

SW-Realisierung eines DAB-Empfängers mit GNU Radio



Masterarbeit
Michael Höin, 2011

1. Introduction

- Software Defined Radio
- GNU Radio (Companion)
- OFDM

2. DAB Standard

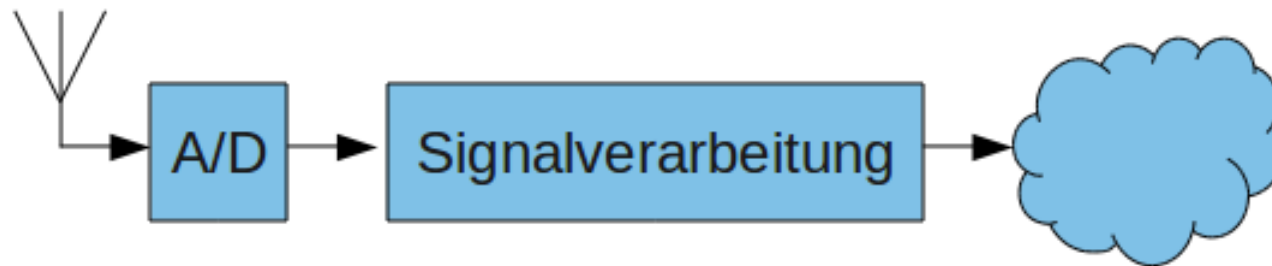
3. Matlabsimulation

4. Implementation in GNU Radio

5. Erreichtes / Ausblick

6. Vorführung

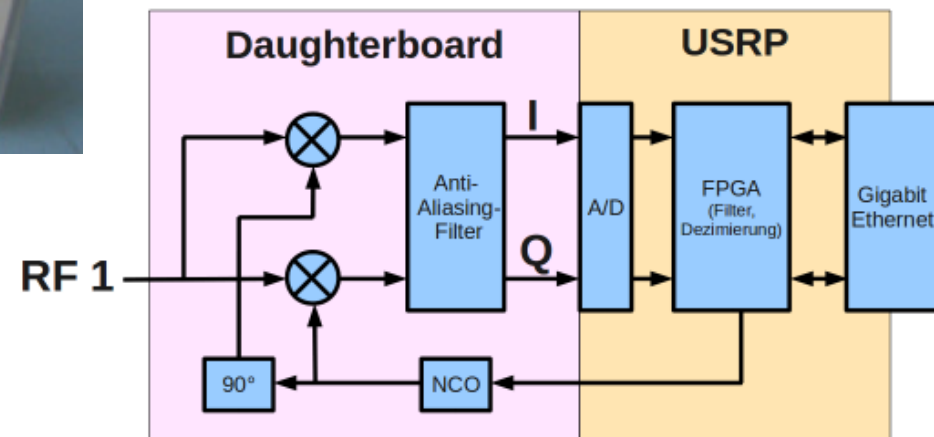
Software Defined Radio (SDR)



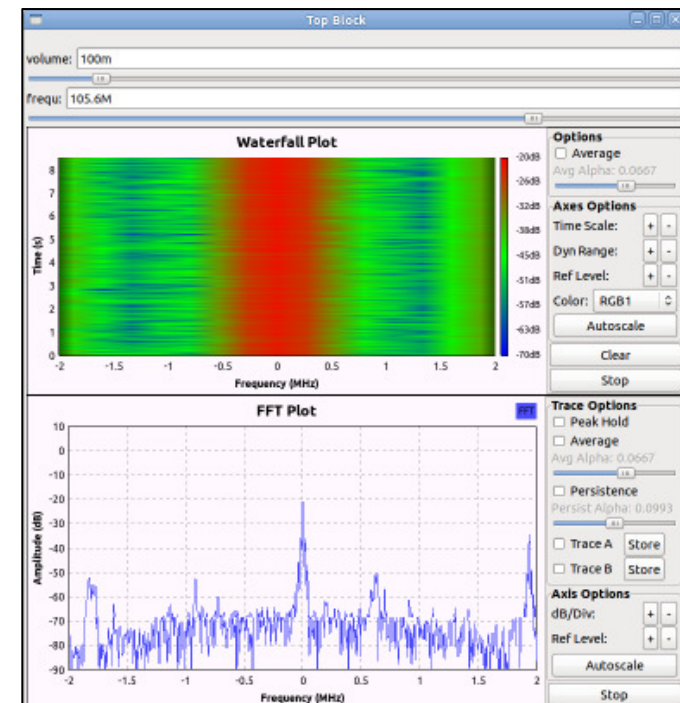
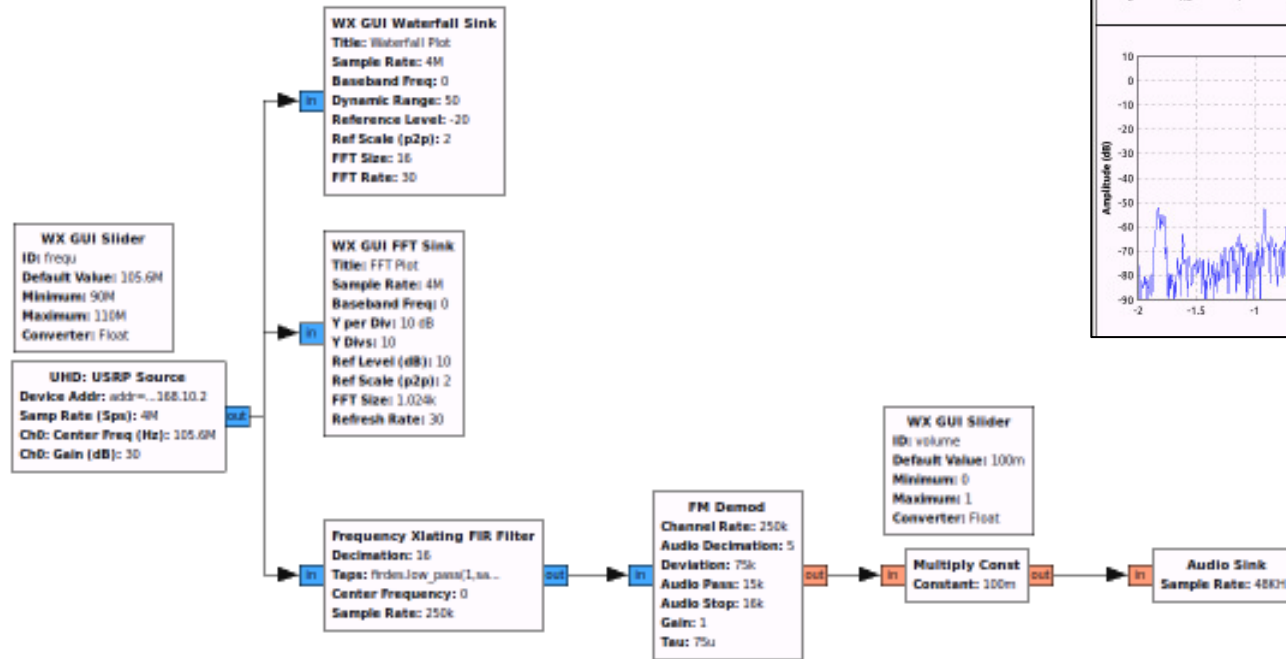
GNU Radio (Ettus Hardware N210)



- 2 x ADC 100 MS/s 14 Bit
- 2 x DAC 400 MS/s 16 Bit
- 1 x Gigabit Ethernet Interface
- 1 x MIMO
- 1 x Frequency Reference Anschluss



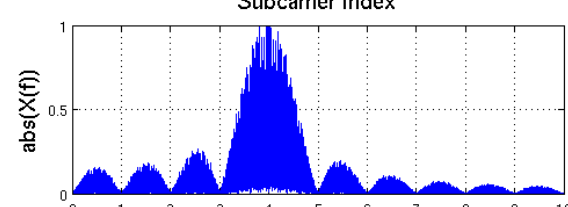
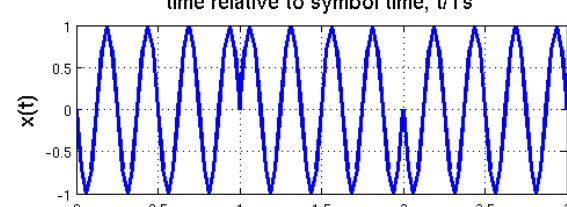
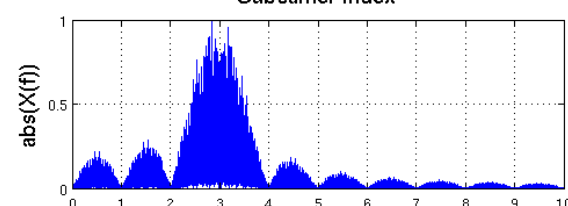
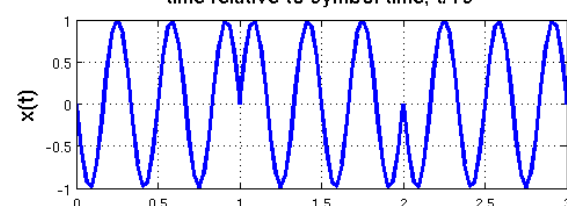
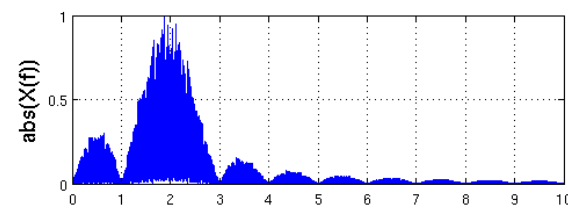
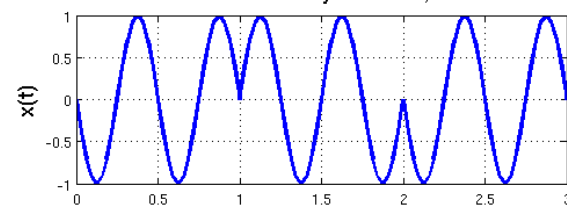
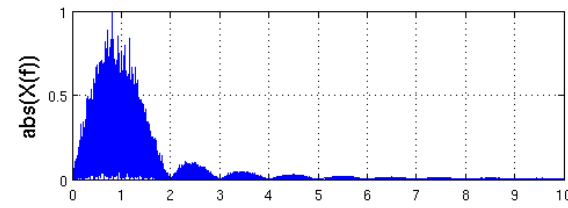
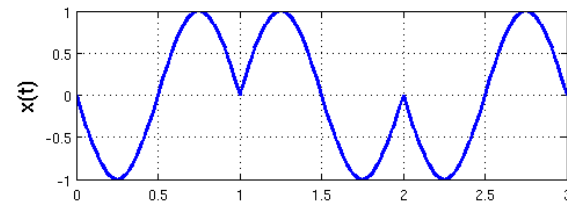
GNU Radio (Companion)



