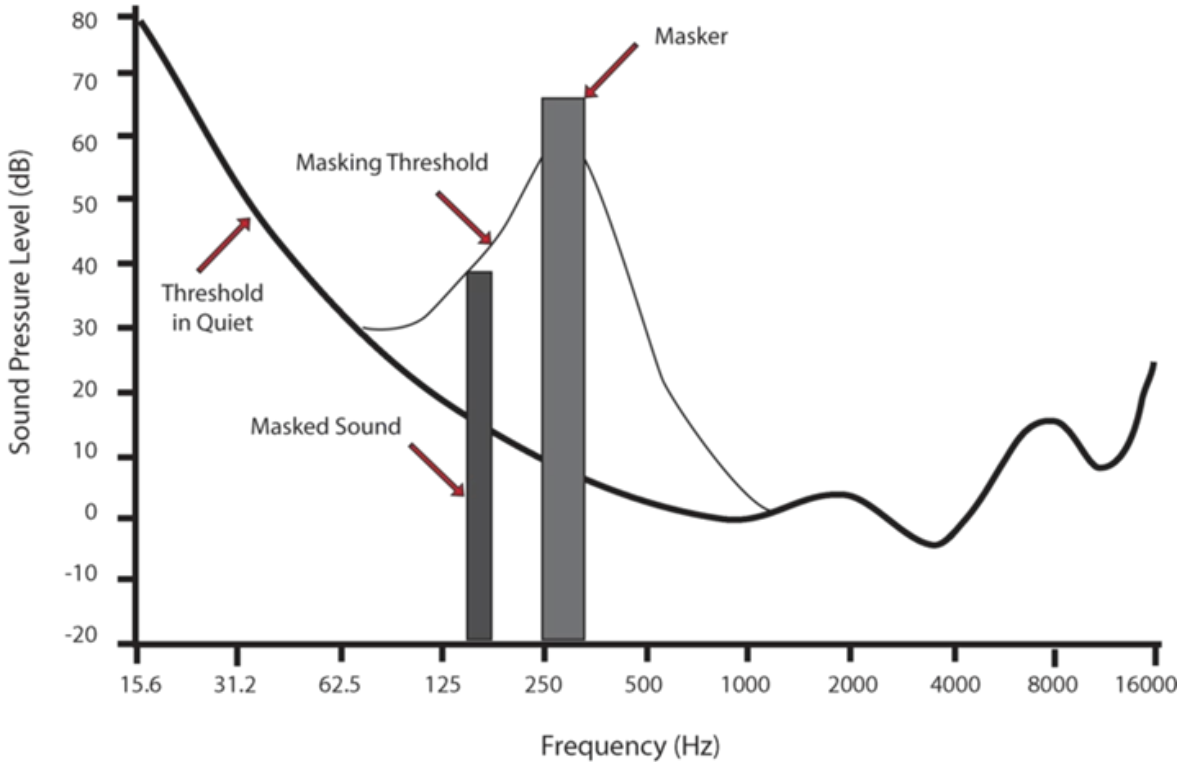
DAB: Source Coding

Concept to skip irrelevant Information

MPEG-2 Audio Compression (Encoding):

Frequency Masking:

If a strong sound is present on one frequency (Masker) then weaker sounds close to it may not be heard because the threshold of hearing is modified



Source: Wikipedia

Digital Transmission

Developing of a Digital Broadcasting System

Synthesis of Band-Limited Orthogonal Signals for Multichannel Data Transmission

By ROBERT W. CHANG

(Manuscript received August 4, 1966)

But 1966 no processor power was available to realize this system

COFDM ***C***oded ***O***rthogonal ***F***requency ***D***ivision ***M***ultiplex

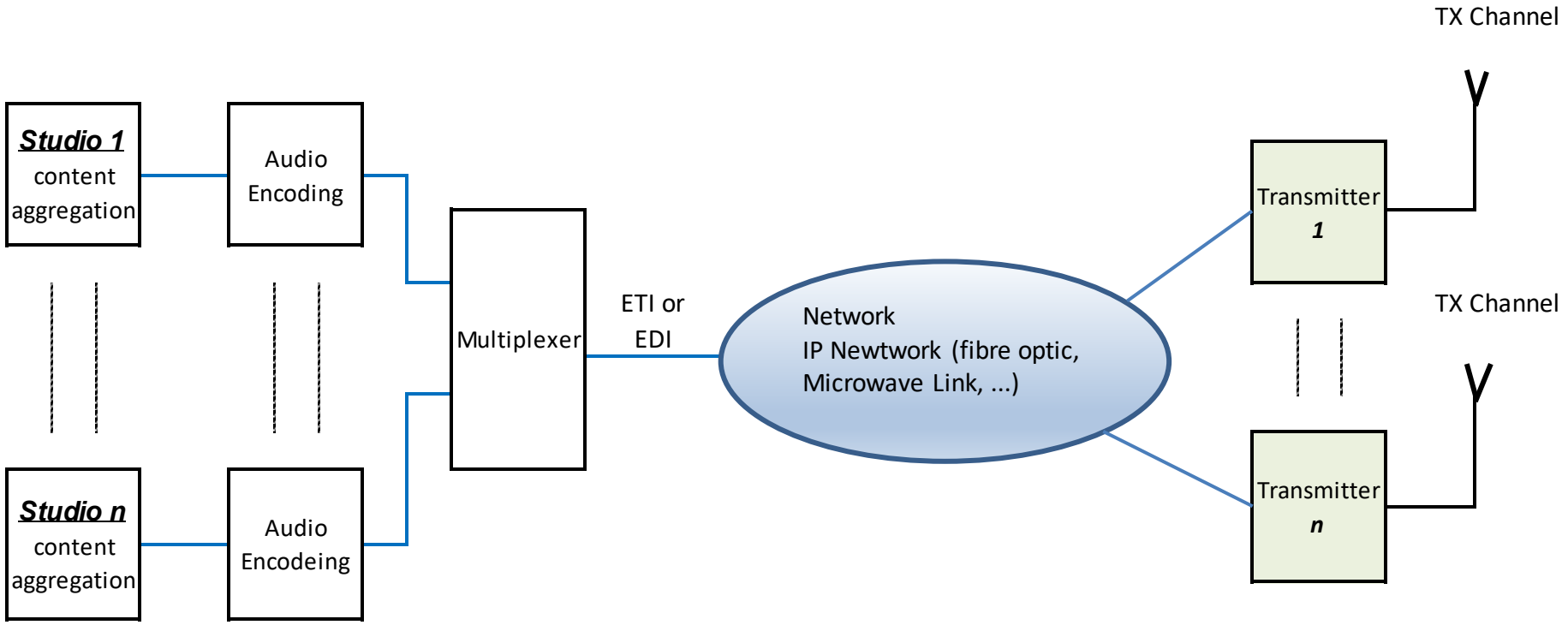
-> multicarrier transmission

C = Forward Error correction

O = Orthogonal (no cross talk between carriers)

FDM = information distributed over many subcarriers

DAB+

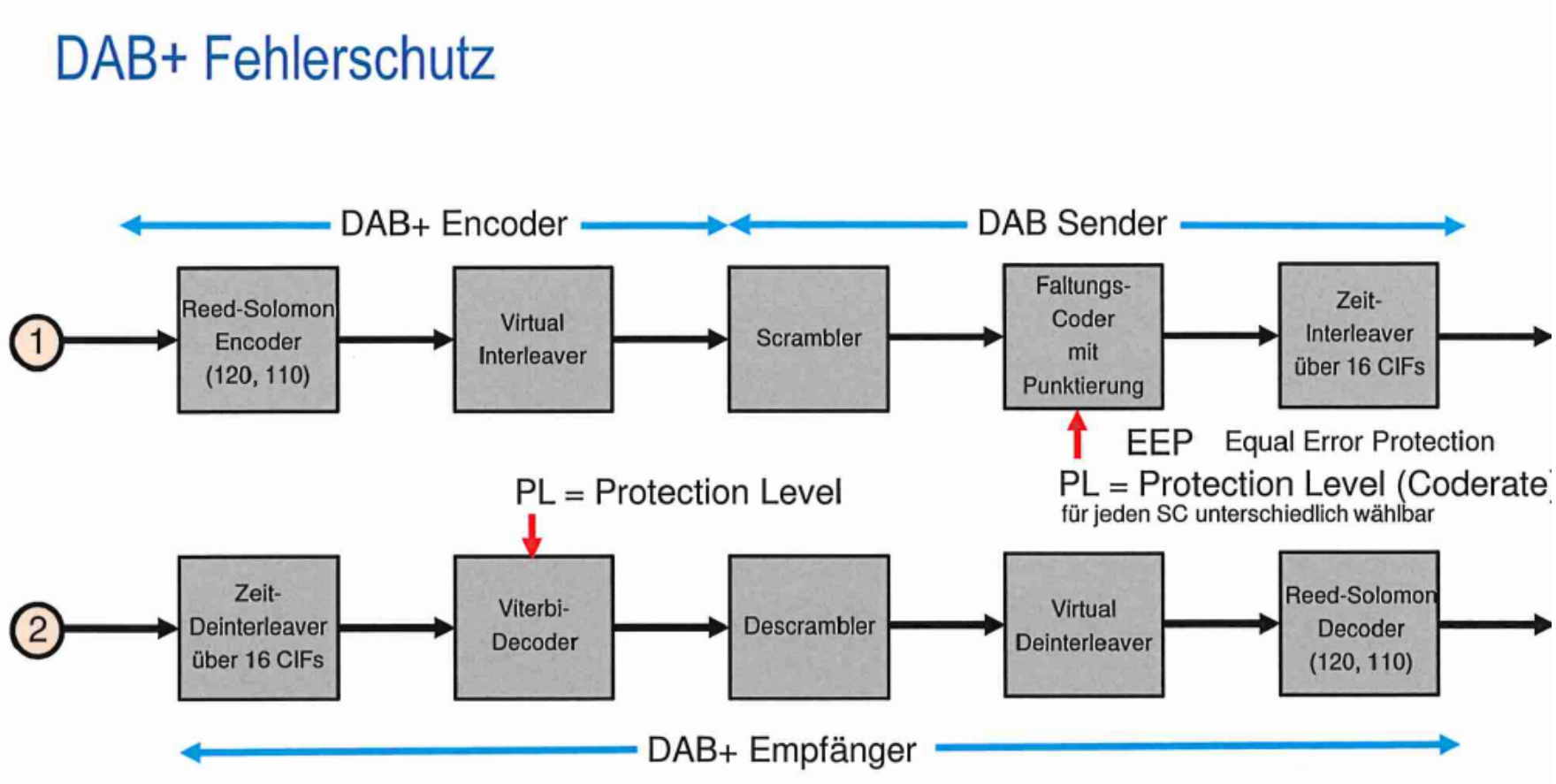

TX Channel
Studio 1
content
aggregation
Audio
Encoding
Multiplexer
ETI or
EDI
Network
IP Newtwork (fibre optic,
Microwave Link, ...)
Transmitter
1
TX Channel
Studio n
content
aggregation
Audio
Encodeing
Transmitter
n

Digital Transmission

Signal processing – ***Channel Encoding***

- Encode source information, **by adding additional information**, sometimes referred to as ***redundancy***, that can be used to detect, and perhaps correct errors in transmission.
- The ***more redundancy*** we add, the ***more reliably*** we can ***detect and correct errors***, but the less efficient we become at transmitting the source data

Error Correction



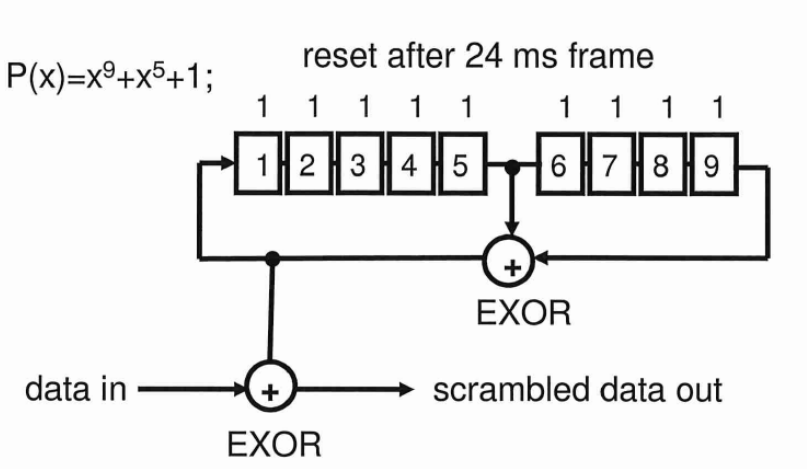
Digital Transmission

Signal processing – ***Channel Encoding***

Scrambler (energy dispersal) - Energieverwischung

- Use an algorithm that converts an input string into a seemingly random output string of the same length, thus avoiding long sequences of bits of the same value; in this context, a randomizer is also referred to as a **scrambler.**

- *DAB will execute a modulo 2 addition (XOR function) with the output of a pseudo-random generator.*
- A pseudo-random bit sequence is a bit sequence
- that appears statistically random, however,
- based on a known algorithm (the key).



Digital Transmission

Signal processing – ***Channel Encoding***

Convolutional Coder - Faltungscoder

Convolutionally encoding the data is accomplished using a shift register and associated combinatorial logic that performs modulo-two addition.