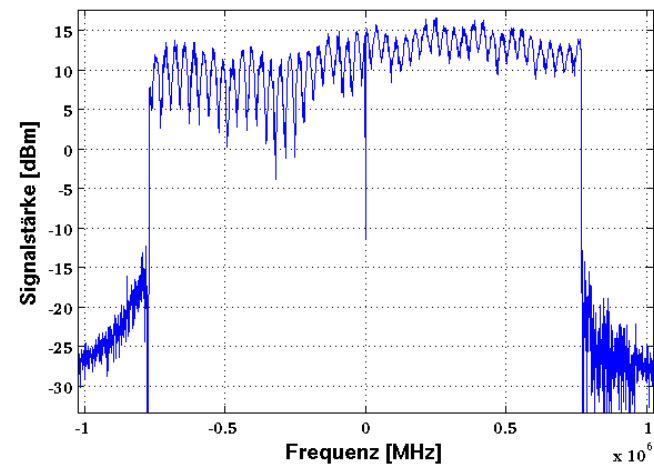
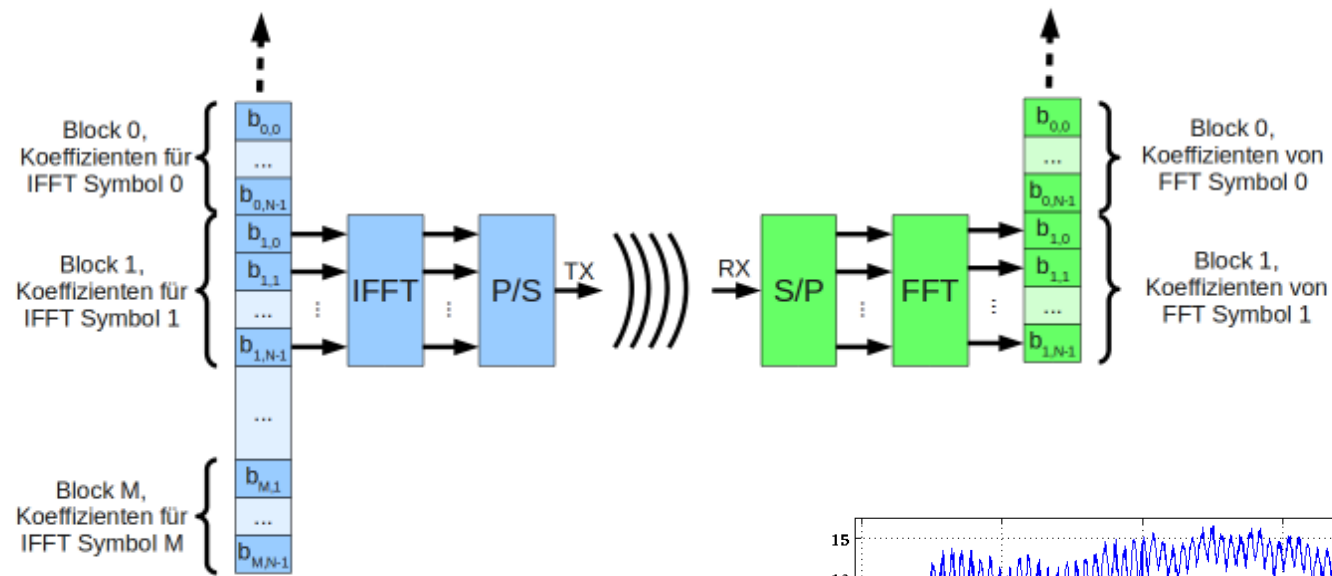
GNU Radio (Python)

```
1 #!/usr/bin/env python
2
3  from gnuradio import gr
4  from gnuradio import audio
5  import howto
6
7  class my_top_block(gr.top_block):
8      def __init__(self):
9          gr.top_block.__init__(self)
10
11         #####
12         # Variablen
13         #####
14         rate = 44000
15         amplitude = 5
16         factor = 0.005
17
18         #####
19         # Objekte (Blöcke) instanziiieren
20         #####
21         src = gr.sig_source_f (rate, gr.GR_SIN_WAVE, 350, amplitude)
22         modif = howto.multiply (factor)
23         dst = audio.sink (sample_rate, "")
24
25         #####
26         # Blöcke verbinden
27         #####
28         self.connect ((src,0), (modif,0), (dst,0))
29
30  if __name__ == '__main__':
31      try:
32          my_top_block().run()
33      except KeyboardInterrupt:
34          pass
```

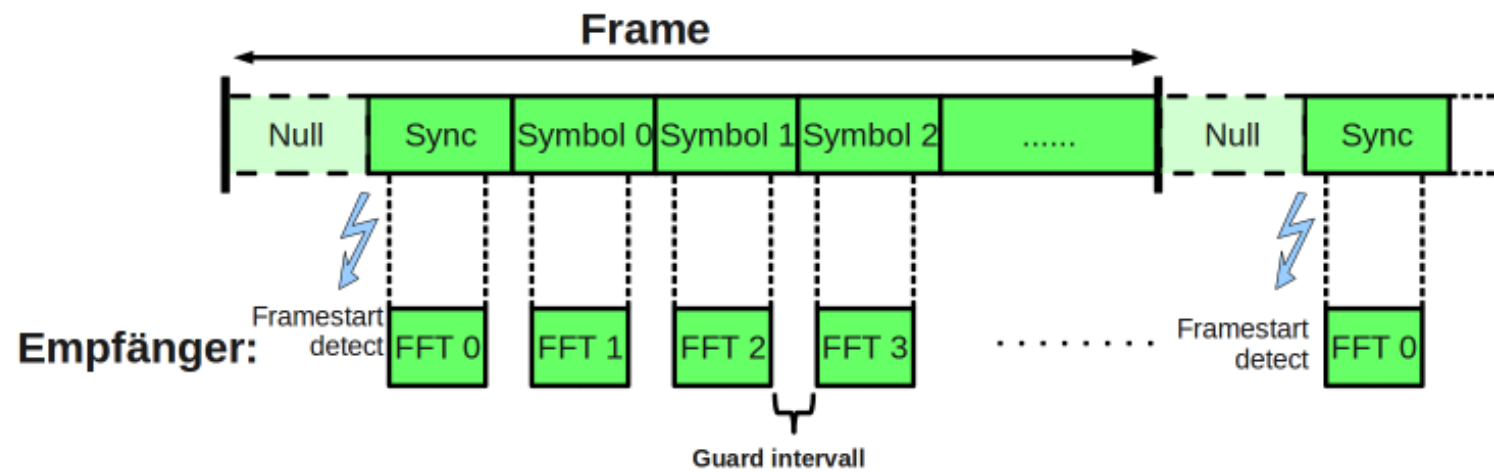
OFDM



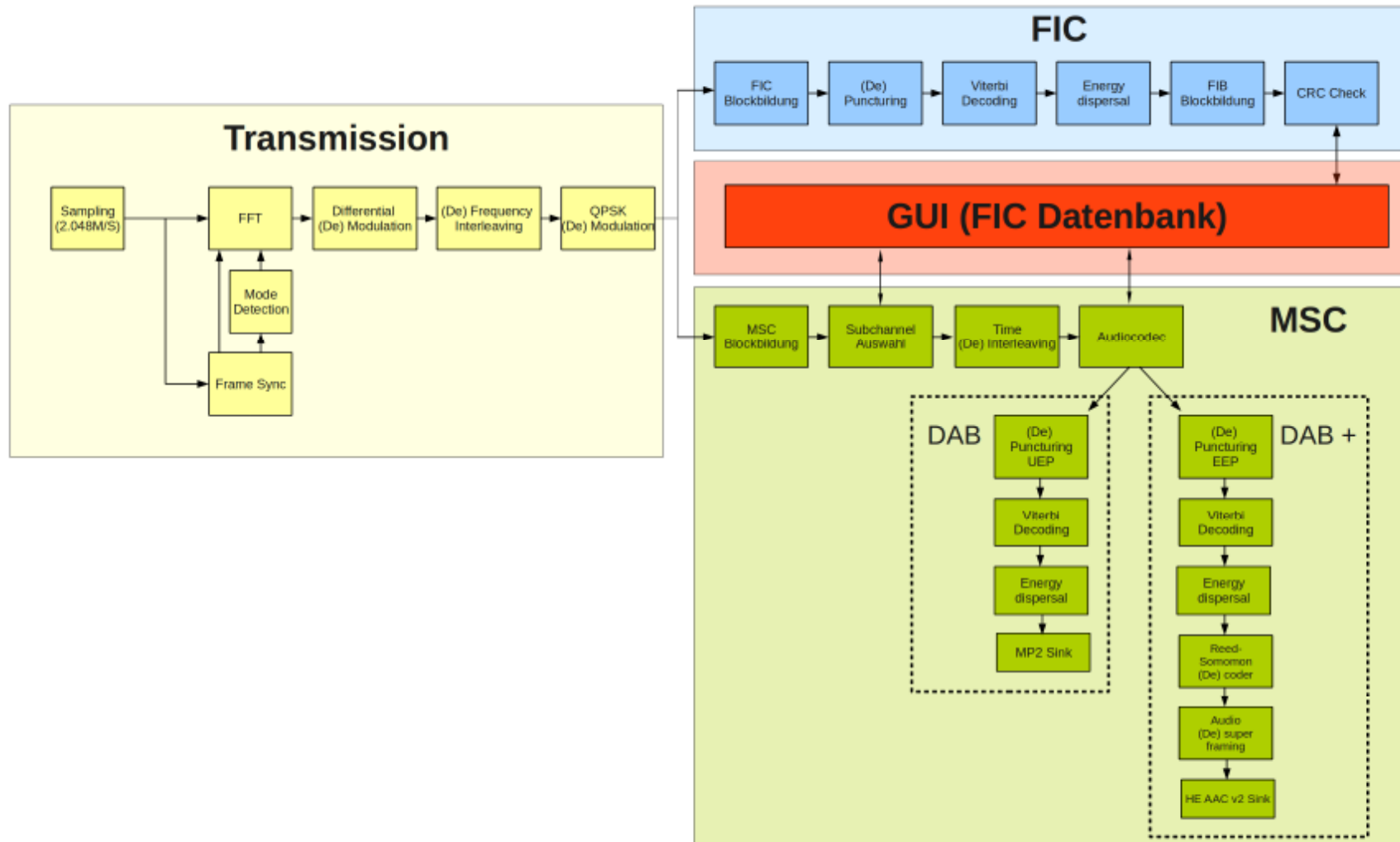
OFDM



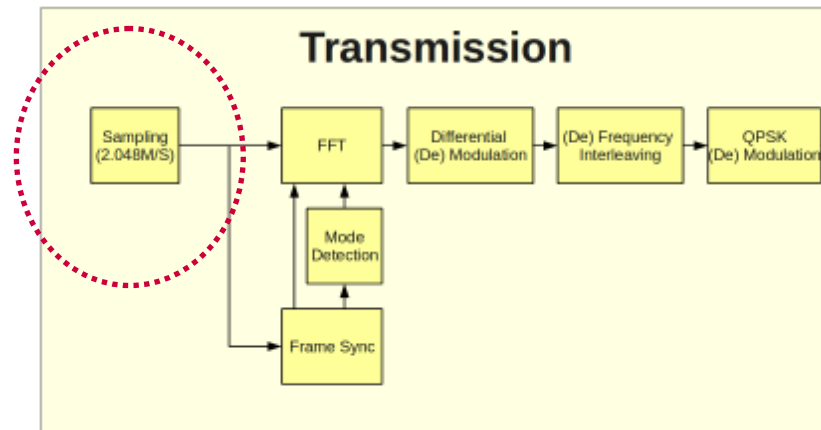
OFDM



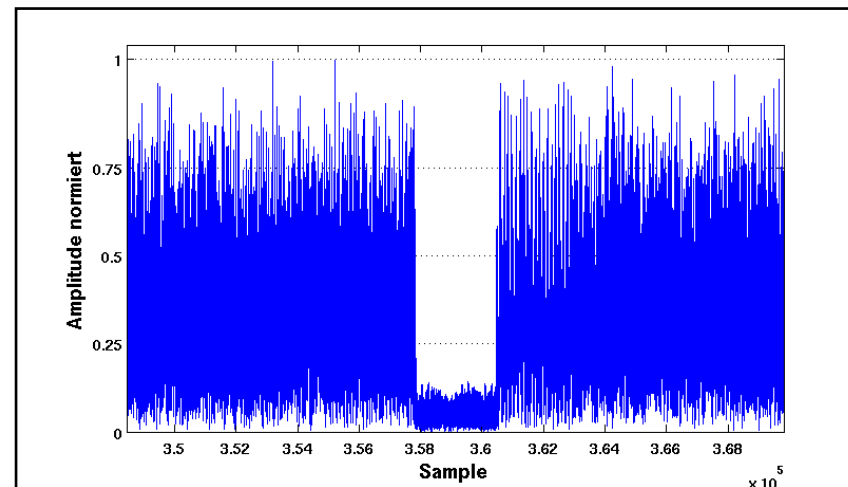
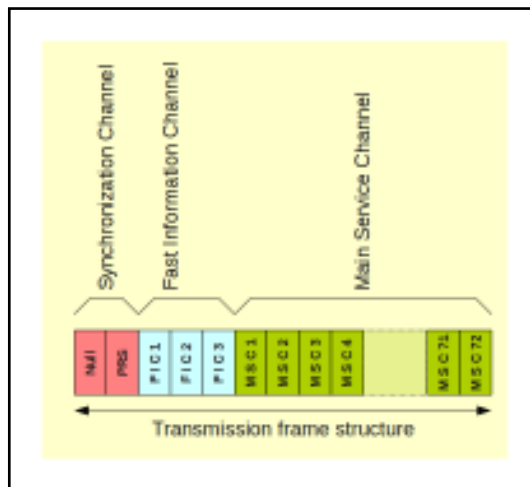
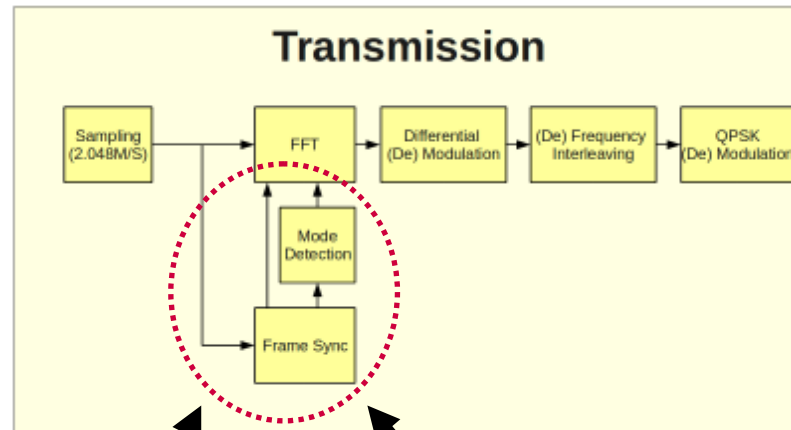
DAB Standard (Übersicht)



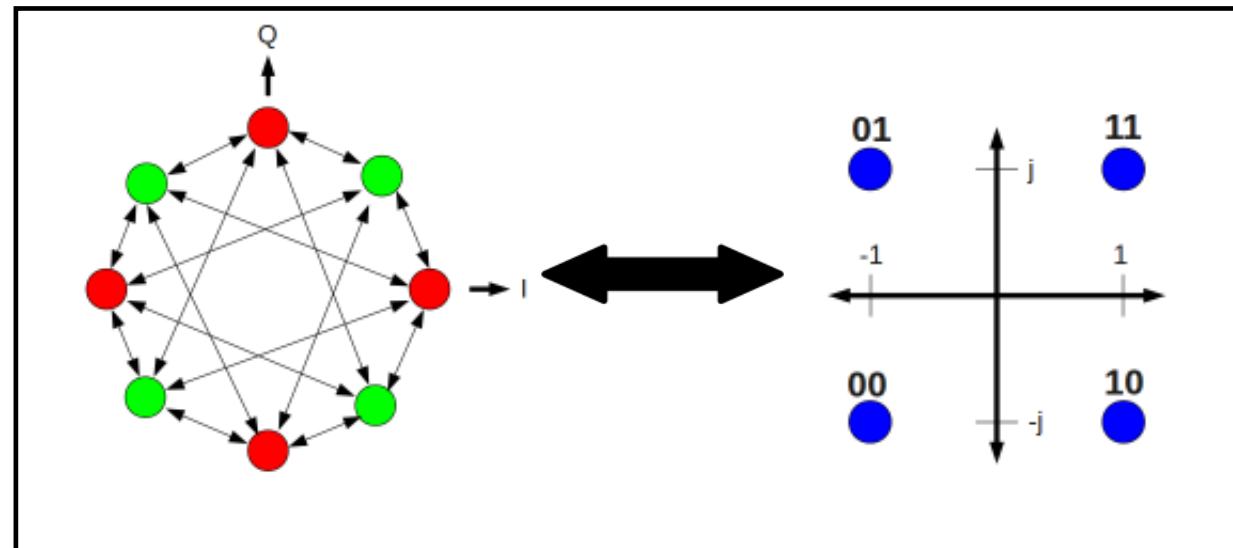
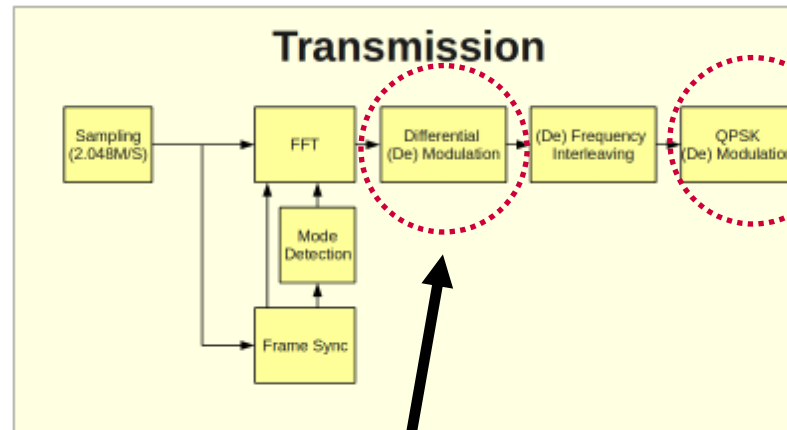
DAB Standard (Transmission)