- The Convolutional code is used over a noisy channel
- The encoder is very simple to implement
- But the decoding is quite complex
- The basic code rate is ½ (called “Mother Code”)
- Puncturing – different FEC settings possible
- The Viterbi algorithm is currently used for decoding

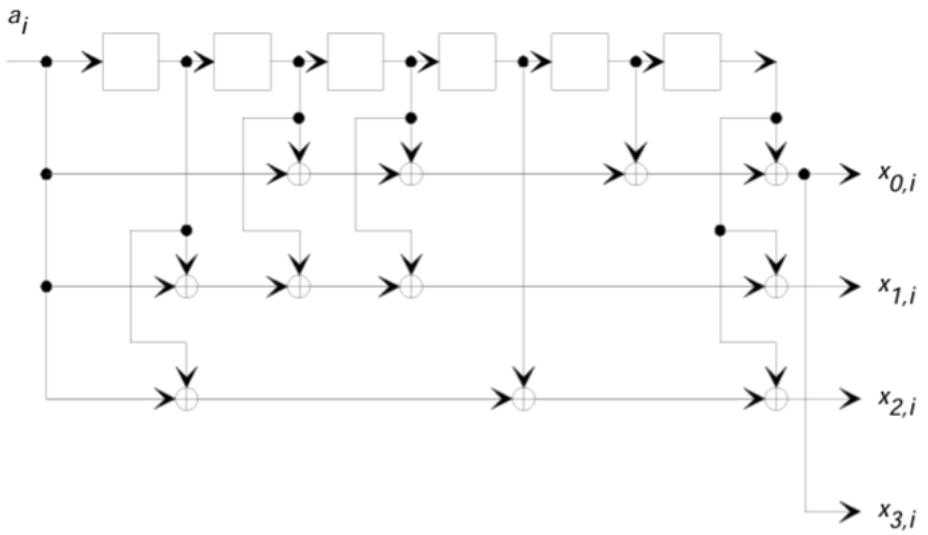
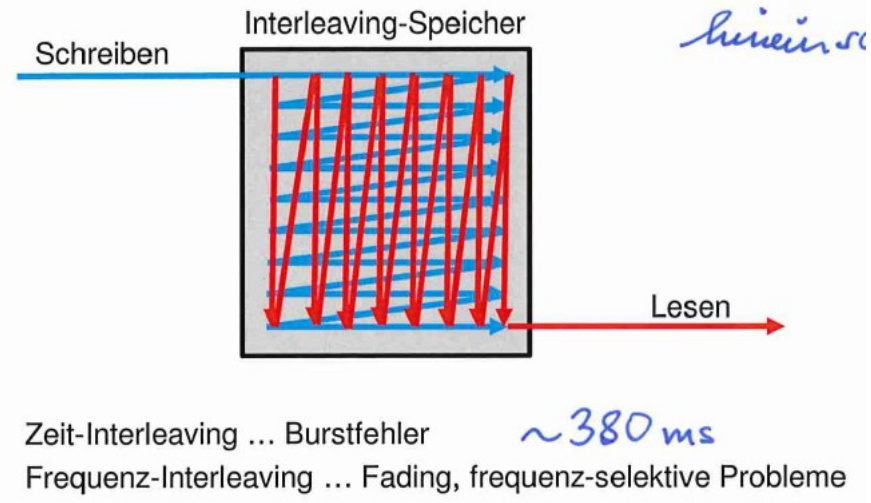


Figure 86: Convolutional encoder

Time Interleaving

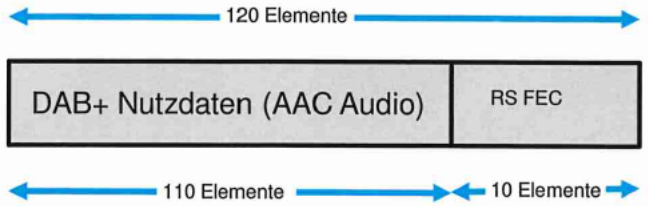
- Time interleaving shall be applied to the output of each convolutional encoder for all sub-channels of the Main Service Channel (MSC). It shall not be applied to the FIC.



DAB+ Error Correction in AAC-Encoder

Fehlerschutz bei DAB+

$Coderate_{Reed\text{-}Solomon\ DAB+} = 110/120$



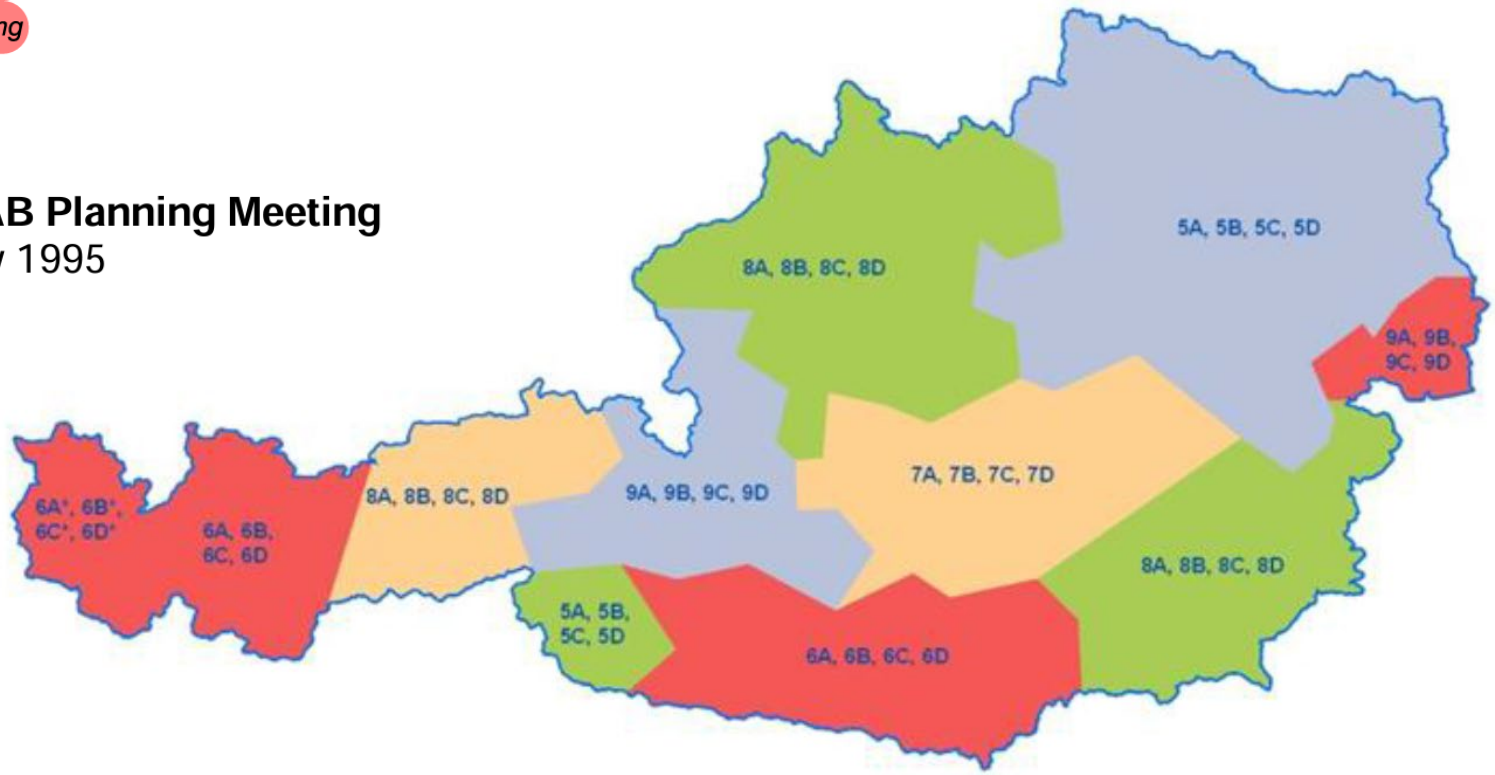
Zusätzlich: virtual Interleaver

Der DAB+ Fehlerschutz passiert vor dem DAB-Sender im DAB+ MPEG-4 AAC-Audio-Encoder.

DAB / DAB+: frequency planning

Digital Audio Broadcasting

The CEPT T-DAB Planning Meeting
Wiesbaden, July 1995



DAB / DAB+: Differences

- An upgraded version of the DAB system was released in February 2007, which is called **DAB+**.
- DAB is not forward compatible with DAB+, which means that DAB-only receivers will not be able to receive DAB+ broadcasts.
- ***DAB+*** is approximately ***twice as efficient as DAB*** due to the adoption of the ***AAC+*** audio codec, and DAB+ can provide high quality audio with as low as 64 kbit/s.
- ***Reception quality*** will also be more robust on DAB+ than on DAB due to the ***addition*** of ***Reed-Solomon*** error correction coding.

DAB / DAB+: Differences

DAB

- Development in the 1980s
- ETSI standard EN 300 401 (mobile, portable and fixed receivers)
- Source coding MPEG 1 layer 2

DAB+

- WorldDAB announced DAB+ in 2006 and released the standard in February 2007
- ETSI standard TS 102 563 (AAC)
- Adoption of Source coding:
  - HE-AAC v2
  - MPEG Surround audio format
  - stronger error correction coding (Reed Solomon)
- Consumer devices marked to be able to receive DAB+

DAB / DAB+: Differences

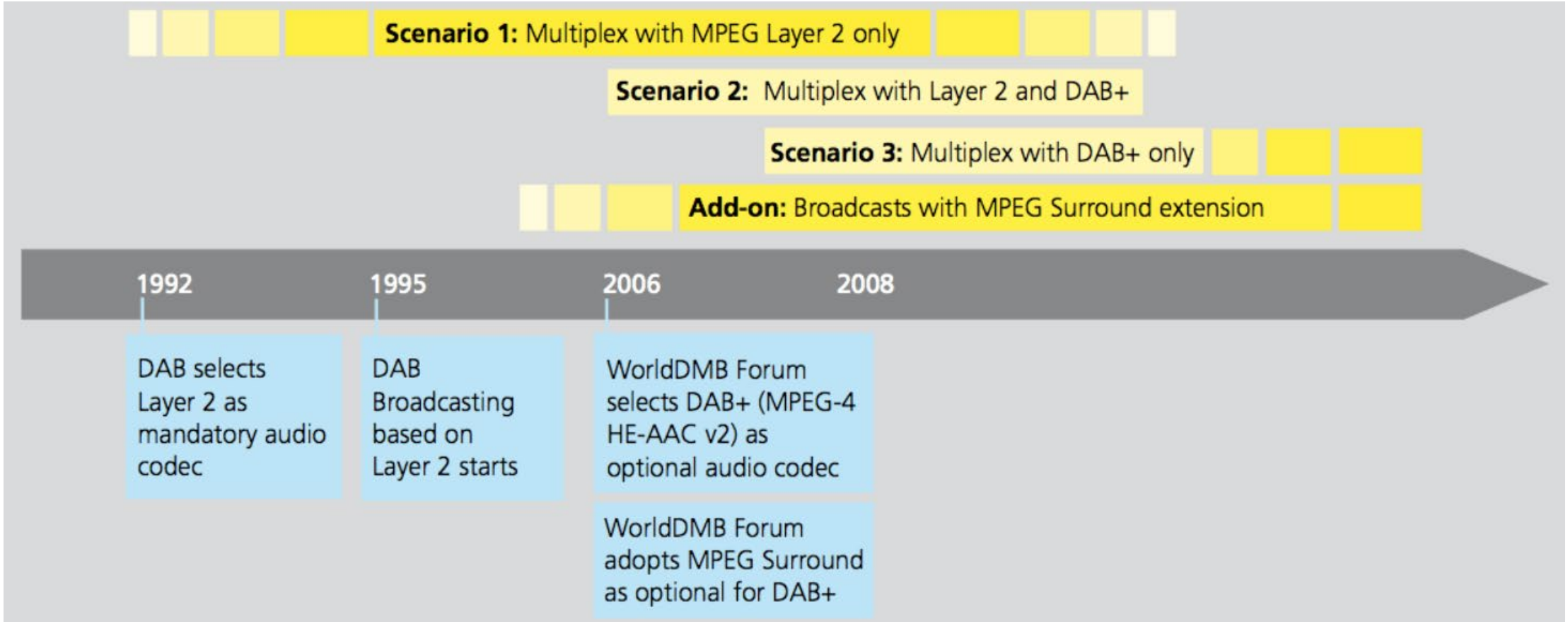
Pro

- Existing network and Transmitters (DAB) can be used
- Difference to DAB only source coding
- More efficient Audio coding based on HE-AAC v2 instead of MPEG
- More consumer devices available

Cons

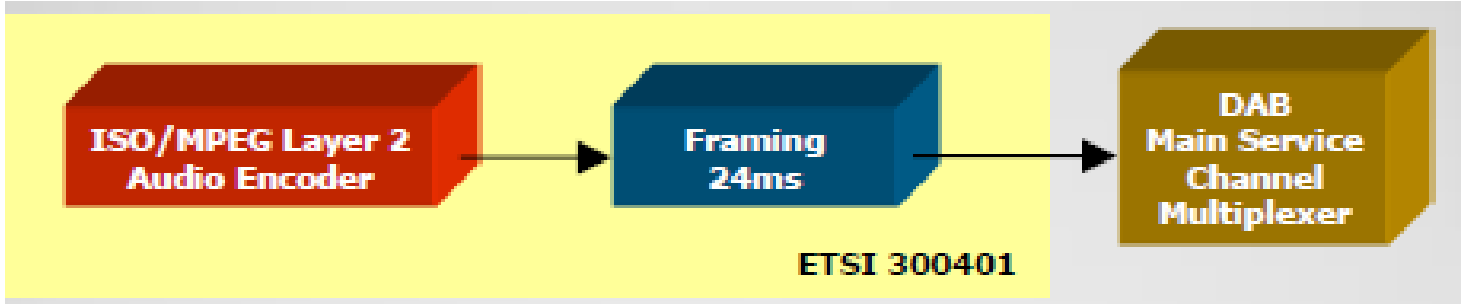
- DAB: not forward compatible
- Forward error correction not up to date:
  - DVB-T2 uses more efficient *BCH* and *LDPC* (inner – outer) coding

DAB / DAB+: Differences

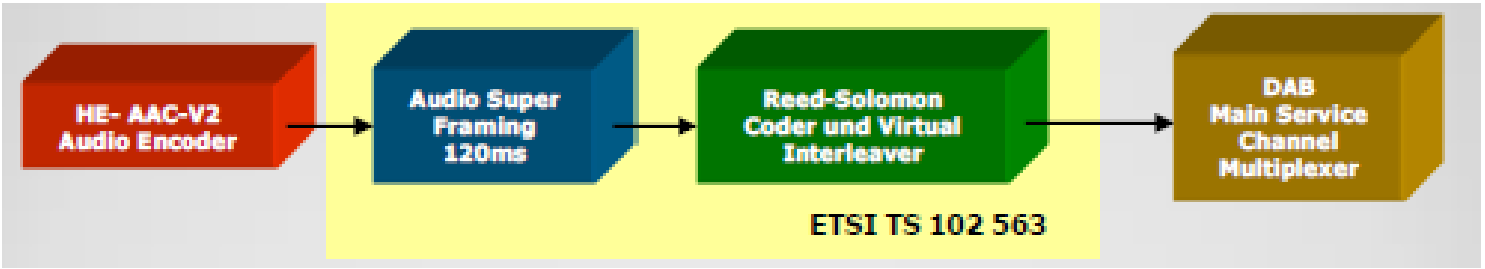


DAB - DAB+: Differences

➢ ***DAB:*** Services in 24 ms Frames to Multiplexer



➢ ***DAB+:*** 120 ms (~ 5 x 24 ms) for compatibility



DAB / DAB+: contribution out from the Multiplexer

- 2 different options available

- 1st: ***ETI*** (***E***nsemble ***T***ransport ***I***nterface)
  - Frame structure
  - 2 MBit/s synchronous stream
    - comes from E1-Interface 30+2 ISDN channels (each 64 kBits/s -> 8 kHz * 8000 samples)
  - Physical interface: G.704 (Multiplexer – OFDM Modulator)
  - ETI-Network Independent (MFN), ETI-Network Adapted (SFN)

- 2nd: ***EDI*** (***E***ncapsulation of **D**AB ***I***nterface)
  - Packet oriented transport

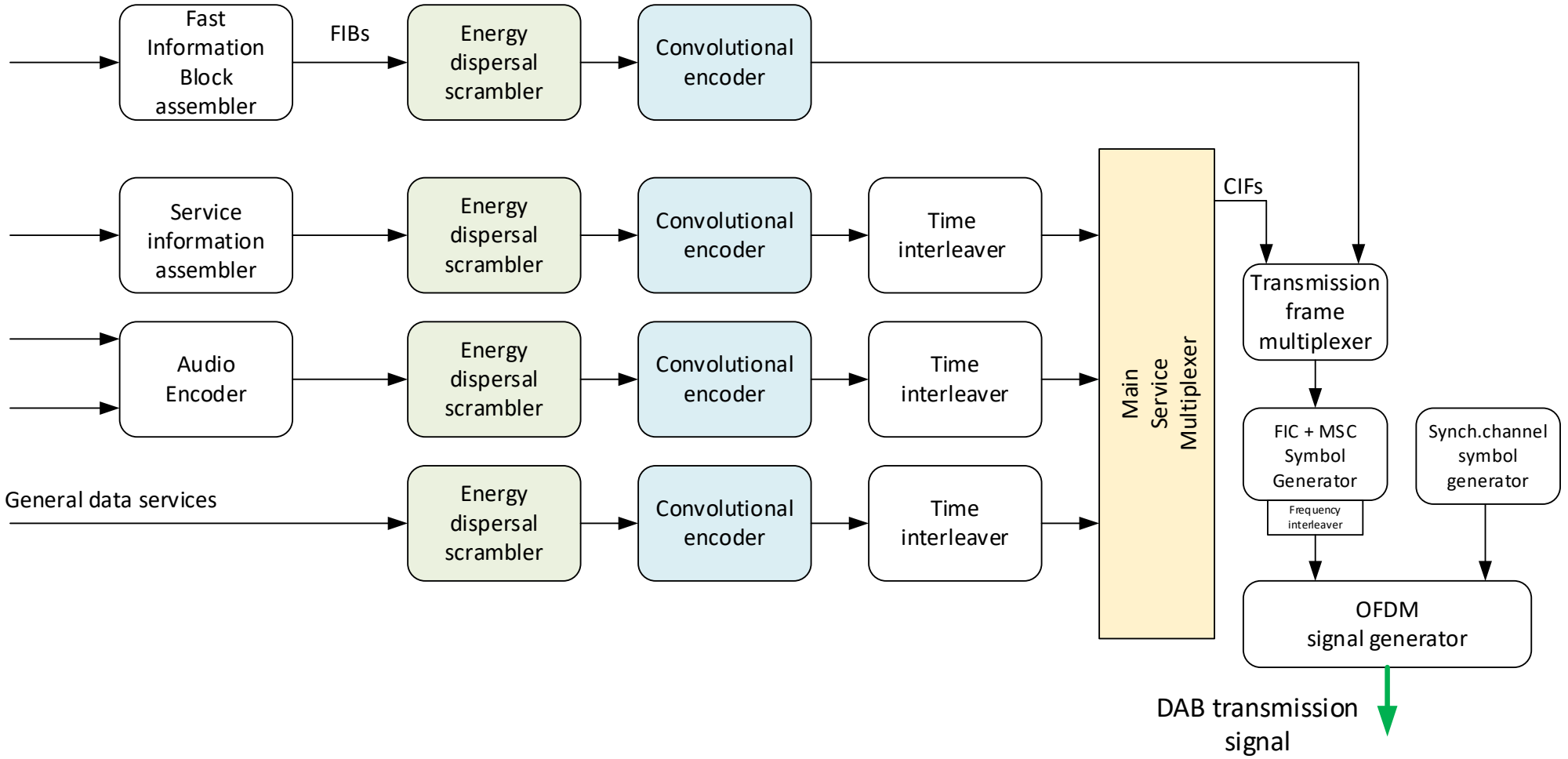
DAB / DAB+: Transmission Frame structure

The DAB transmission system combines three channels

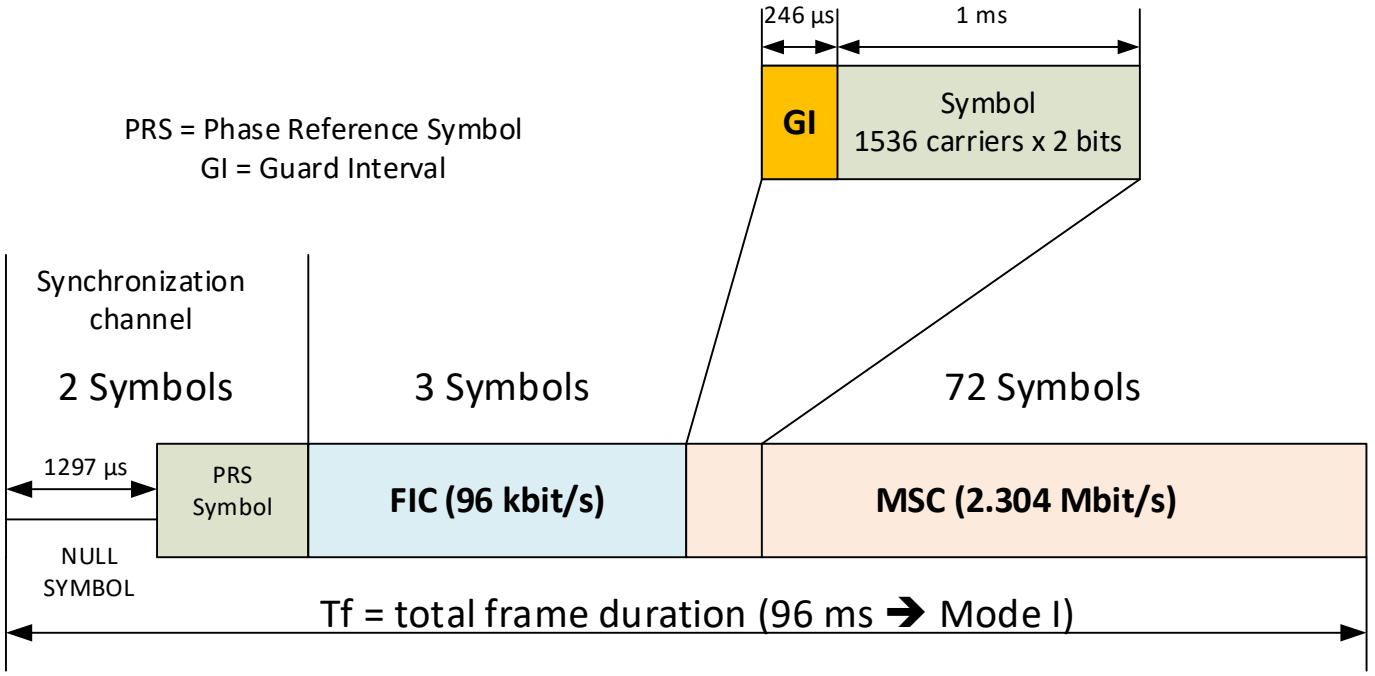
- **Synchronization channel**
- **FIC** (***F****ast* ***I****nformation* ***C****hannel*)
- **MSC** (***M****ain* ***S****ervice* ***C****hannel*)

Each channel supplies data from different sources and these data are provided to form a transmission frame

DAB / DAB+: Multiplexer



DAB: Transmission Frame



DAB: Transmission Frame structure

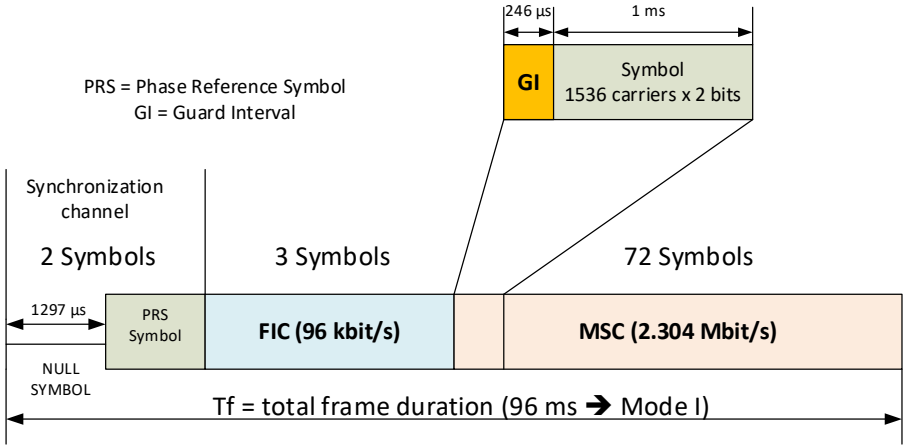
Synchronization channel

– used internally within the transmission system for basic demodulator functions like

- **AFC** (***A****utomatic* ***F****requency* ***C****ontrol*),
- **AGC** (***A****utomatic* ***G****ain* ***C****ontrol*) and
- **PRS** (***P****hase* ***R****eference* ***S****ymbol*)

– Nullsymbol: every 2nd cyclic TII

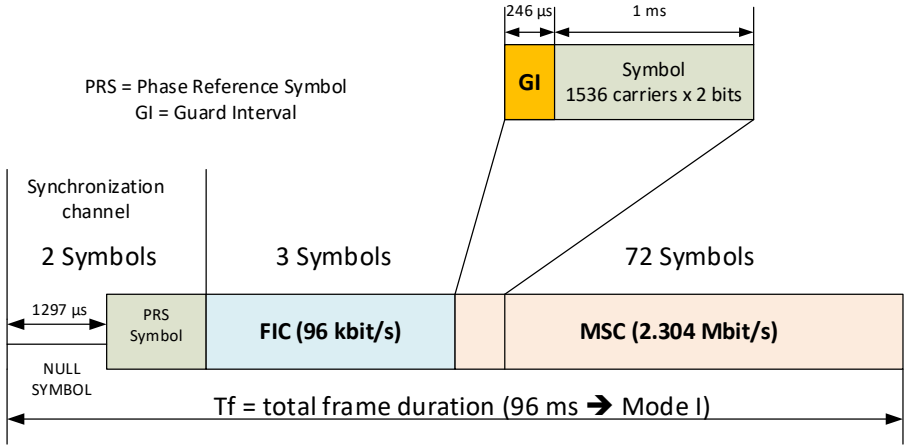
TII: Transmitter ID



DAB: Transmission Frame structure

FIC (***F****ast* ***I****nformation* ***C****hannel*)

The FIC is limited in its capacity, but is capable of supplying information to a receiver faster than the main service channel allows. This is possible because the FIC is **not** subjected to the **time interleaving** part. Convolutional coding protection level is permanently fixed (CR = 1/3).
In order to achieve an acceptable error performance, FIC information is repeated regularly.