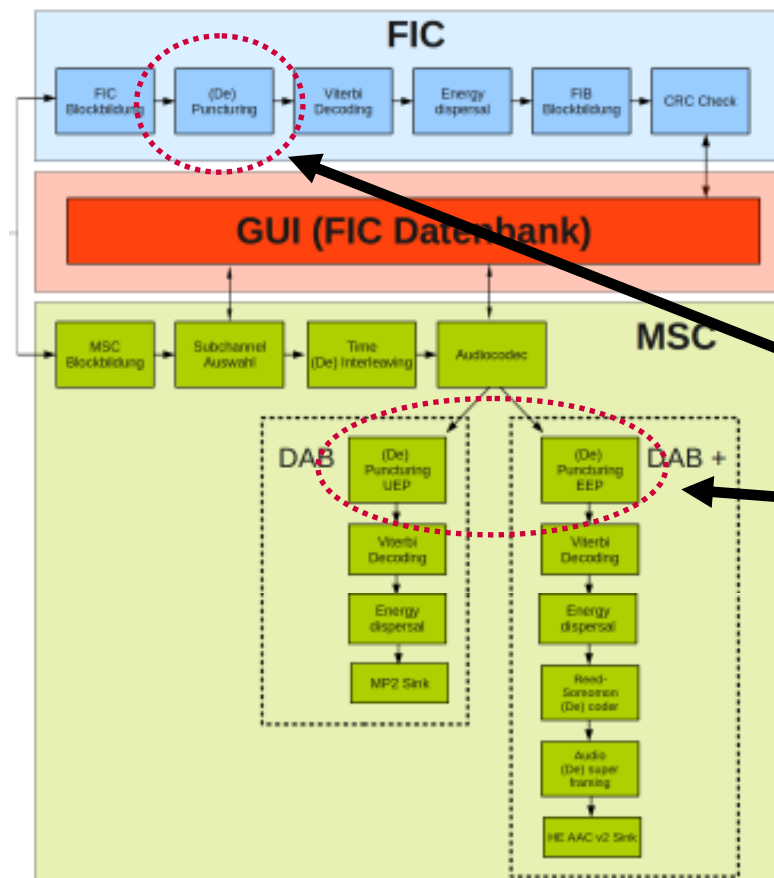
DAB Standard (Transmission)



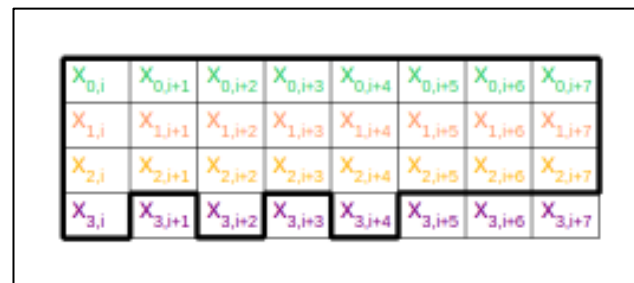
DAB Standard (Transmission)



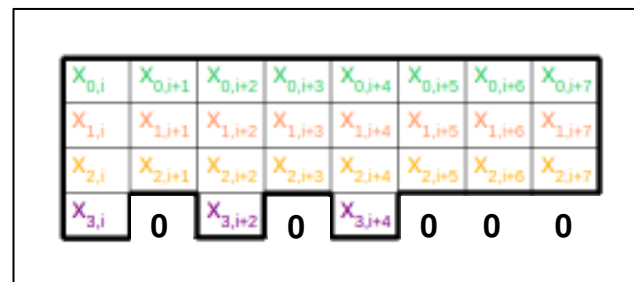
DAB Standard (FIC, MSC)



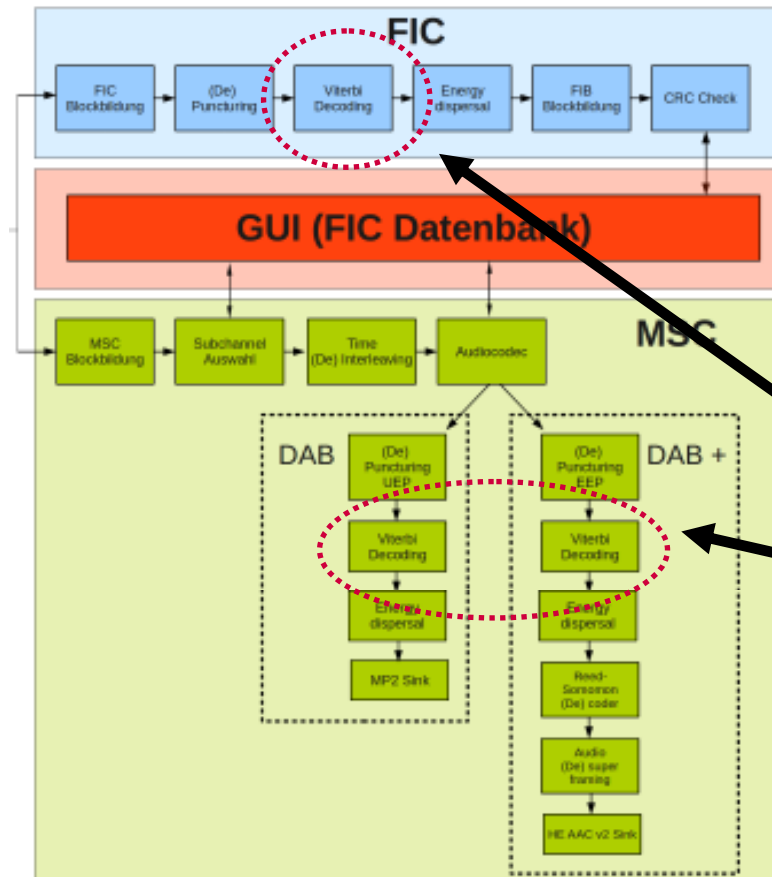
Transmitter



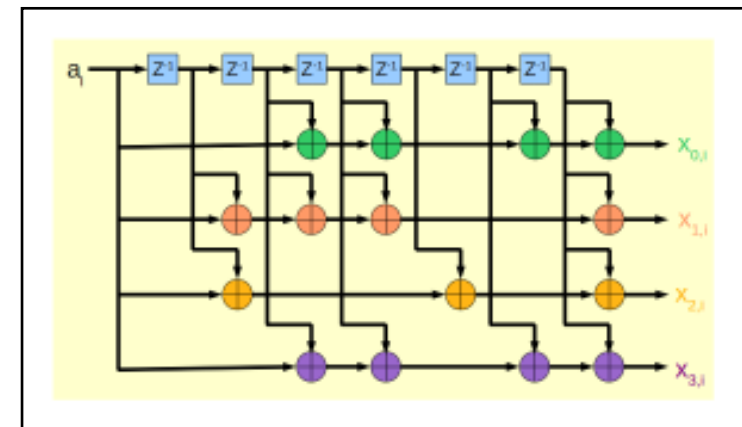
Receiver



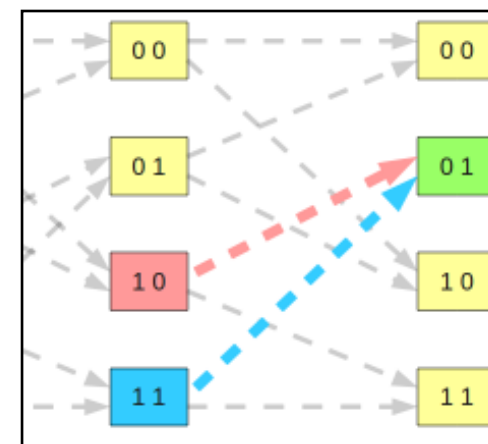
DAB Standard (FIC, MSC)