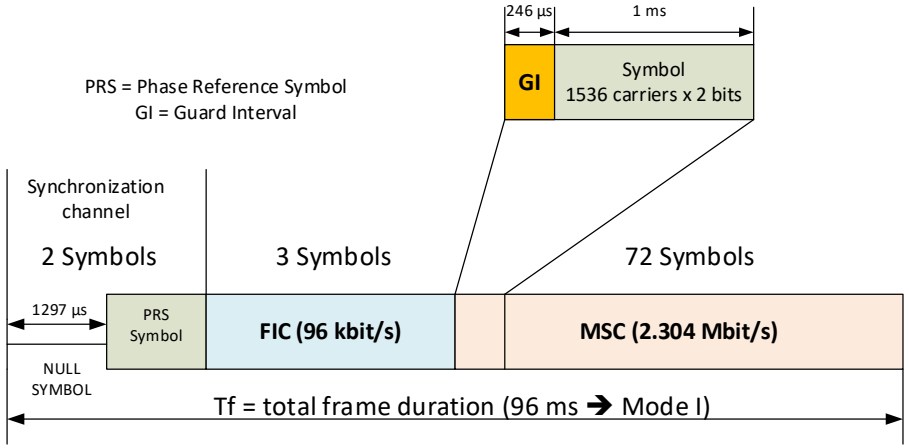


DAB: Transmission Frame structure

FIC (***F****ast* ***I****nformation* ***C****hannel*)

- ***MCI*** – Multiplex Configuration Information
- ***SI*** – Service Information
- ***EI*** - Ensemble Information
- ***FIDC*** – FI Data Channel (e.g TMC)

- Fixed FEC
- Not time interleaved



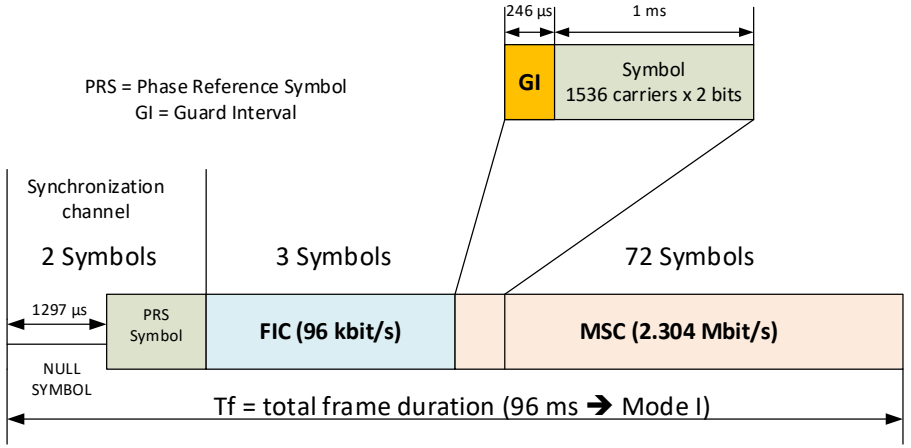
DAB: Transmission Frame structure

➢**MSC** (***M****ain* ***S****ervice* ***C****hannel*) – use to carry audio, PAD and data service components.

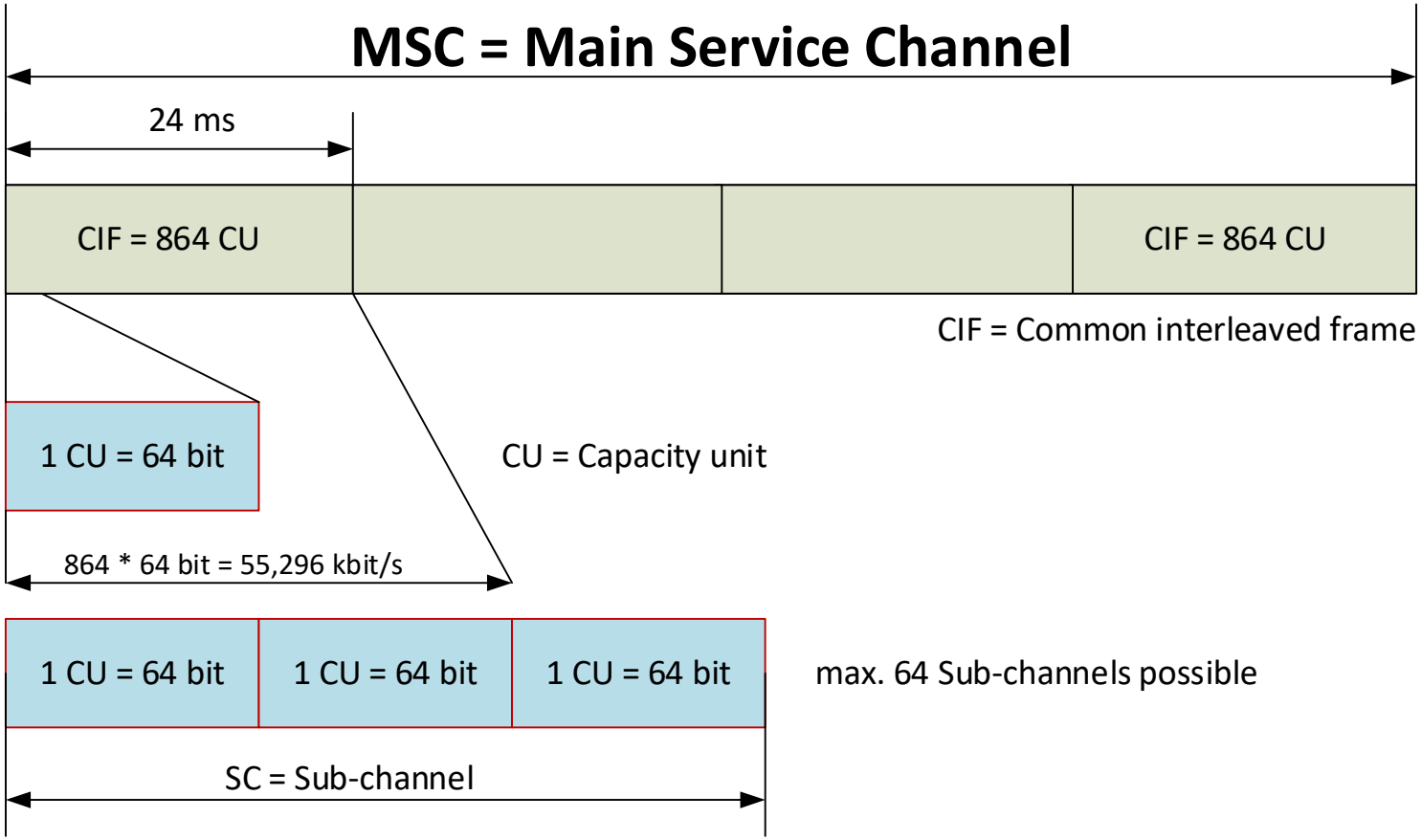
The MSC is a time-interleaved data channel divided into a number of **sub-channels** which are individually convolutional coded, with equal or unequal error protection

PAD (Programme Associated Data):

text, label, name of the song, the artist and the genre of music, slide show



DAB: MSC


MSC = Main Service Channel
24 ms
CIF = 864 CU
CIF = 864 CU
CIF = Common interleaved frame
1 CU = 64 bit
CU = Capacity unit
864 * 64 bit = 55,296 kbit/s
1 CU = 64 bit
1 CU = 64 bit
1 CU = 64 bit
max. 64 Sub-channels possible
SC = Sub-channel

DAB: MSC

- The MSC is made up of Common Interleaved Frames (CIFs). The **CIF** contains of 55296 bits.
- The smallest addressable unit of the CIF is the Capacity Unit (**CU**), comprising 64 bits. Therefore, the CIF contains **864 CU**s (55296/64)
- The MSC is divided into sub-channels. Each sub-channel shall occupy an integral number of consecutive CUs and is individually convolutional encoded.
- Each sub-channel consist of audio service components and data elements.

Gross bit rate:

864 CU * 64 bit = 55296 bit in 24ms ➔ **2.304 Mbit/sec**.

There are two transport modes in the MSC:

- the **stream mode** (multiples of 8 kbit/s). Deliver data transparently from source to destination (audio)
- **packet mode** for data service components

DAB+: Multiplex calculations

- ***DAB+*** offers an equal error protection = **EEP** (*equal error protection*)
- One frame has 864 CUs
- Each service is transported in a SC (service channel) with a capacity of n * CUs
- It is possible that each subchannel has a different error protection

The sum of all SC must be < 864 CUs

DAB+: Multiplex calculations

FEC Code	Code Rate	Capacity (kbps)	Number of 64kbps channels	Approximate power required relative to 3A
1A	1/4	576	9	-3 to -6dB
2A	3/8	864	13	-2 to -3dB
3A	1/2	1152	18	0
3B	2/3	1536	24	+3dB
4A	3/4	1728	27	+6dB

DAB+ MUX I,II;III in Austria use FEC EEP-3A !

DAB / DAB+: Multiplex calculations

Bitrate example:

- 54 CU (EEP-3A) >> Subchannel bitrate = 72 kbit/sec.
- Additional Reed Solomon RS (120,110)
- Net Bitrate: 72 * (110/120) = 66 kbit/sec.
- For DL+ (text, titel ...) approx. 600 bit/sek.
- For MOT (Cover ...) approx. 5400 bit/sek.

Net bitrate for audio: 59 kbit/sek. AAC

DAB+: Multiplex configuration example

Subchannels

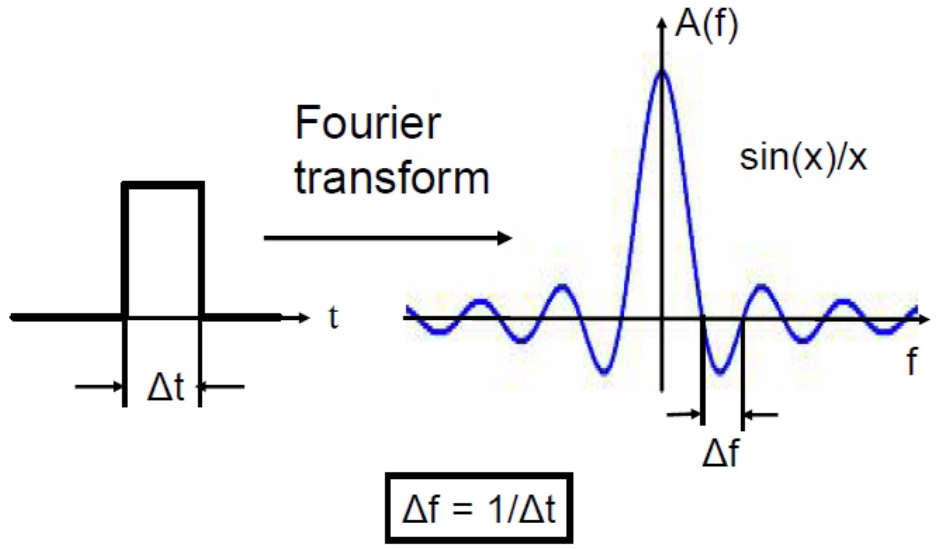
Status	PAD	TA+CID	Errors	SubChId	Type	Prot. Level	SAD	Size	Rate	Mode	Freq.	Flags	Service
●	●	○	0	0	DAB+ audio	EEP 3-A	0 CU	54 CU	72 kBit/s	stereo+SBR	24 kHz		arabella MAGIC
●	●	○	0	1	DAB+ audio	EEP 3-A	54 CU	54 CU	72 kBit/s	stereo+SBR	24 kHz		Radio Maria
●	●	○	0	2	DAB+ audio	EEP 3-A	108 CU	72 CU	96 kBit/s	stereo+SBR	24 kHz		ENERGY
●	○	○	0	3	DAB+ audio	EEP 3-A	180 CU	54 CU	72 kBit/s	stereo+SBR	24 kHz		jö.live
●				4	packet-mode...	EEP 3-A	234 CU	12 CU	16 kBit/s				EPG ORS
●	●	○	0	6	DAB+ audio	EEP 3-A	246 CU	54 CU	72 kBit/s	stereo+SBR	24 kHz		Rock Antenne
●	○	●	4 0	7	DAB+ audio	EEP 3-A	300 CU	60 CU	80 kBit/s	stereo+SBR	24 kHz		#Radio ONE
●	○	○	0	8	DAB+ audio	EEP 3-A	360 CU	30 CU	40 kBit/s	stereo+SBR+PS	24 kHz		ERF Süd
●	●	○	0	9	DAB+ audio	EEP 3-A	390 CU	54 CU	72 kBit/s	stereo+SBR	24 kHz		*STEPHANSDOM*
●	●	○	0	10	DAB+ audio	EEP 3-A	444 CU	54 CU	72 kBit/s	stereo+SBR	24 kHz		'WELLE 1
●	○	●	8 0	11	DAB+ audio	EEP 3-A	498 CU	54 CU	72 kBit/s	stereo+SBR	24 kHz		* 88.6 *
●	●	○	0	12	DAB+ audio	EEP 3-A	552 CU	30 CU	40 kBit/s	stereo+SBR+PS	24 kHz		Mein Kinderradio
●	●	○	0	13	DAB+ audio	EEP 3-A	582 CU	54 CU	72 kBit/s	stereo+SBR	24 kHz		arabella HOT
●	●	○	0	14	DAB+ audio	EEP 3-A	636 CU	54 CU	72 kBit/s	stereo+SBR	24 kHz		Antenne Österrei
●	●	○	0	15	DAB+ audio	EEP 3-A	690 CU	54 CU	72 kBit/s	stereo+SBR	24 kHz		Radio Flamingo
●	●	○	0	16	DAB+ audio	EEP 3-A	744 CU	54 CU	72 kBit/s	stereo+SBR	24 kHz		OE24
●	●	○	0	17	DAB+ audio	EEP 3-A	798 CU	54 CU	72 kBit/s	stereo+SBR	24 kHz		KLASSIK RADIO