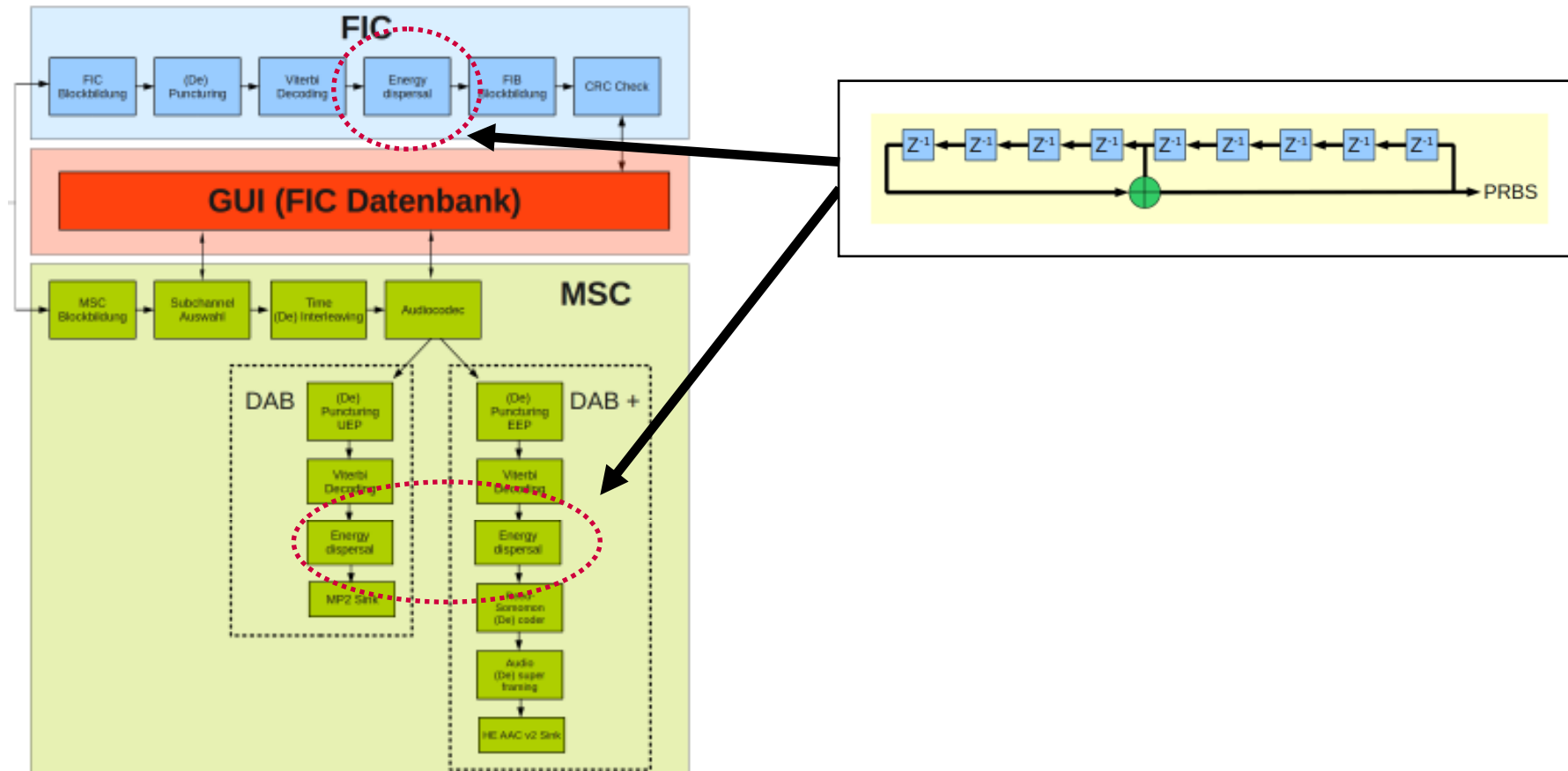
Transmitter



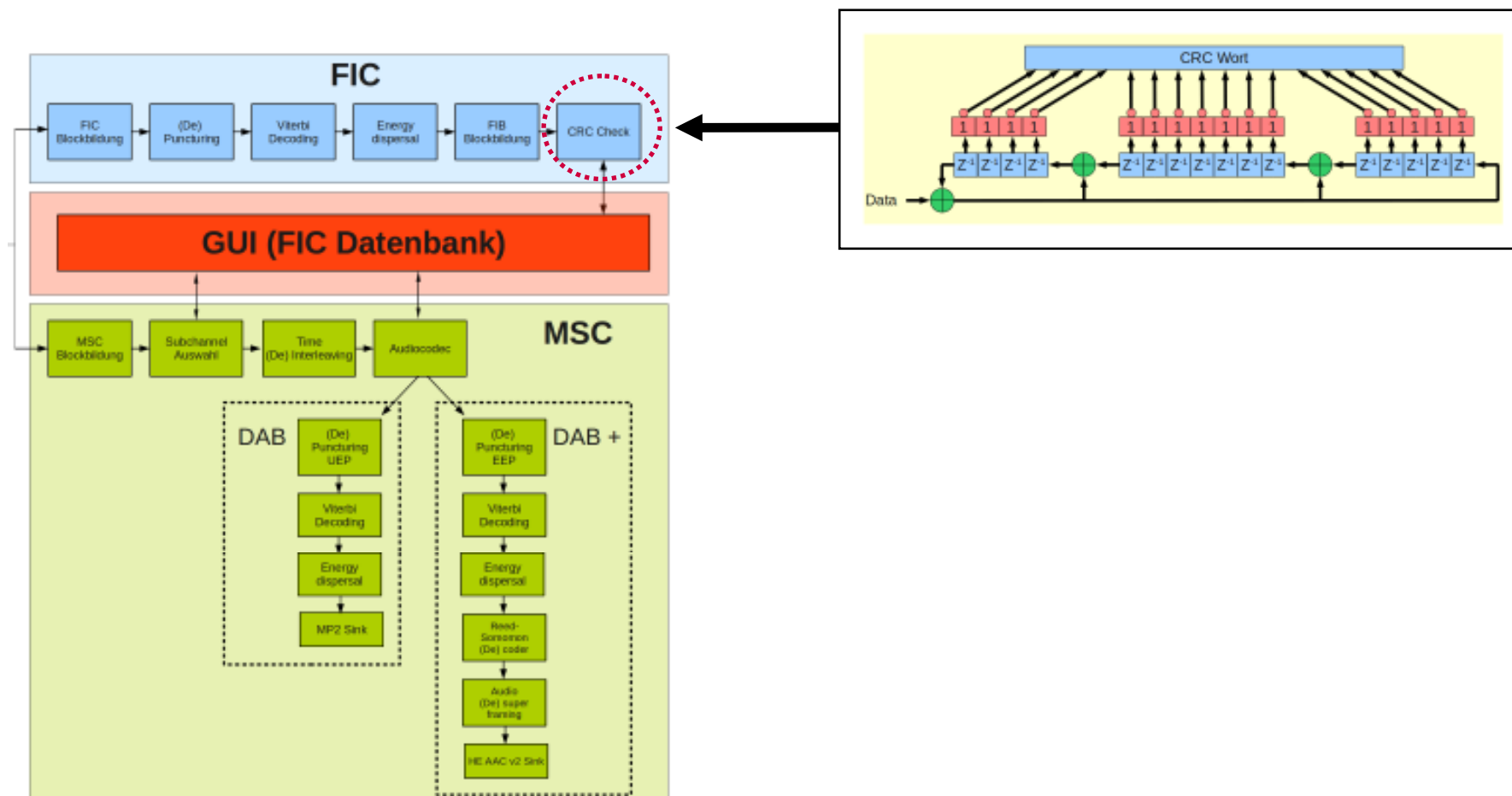
Receiver



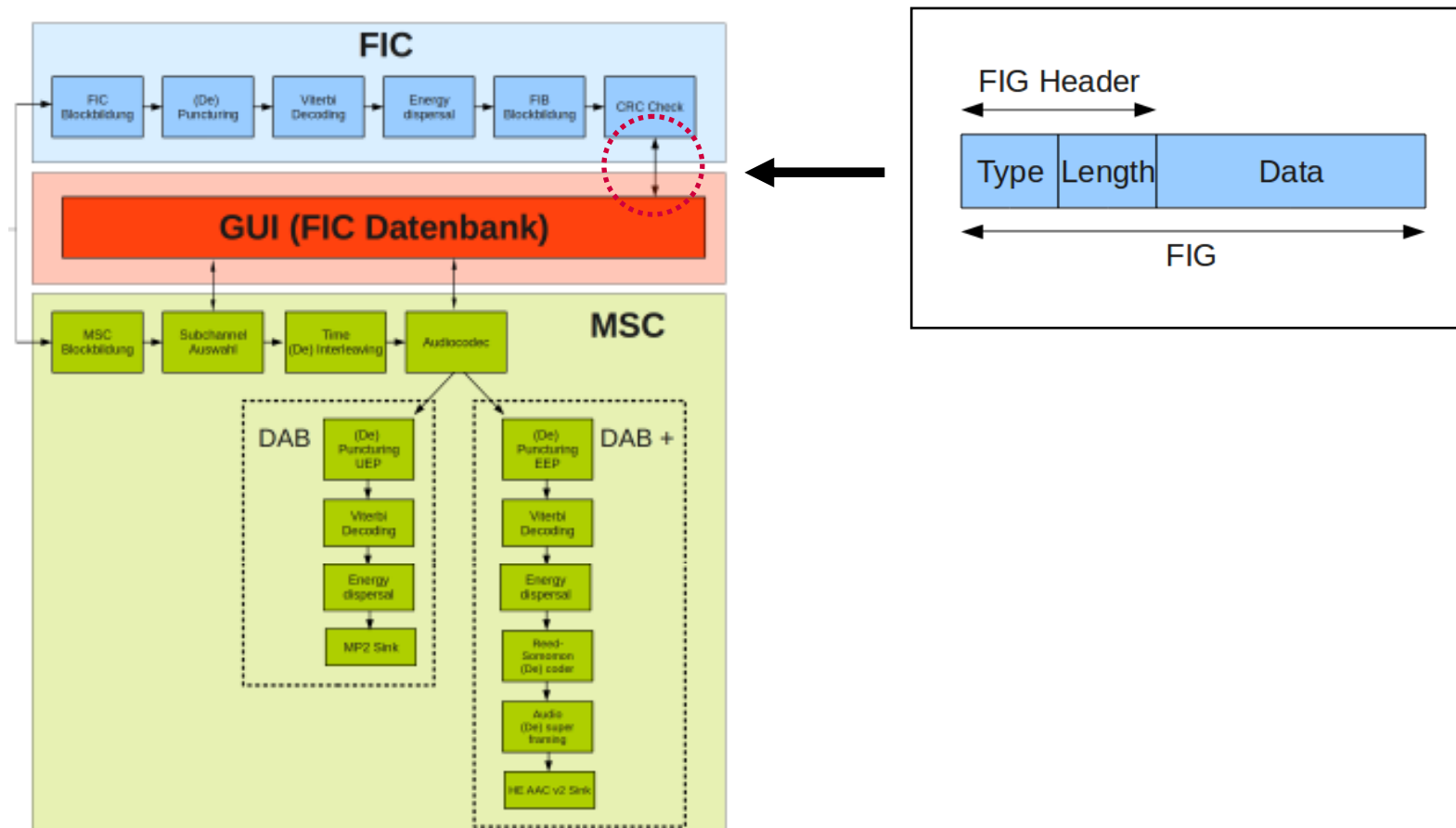
DAB Standard (MSC)