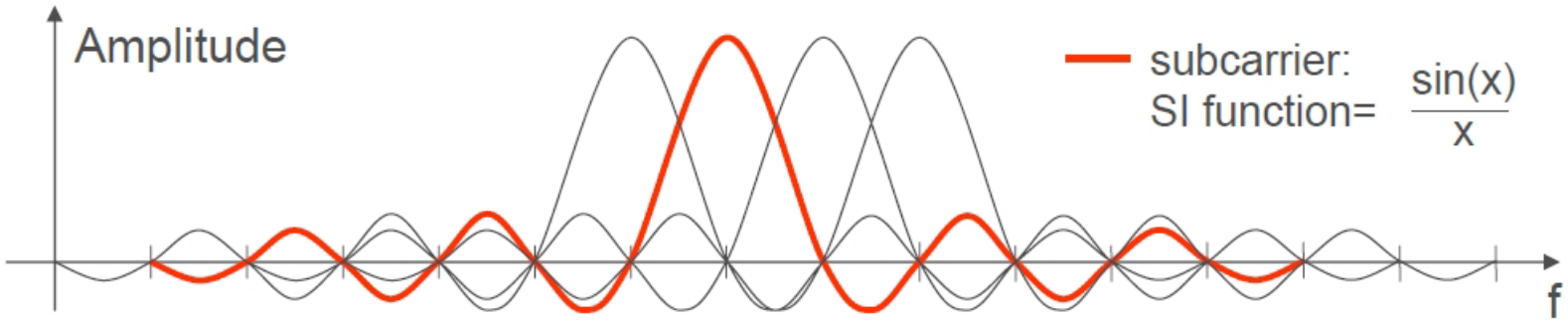
Digital Transmission

Multicarrier - Solution

Orthogonality condition:

$$f = \frac{1}{\Delta t}$$



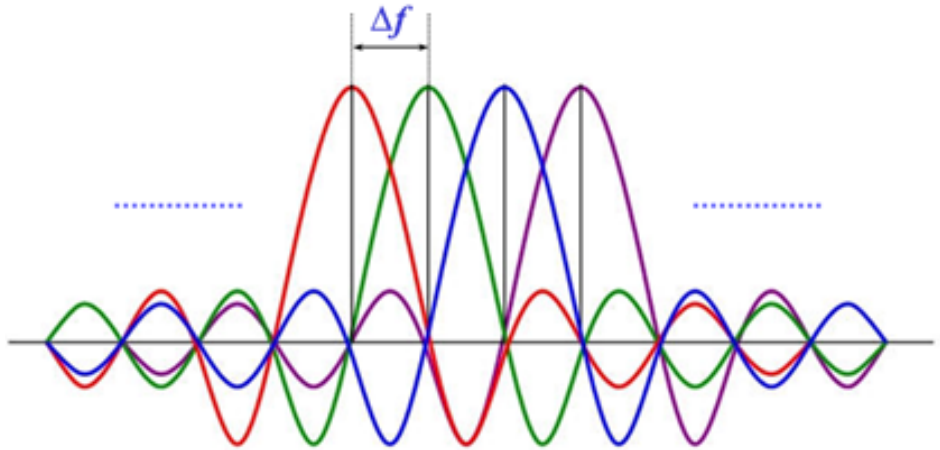


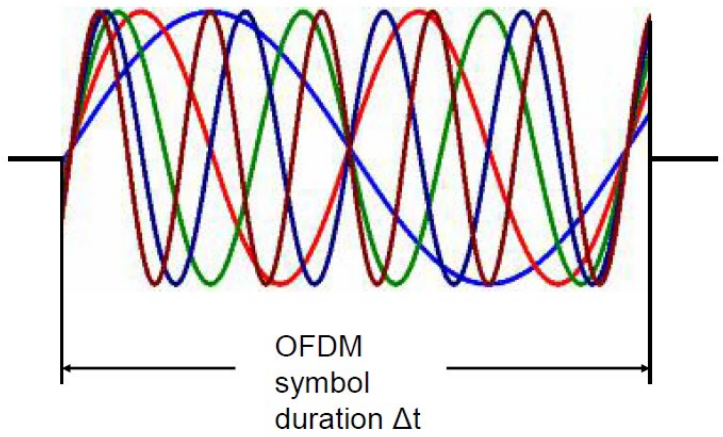
Digital Transmission

Multicarrier - ***Solution***

Orthogonality condition:

- An OFDM signal consists of a number of closely spaced modulated carriers.
- Although the ***sidebands from each carrier overlap***, they can still be ***received without the interference*** that might be expected ***because they are <u>orthogonal</u> to each other***.
- This is achieved by having the carrier spacing equal to the reciprocal of the symbol period.





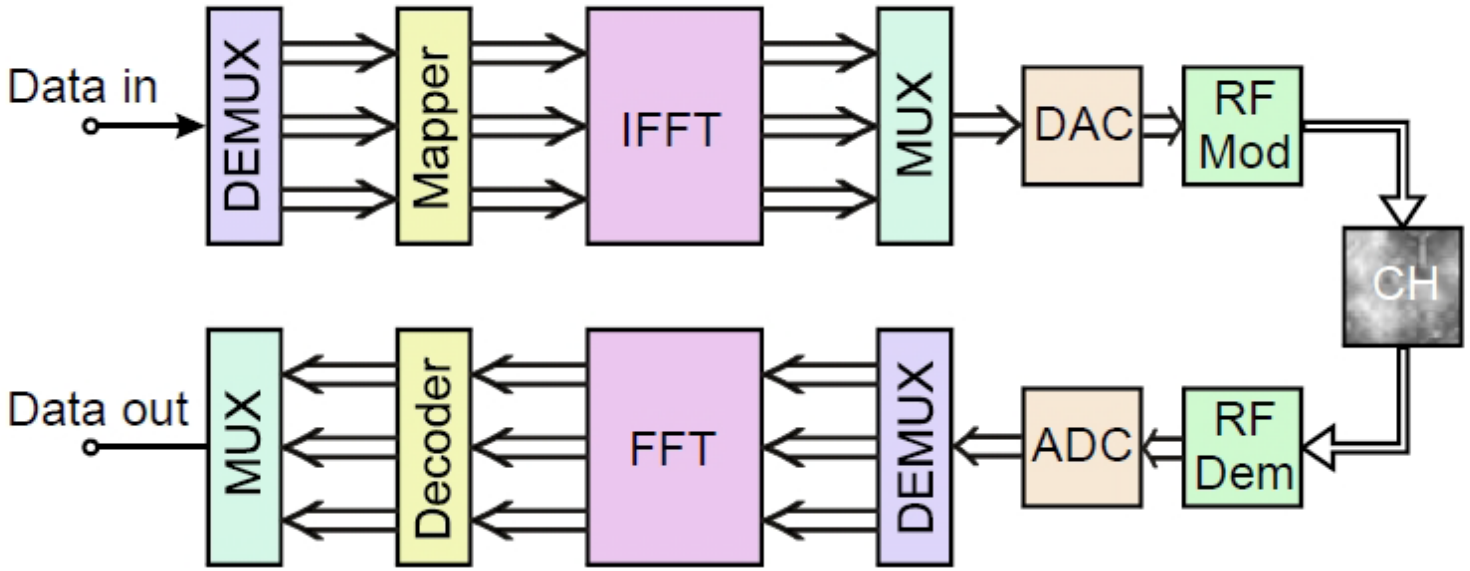
Source: rohde&schwarz

Digital Transmission

Multicarrier - ***Solution***

But how we can produce thousands of orthogonal subcarriers ?

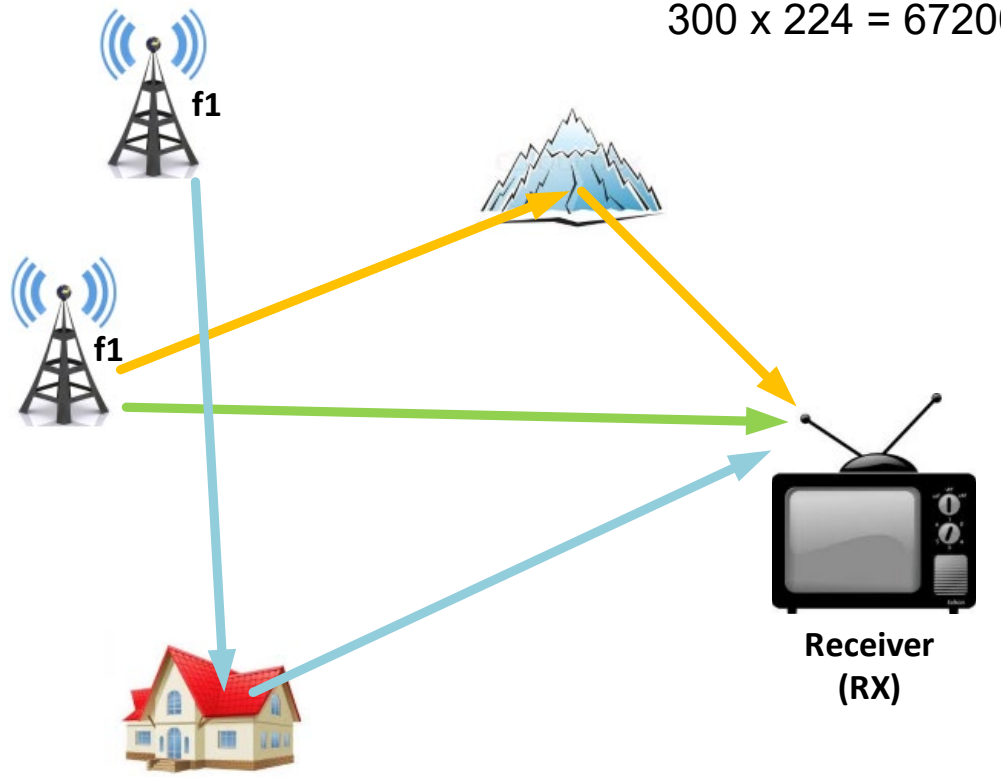
- In principle we need ***"n"*** I/Q modulators but this is not possible to realize.
- The ***IFFT*** (*Inverse Fast Fourier Transform*) at the transmitter side solve this problem. So we use numerical mathematic in a high integrated processor.



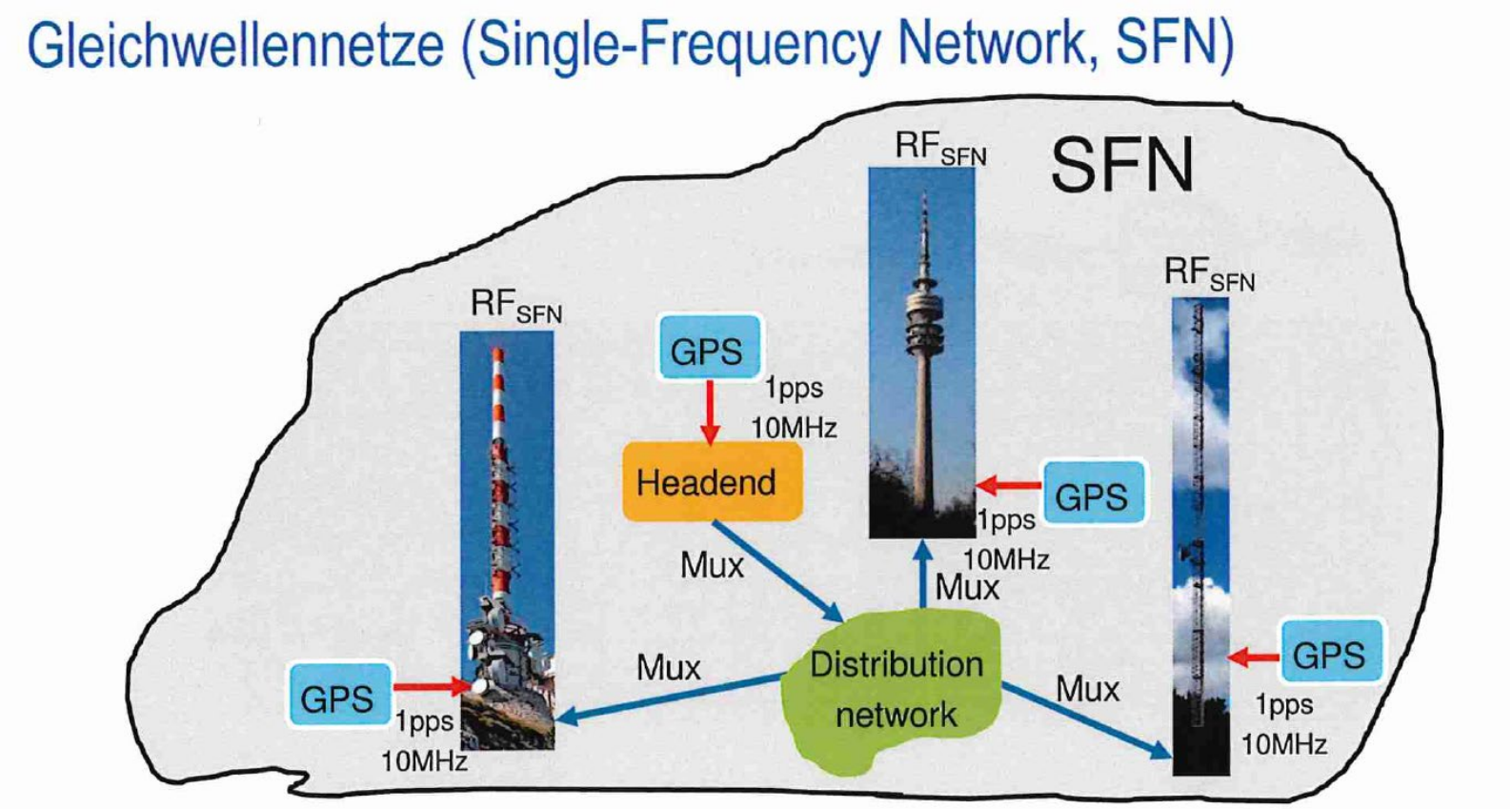
Digital Transmission

Interference - ***Guard Interval***

Example:
GI = 224 µs (8K, ¼)
1 µs = 300m
300 x 224 = 67200m = 67,2 km



DAB+ - Single Frequency Network



Walter Fischer Rhode & Schwarz

Digital Transmission

Intersymbol Interference – ***Guard Interval***

The **purpose** of the guard interval **is** to introduce **immunity to propagation delays**, like

- ***ISI*** (*Intersymbol Interference*),
- ***multipath reflections*** and
- ***frequency selective fading***,

to which digital data is normally very sensitive.

In COFDM, the beginning of each symbol is preceded by a guard interval. As long as the echoes fall within this interval, they will not affect the receiver's ability to safely decode the actual data, as data is only interpreted outside the guard interval.