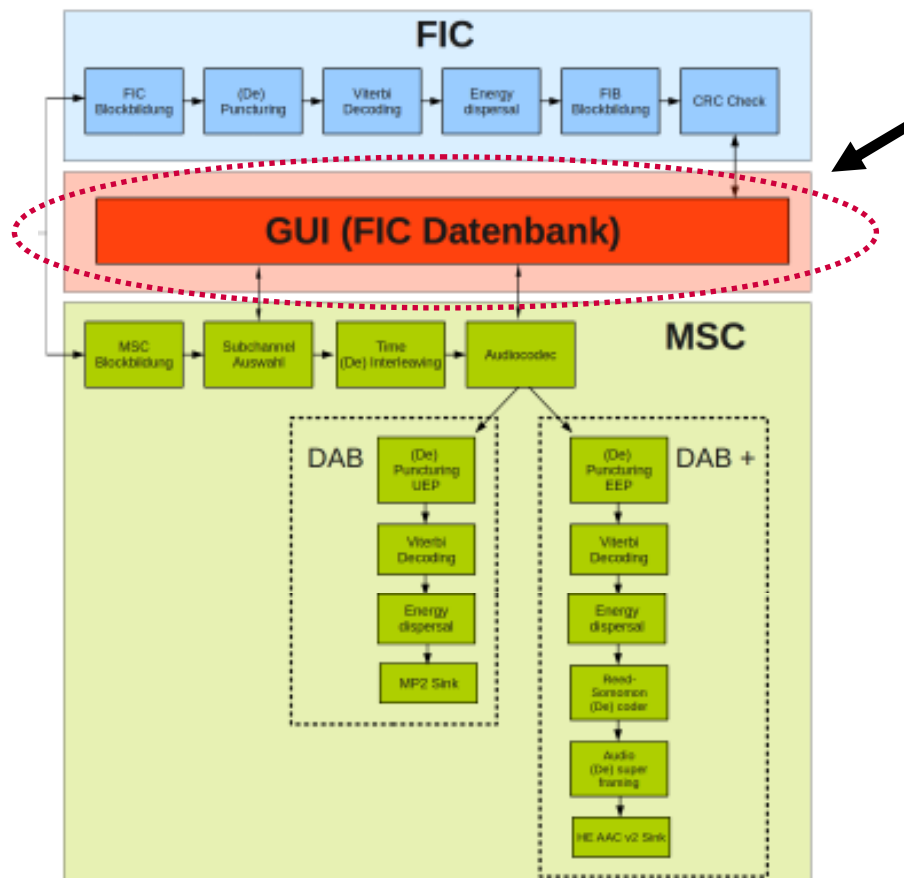
DAB Standard (FIC)



DAB Standard (FIC)

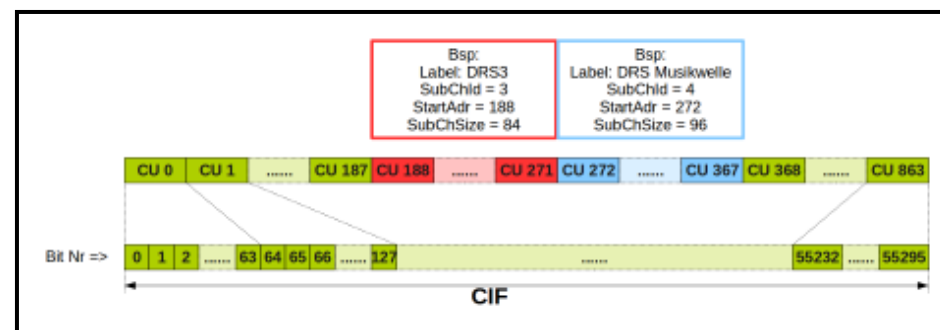
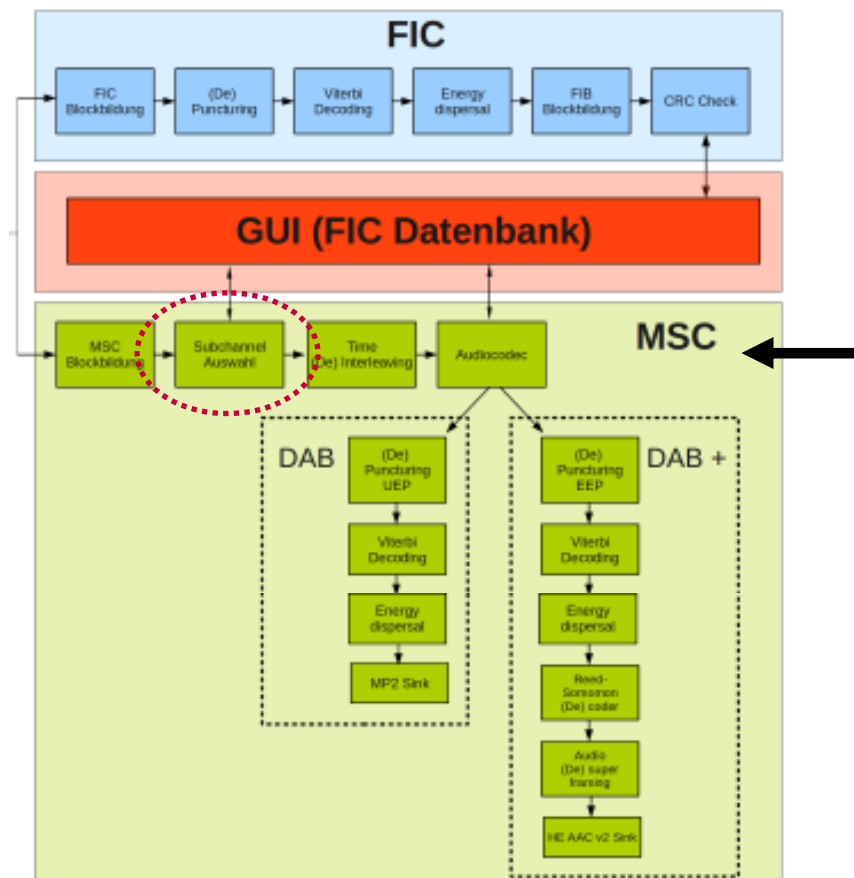


DAB Standard (Datenbank)

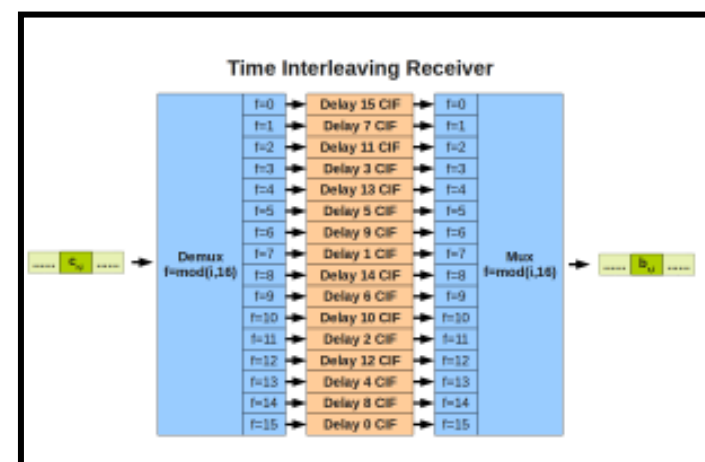
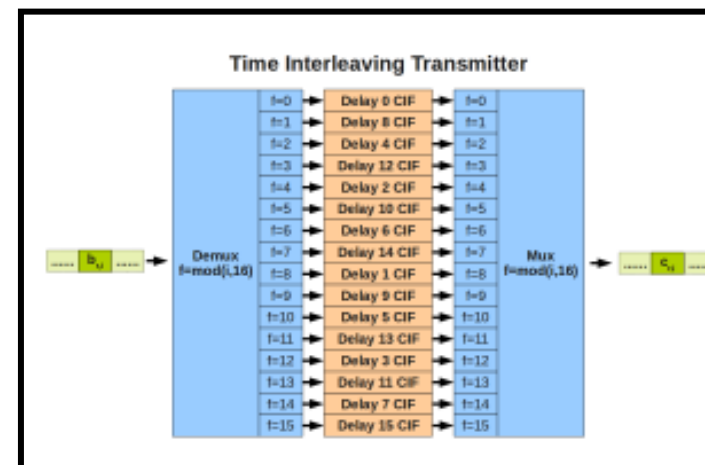
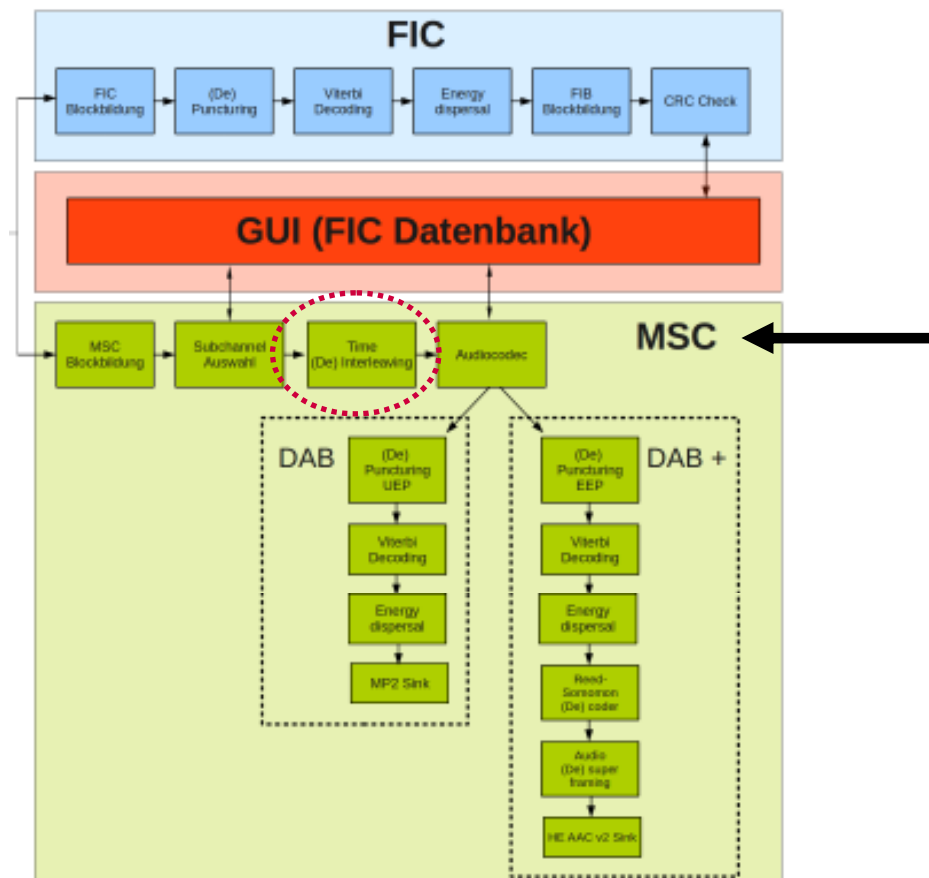