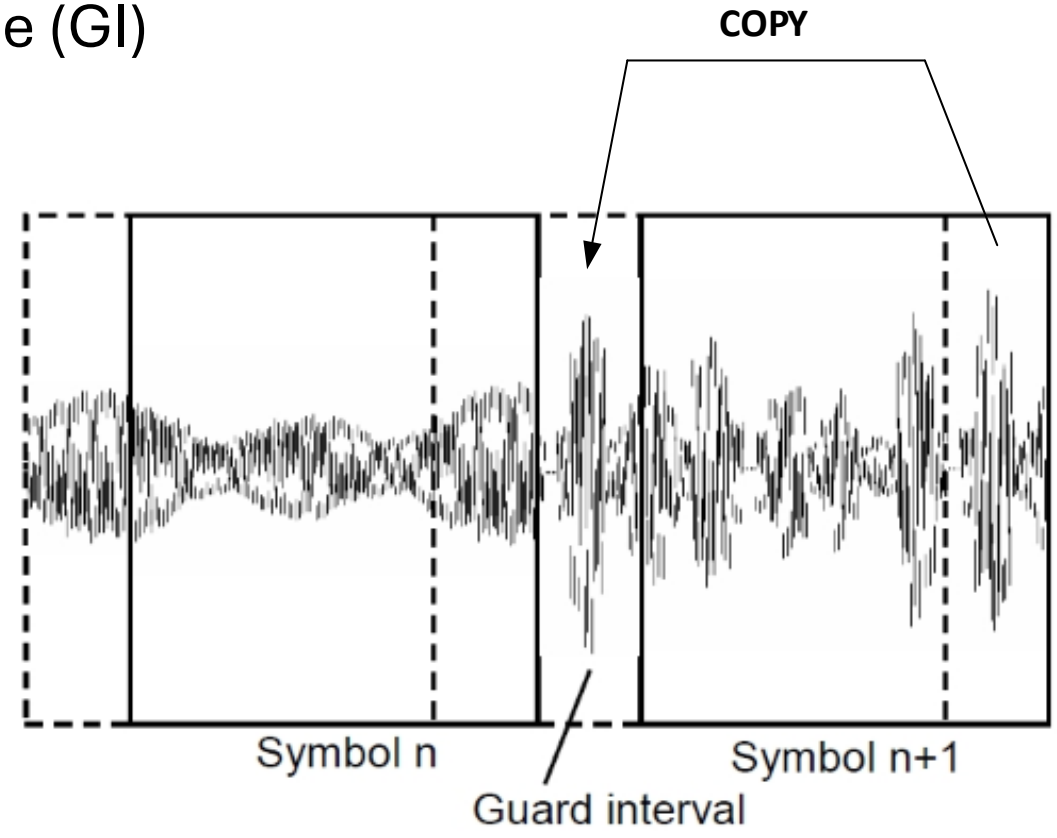
Therefore (IMPORTANT):

- **A Guard interval reduces the transmission capacity.**
- **A Guard Interval is a proportion of the time there is no new data transmitted. In fact during the guard interval we transmit a small part of the next symbol.**

Digital Transmission

Intersymbol Interference – ***Guard Interval***

- Content of the frame (GI)



Source: Rohde&Schwarz

Gleichwellennetze … Single-Frequency Networks (SFN)

Gleichwellennetze (SFNs) sind Sendernetze, in denen einige oder viele Sender ein absolut identisches Sendesignal auf der gleichen Frequenz, vollkommen synchron abstrahlen.
Zweck: Frequenzen sparen und über ein größeres Versorgungsgebiet wieder verwenden.
OFDM eignet sich ideal dafür, um Gleichwellennetze zu bilden, da ein Gleichwellennetz nichts anderes darstellt als ein „künstliches menschengemachtes" Mehrwegeausbreitungsnetz …

Gleichwellennetze müssen vollkommen …

- frequenzsynchron (… 10^{-9} … 10^{-12}),
- datensynchron und
- zeitsynchron,

sein und

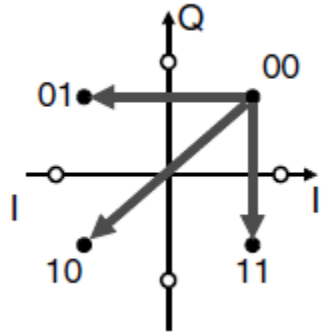
- die Schutzintervallbedingung (max. Senderabstände, SFN-Netzplanung) erfüllen.

4 Bedingungen müssen erfüllt sein

Ein Receiver empfängt in einem SFN immer ein Summensignal als Überlagerungssignal aller SFN-Sender.

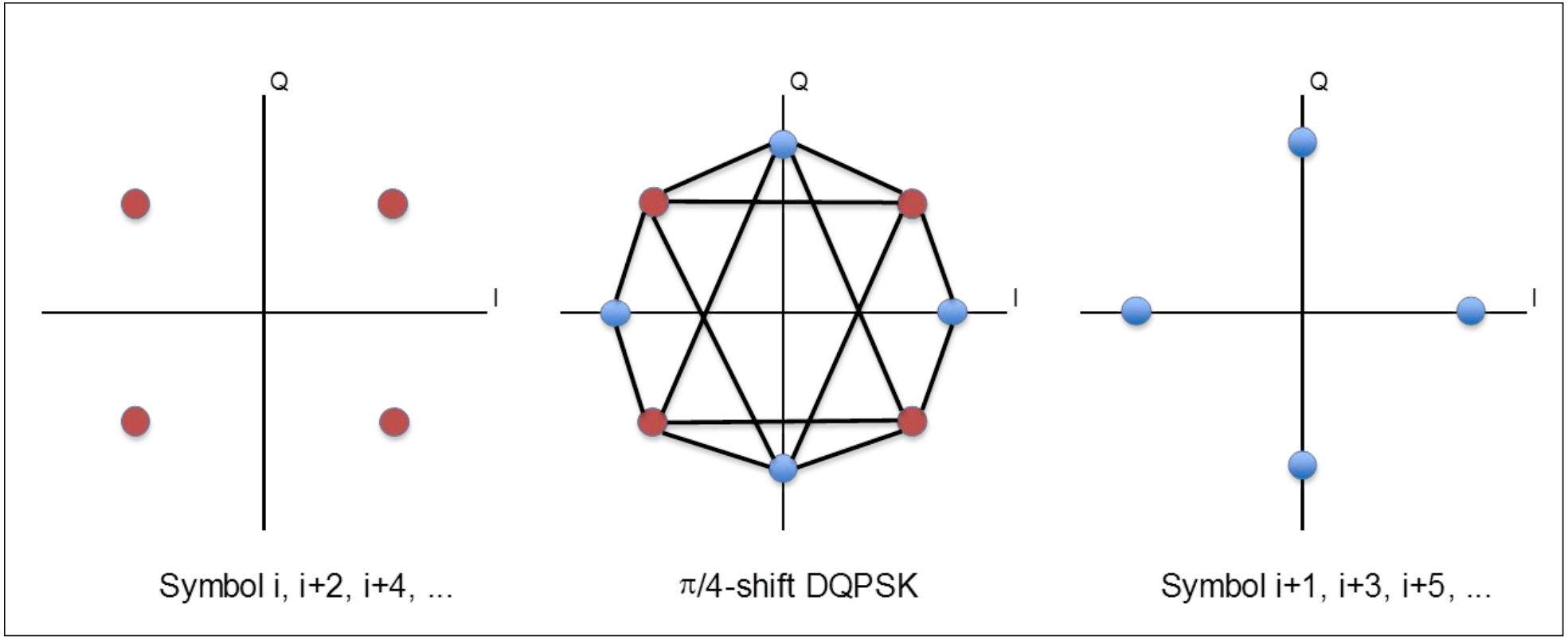
DAB / DAB+: DQPSK - Basis

- DQPSK:
  - Instead of absolute differential mapping
  - Information based on difference from pre-symbol
- Pro:
  - No channel correction necessary
- Con:
  - 3 dB more C/N necessary
  - Zero crossing (phase shift +/- 180°)



DAB / DAB+: Modulation π/4 DQPSK

Avoiding zero crossing by shifting carrierphase 45° between symbols



Source:

W. Fischer, *Digitale Fernseh- und Hörfunktechnik in Theorie und Praxis*, 4. Aufl.,Springer Vieweg, Berlin Heidelberg

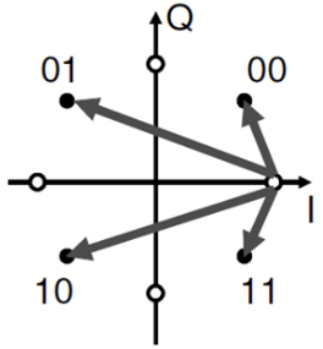
DAB / DAB+: Modulation π/4 DQPSK

- From symbol to symbol the carrier phase changes by 45 degree.
- Only +/- 45° and +/- 135° phase shift
- no 180° phase shift necessary
- Phase information from the PRS

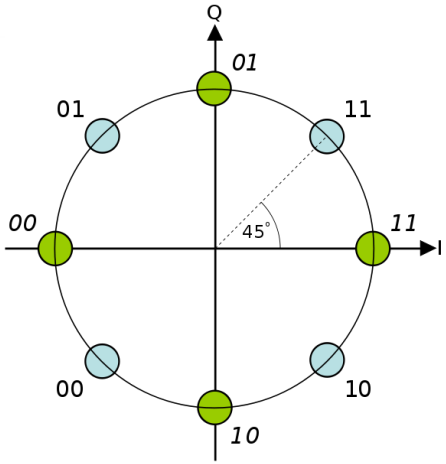
  (***P****hase* ***R****eference* ***S****ymbol*) – *CAZAC (n*90)*

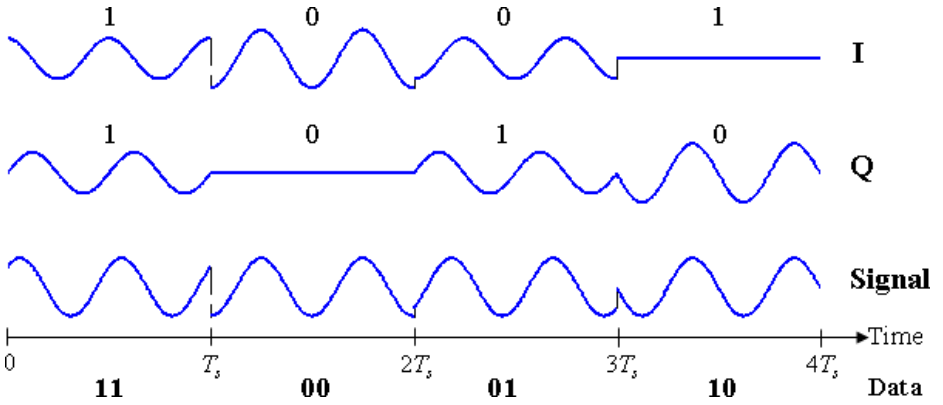
CAZAC – constant amplitude zero autocorrelation

- even symbol: n*45
- odd symbol: n*90



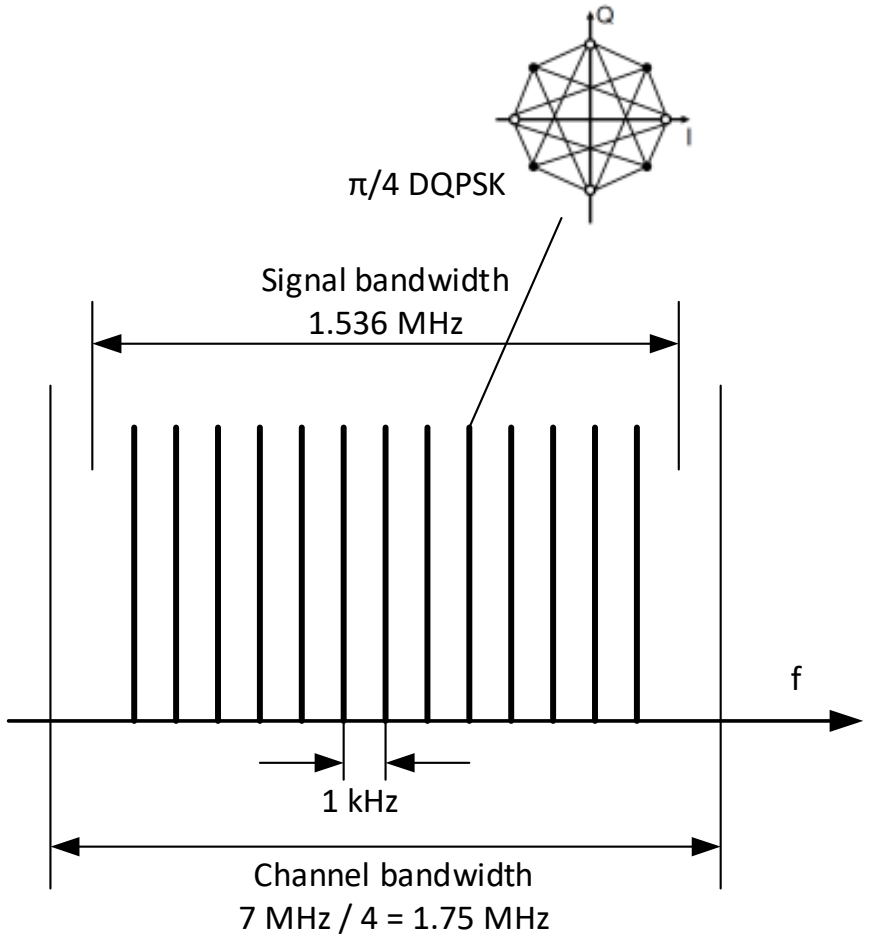
π/4-shift-DQPSK



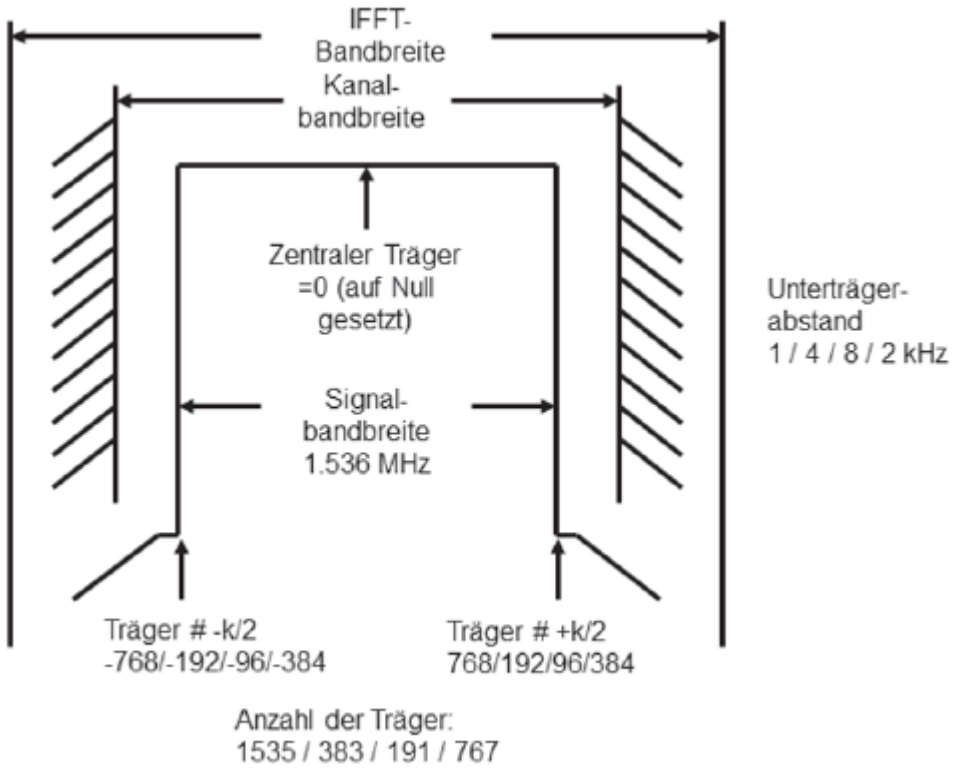


DAB / DAB+: Modulation π/4 DQPSK

- COFDM Multicarrier
- 1536 carrier
- Carrier spacing 1 kHz

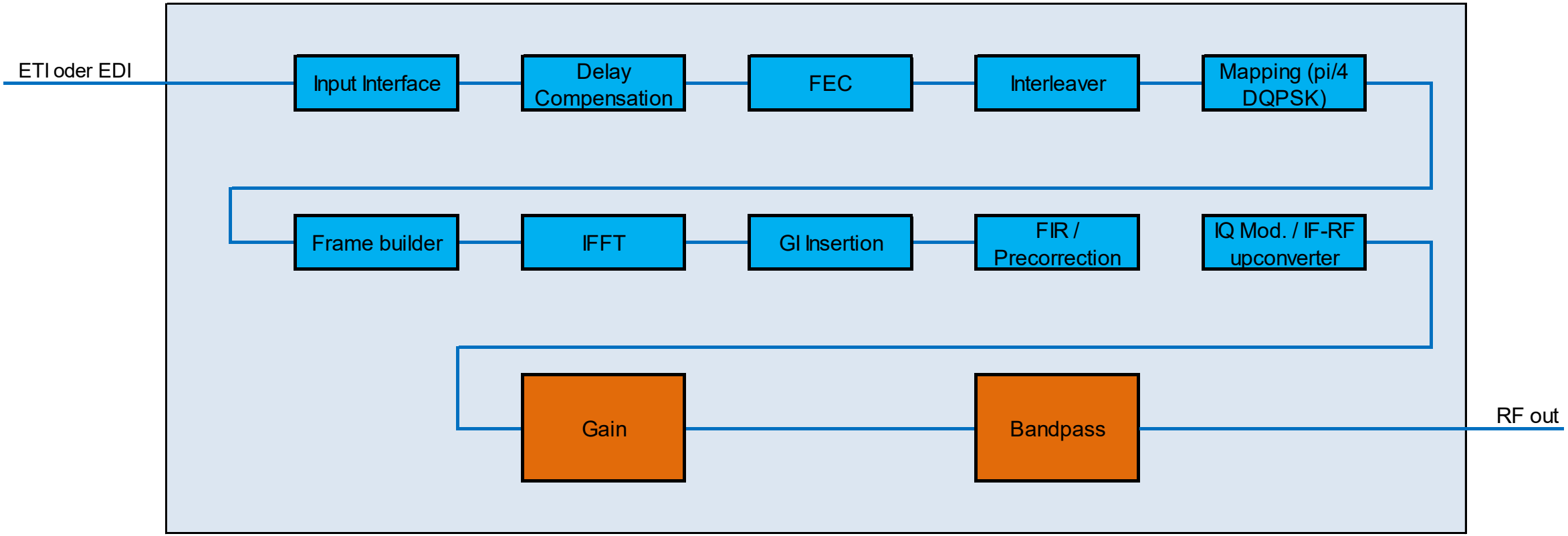


DAB / DAB+: channel spectrum



Source: W. Fischer

DAB / DAB+: Modulator more specific

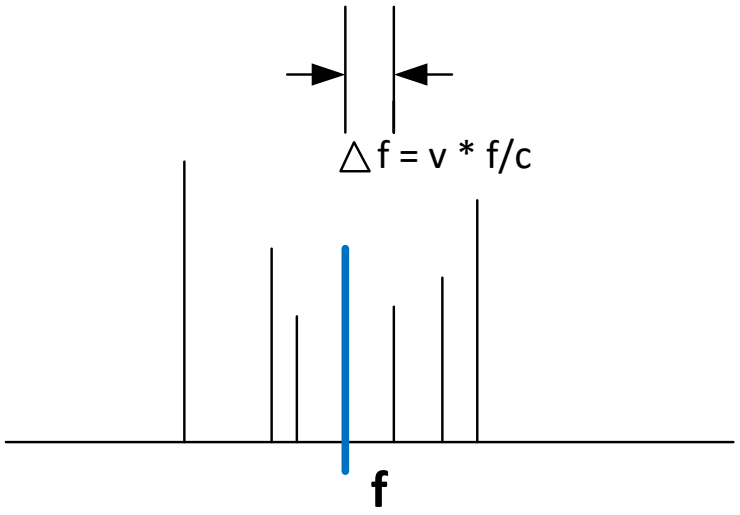


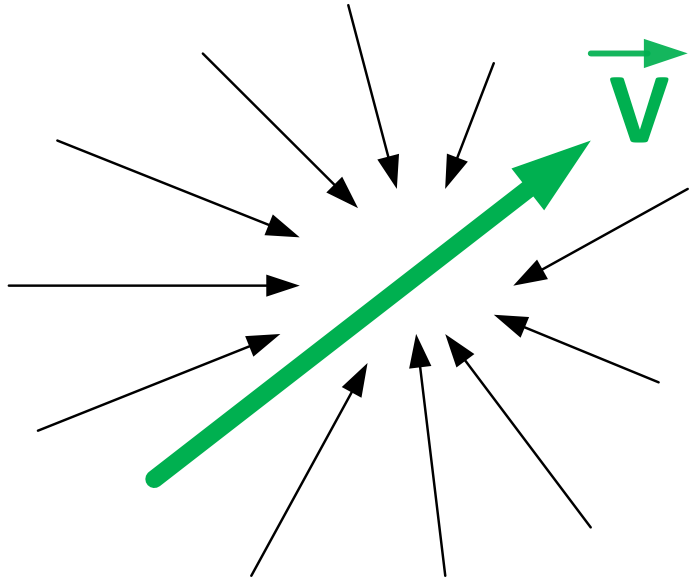
DAB / DAB+: Transmission Modes

meanwhile only Mode I available

Parameters	Mode		
	I	II	III
Application	SFN	Terrestrial	Satellite
Frame duration (T_f)	96 ms	24 ms	24 ms
Symbol duration (T_s)	1 ms	250 µs	125 µs
Guard interval (T_g)	248 µs	62 µs	31 µs
No. of symbols / frame (J)	76	76	153
No. Of carriers / symbol (N)	1536	384	192
Carrier spacing (f_s)	1 kHz	4 kHz	8 kHz
Bandwidth (f_w)	1536 kHz	1536 kHz	1536 kHz
Max. frequency (f_m)	250 MHz	1 GHz	2 GHz

DAB / DAB+: Doppler effect

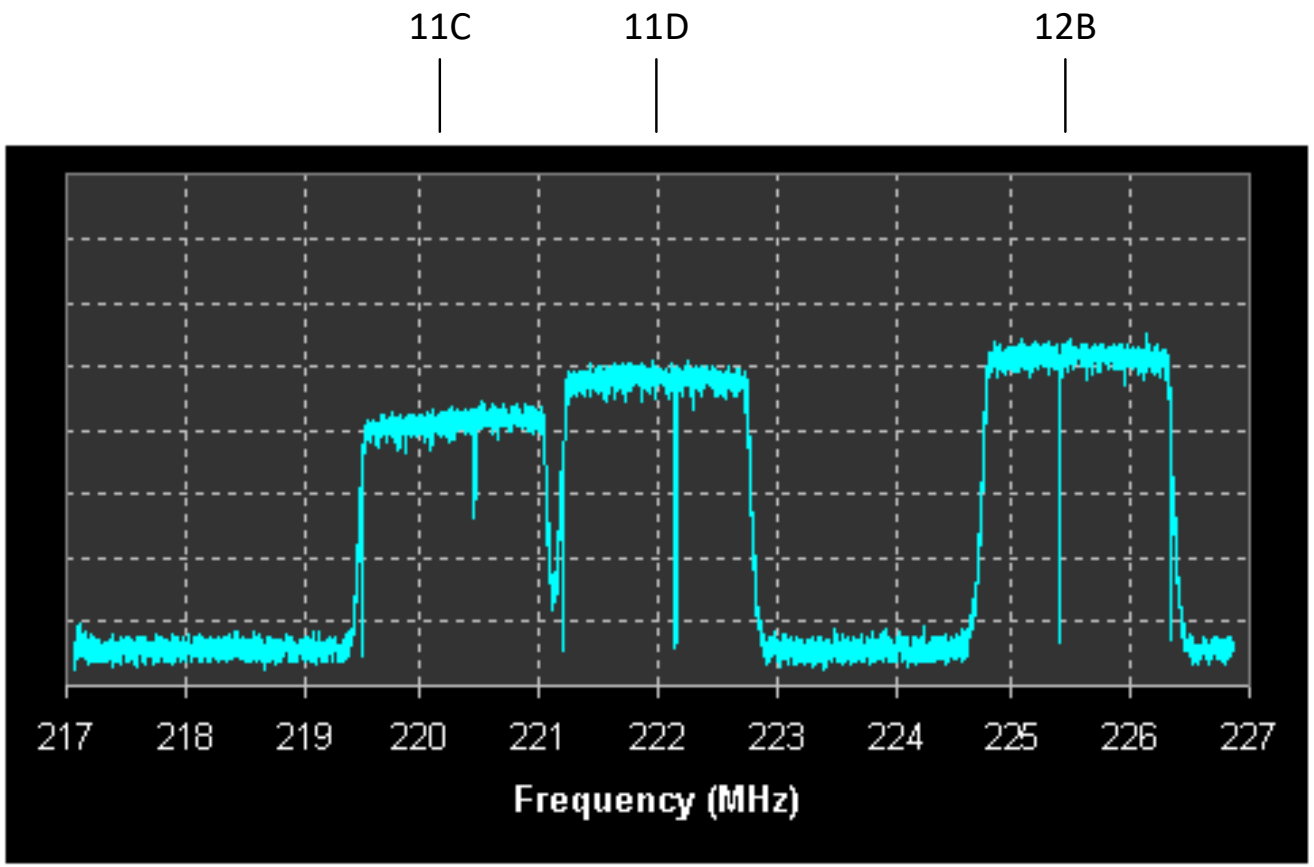




Example:
v = 100 km/h = 27,7m/s
c = 3 * 10^8 m/s
f = 200 MHz = 200 * 10^6 Hz
Δ f = 18,5 Hz

Christian Doppler

DAB / DAB+: Spectrum



DAB / DAB+: Applications

PAD (***P****rogramme* ***A****ssociated* ***D****ata*)

Used to describe data embedded into an audio stream such as DLS or Slideshow which is related to the programme being broadcast at that time.

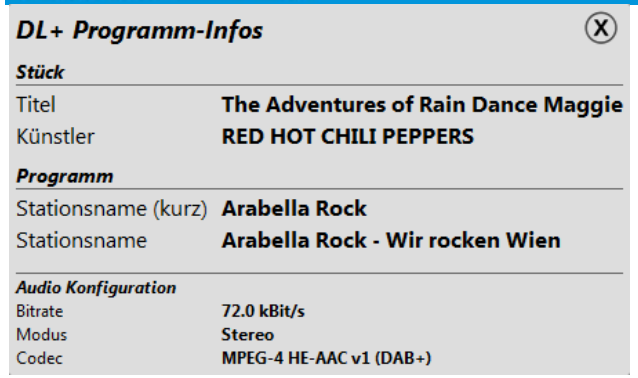
NPAD (***N****on* ***P****rogram* ***A****ssociated* ***D****ata*)

Data – transmit together with the DAB ensemble

DAB / DAB+: Applications

DLS (***D****ynamic* ***L****abel* ***S****egment*) > DL / DL+

Supplementary data services in text form (up to 128 characters) running alongside the DAB or DAB+ radio programme. Similar to RDS on FM radio.