	Label	ID	Kanal	Subchan ID	Language	Start Adr	Size	Protection	ASCTy
Ensemble	SRG SSR D01	16385	12C					
Services	DRS 3	17331		3	German	188	84	UEP 4	0
	DRS Musikwelle	17332		4	German	272	96	UEP 3	0
								
Ensemble	SMC_D02	16386	7D					
Services	Energy Zuerich+	20243		6	German	240	48	EEP 3A	63
								
								

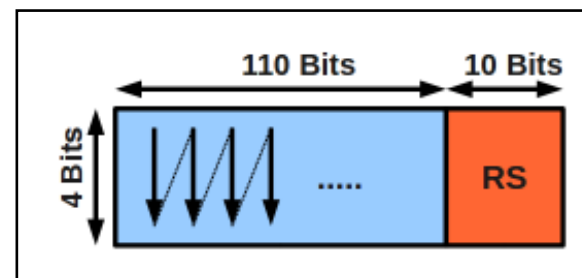
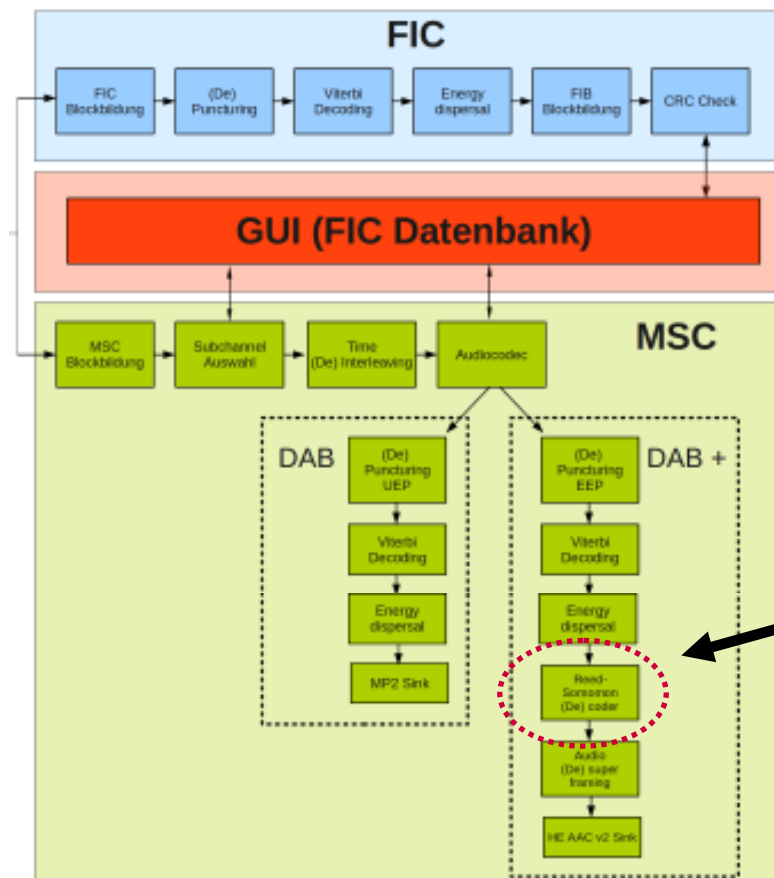
DAB Standard (MSC)



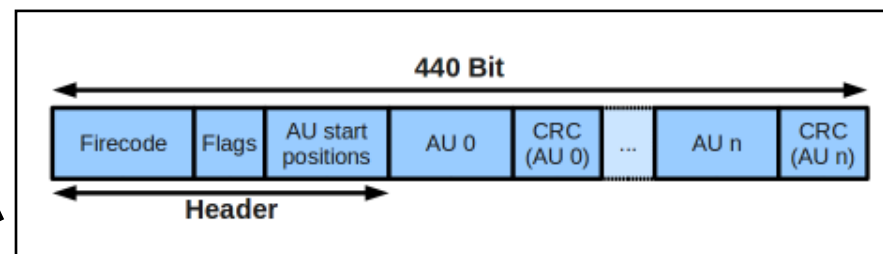
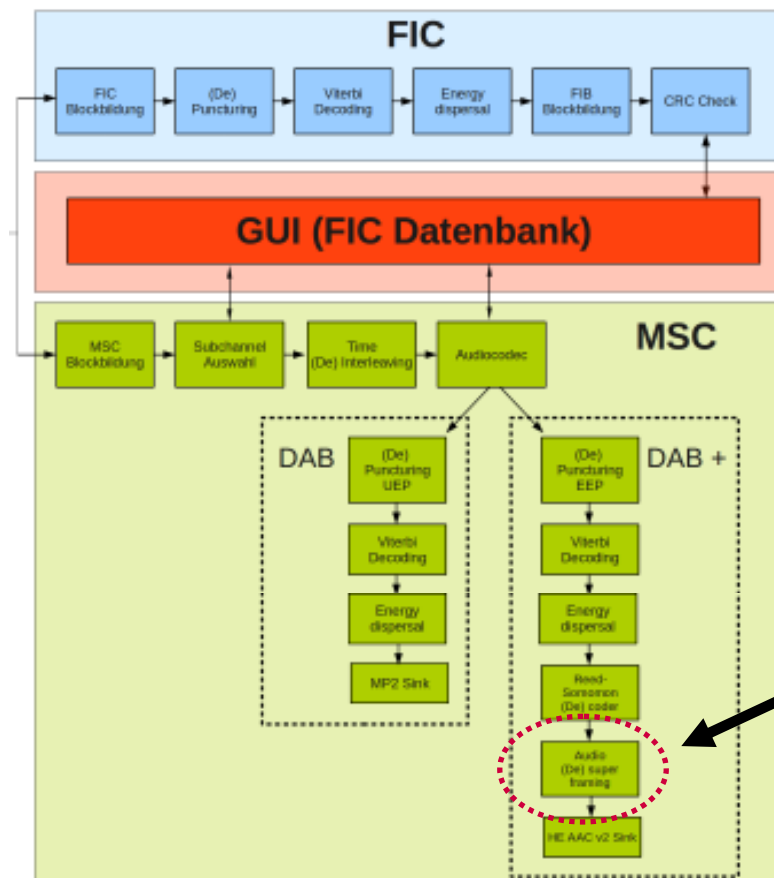
DAB Standard (MSC)



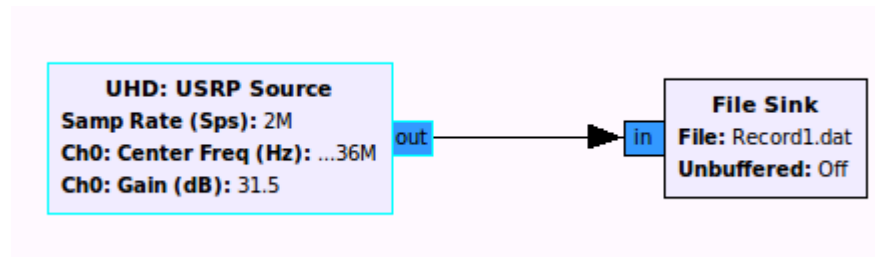
DAB Standard (MSC)