DAB / DAB+: Applications

MOT (***M****ultimedia* ***O****bject* ***T****ransfer* ***P****rotocol*)

specifies a transmission protocol, which allows to broadcast various kinds of data using DAB. It is tailored to the needs of Multimedia services and the specific constraints given by the broadcasting characteristics of the DAB system. After reception this data can be processed and presented to the user (text, pictures, video or audio sequences)

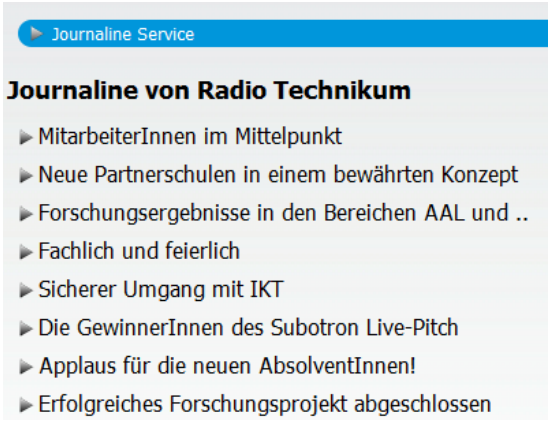
DAB / DAB+: Applications

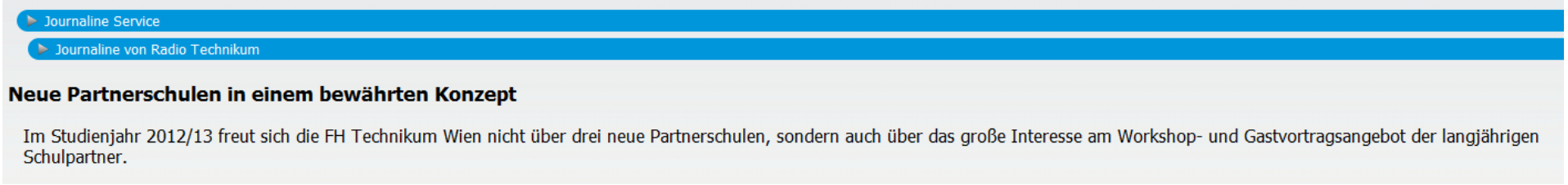
Journaline

Hierarchically categorized text information (“teletext for radio”)

Push & store service (Immediately available)

Can be setup as PAD or Stand-alone service





DAB / DAB+: Applications

EPG

DAB / DAB+: Applications

TPEG (*Transport Protocol Expert Group*)

- TPEG-RTM: Road Traffic Message Application
- TPEG-PTI: Public Transport Information
- RTM – Road Traffic Messages
- TEC – Traffic Event Compact
- TFP - Traffic Flow Prediction
- PTI – Public Transport Information
- PKI – Parking Information
- SPI – Speed Limit Information
- BSI – Bus Service Information
- WEA – Weather
- POI – Points of Interest
- CTT – Congestion and Travel Time

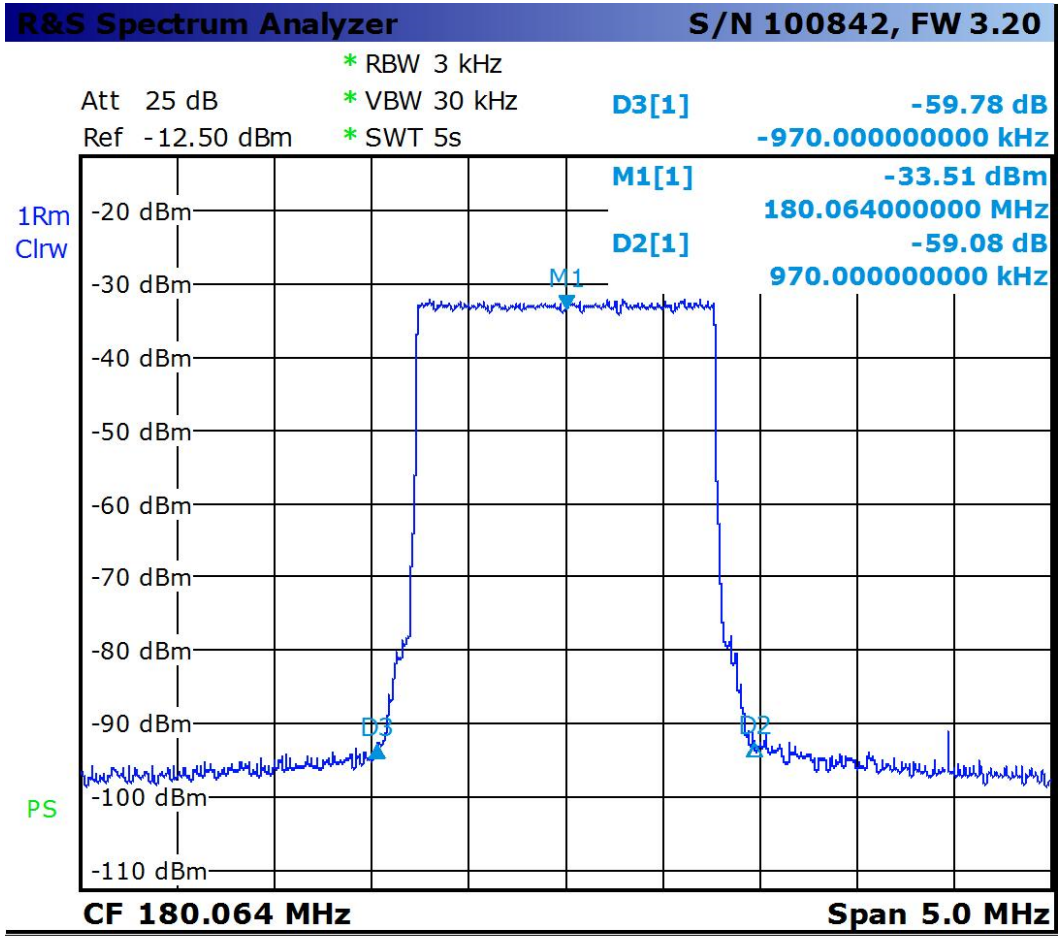
DVB-T2 / DAB+:

Measurements

DVB-T2 / DAB+: Spectrum Analyzer settings

Legend: DVB-T2 / DAB+ / same settings

- **Frequency**: *Channel center*
- **Span**: *20 / 5 MHz*
- **Trace / Detector**: *RMS*
- **RBW**: *10 / 3 kHz*
- **VBW** = RBW * (3…10) *30 kHz*
- **Sweep Time**: *2 – 5 sec.*



Zusatz: Probleme DAB+ Empfang

- Keine ausreichend Bedeckung (viele Empfangslücken)
- Unterschiedliche DAB Chips – daher Zertifizierung

digitalradio DAB+ DAB FM certified

https://getdigitalradio.com/ways-to-listen/dab-digital-radio/recommended-digital-radios

Digital Radio Tick Mark scheme

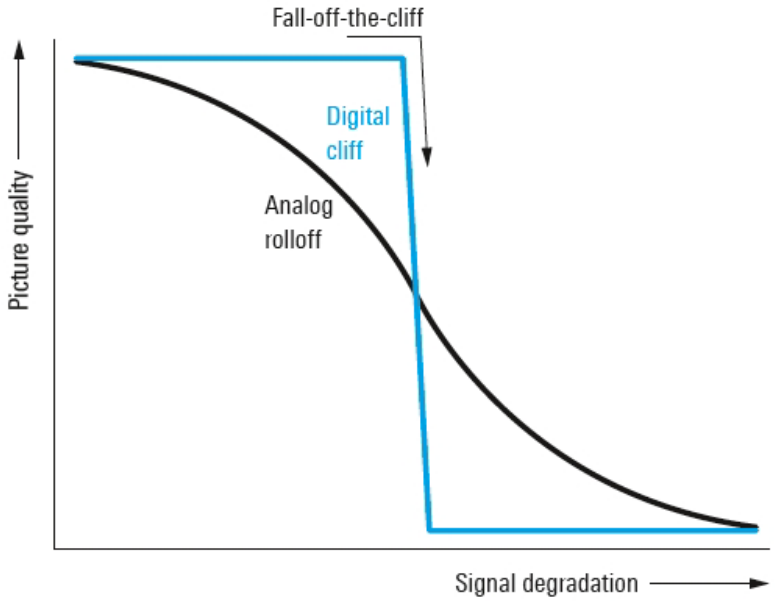
Signalstörungen: LED, Schaltnetzteile, PV,
Signaldämpfung: metallisierte Fenster, moderne Bautechnik (Dämmung)
Indoorempfang – wo ist der beste Empfang? Problem richtiger Suchlauf
FIC findet alles – aber nicht alles empfangbar …..

Digital Transmission

Cliff Effect

If an error level exceeds the number of errors that can be corrected by the FEC design, then the system will fail dramatically. This leads to a behaviour, often dubbed the "**cliff effect**“. This is a step function in performance that occurs when errors exceed the critical level. When the error level is below that critical level for which the FEC can compensate, a transmission will seem relatively error free, even in the presence of a large number of errors.

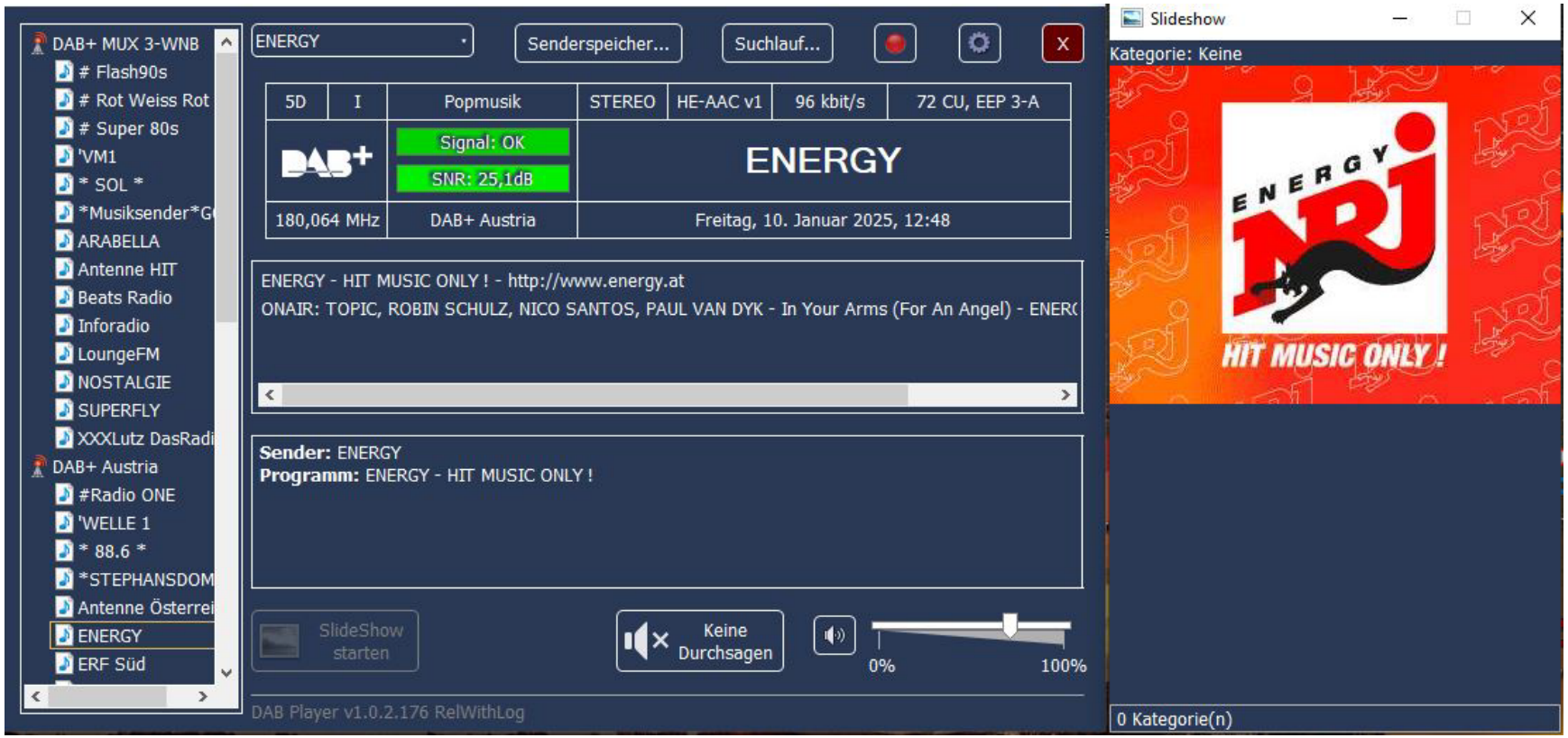
Then, all of a sudden, things may go drastically wrong if the critical level is exceeded, the performance "***falls off the cliff***“



DAB+ Empfang mit Röhrenradio

- https://hse-radio.hier-im-netz.de/dab.htm
- *Die Lösung ist einfach. Eine Leiterplatte beinhaltet einen DAB+ Empfänger, einen Oszillator, der mit dem im Radio vorhandenen UKW- oder MW-Oszillatorkreis schwingt und den digitalen Tuner abstimmt und einen AM- oder FM modulierten Generator für die Radio- ZF. Die Stromversorgung wird hauptsächlich aus der Anodenspannung gewonnen. Der gewünschte Sockel ist im Preis enthalten.*
- *Die Leiterplatte kann mit verschiedenen Sockeln versehen, für bestimmte Zwischenfrequenzen bestückt und auf fast alle Mischröhren angepaßt werden. Manche Sockel sind rar geworden, hierfür wird die Zusendung einer alte Röhre notwendig. Durch einen isolierten Antennenübertrager können auch Allstromgerate DAB+ empfangen.*

DAB+ Empfang mit RTL-SDR + DAB Player



https://www.ukwtv.de/cms/downloads-aside/281-dab-player-von-andreas-gsinn.html

+richtigen Treiber – bei mir RTL SDR = Treiber 2

DAB+

Danke