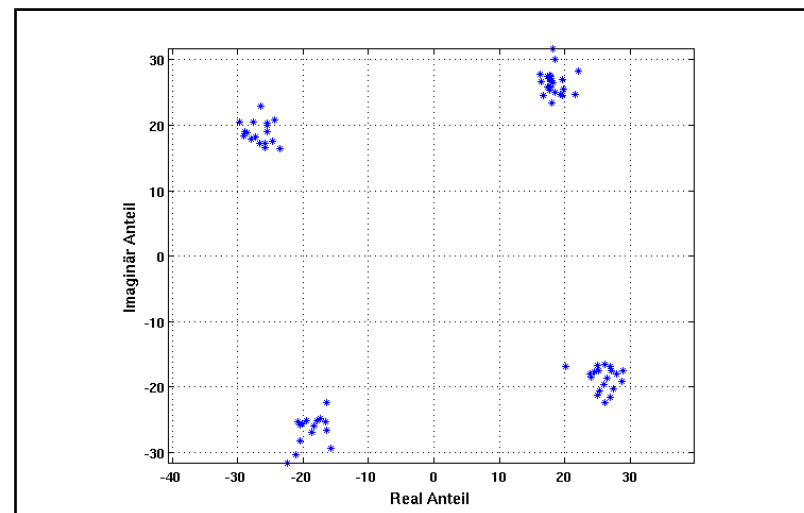
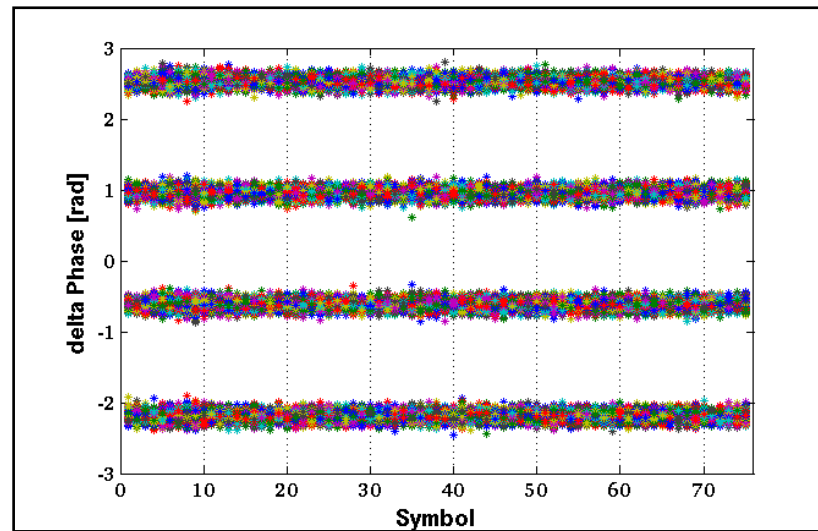
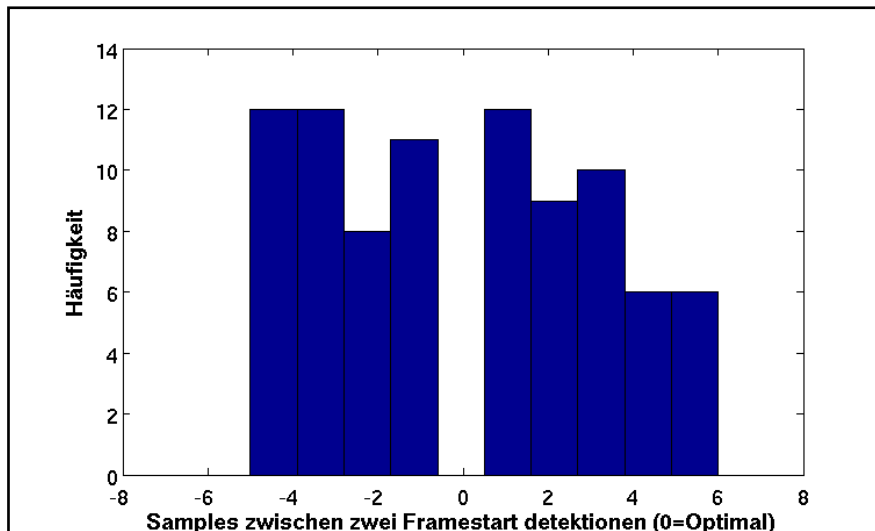
DAB Standard (MSC)



Matlabsimulation (Signalaufzeichnung)



Matlabsimulation (Frame- Analyse)



Matlabsimulation (FIC)

```
Type: 0 Extension: 0 C/N: 0 OE: 0 P/D: 0 EId: 16385 ChangeFlag: 0 ALFlag: 0 CIFCount: 75 OccurrenceChange: 176
Type: 0 Extension: 2 C/N: 0 OE: 0 P/D: 0 SId: 17385 MSC stream audio ASCTy: 63 SubChId: 10 P/S: 1 CAFlag: 0
    SId: 17332 MSC stream audio ASCTy: 0 SubChId: 4 P/S: 1 CAFlag: 0
    SId: 17373 MSC stream audio ASCTy: 63 SubChId: 13 P/S: 1 CAFlag: 0
    SId: 17329 MSC stream audio ASCTy: 0 SubChId: 1 P/S: 1 CAFlag: 0
    SId: 17334 MSC stream audio ASCTy: 0 SubChId: 12 P/S: 1 CAFlag: 0
Type: 1 Extension: 1 OE: 0 Charset: 0 SId: 17329 Service Label: DRS 1
Type: 1 Extension: 1 OE: 0 Charset: 0 SId: 17137 Service Label: CH-POP
Type: 0 Extension: 10 C/N: 0 OE: 0 P/D: 0 Date: 2011/03/28 Time: 12:53 UTC
Type: 0 Extension: 1 C/N: 0 OE: 0 P/D: 0 SubChID: 2 StartAdr: 84 UEP ProtLevel: 4 SubChSize: 104 BitRate: 160
    SubChID: 8 StartAdr: 632 UEP ProtLevel: 4 SubChSize: 70 BitRate: 112
    SubChID: 7 StartAdr: 548 UEP ProtLevel: 4 SubChSize: 84 BitRate: 128
    SubChID: 9 StartAdr: 702 UEP ProtLevel: 3-A SubChSize: 24
    SubChID: 12 StartAdr: 785 UEP ProtLevel: 3 SubChSize: 42 BitRate: 56
    SubChID: 1 StartAdr: 0 UEP ProtLevel: 4 SubChSize: 84 BitRate: 128
Type: 0 Extension: 17 C/N: 0 OE: 0 P/D: 0 SId: 17369 S/D: 0 P/S: 0 CCFlag: 0 IntCode: 3 French
    SId: 17332 S/D: 0 P/S: 0 CCFlag: 0 IntCode: 26 German
    SId: 17137 S/D: 0 P/S: 0 CCFlag: 0 IntCode: 10 German
    SId: 17138 S/D: 0 P/S: 0 CCFlag: 0 IntCode: 13 German
Type: 1 Extension: 0 OE: 0 Charset: 0 EId: 16385 Ensemble Label: SRG SSR D01
Type: 0 Extension: 9 C/N: 0 OE: 0 P/D: 0 LTO: +2.0h ECC: 225 InterTabId: 1
Type: 0 Extension: 5 C/N: 0 OE: 0 P/D: 0 MSC Stream SubChId: 10 Italian
    MSC Stream SubChId: 6 German
    MSC Stream SubChId: 4 German
    MSC Stream SubChId: 11 Romansh
    MSC Stream SubChId: 8 German
    MSC Stream SubChId: 13 English
```

Matlabsimulation (Audiocodec)

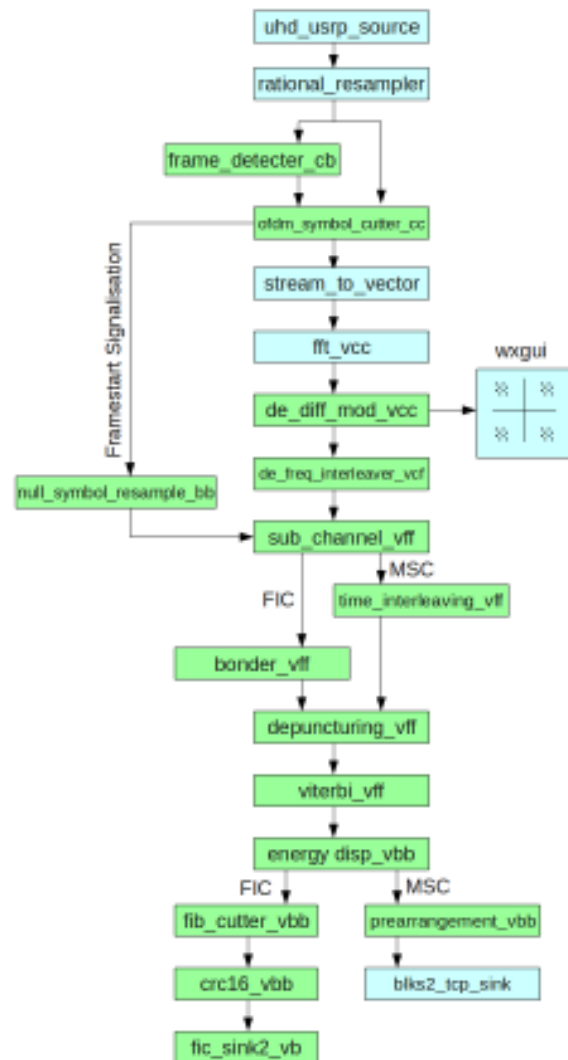
DAB

~~**DAB+**~~



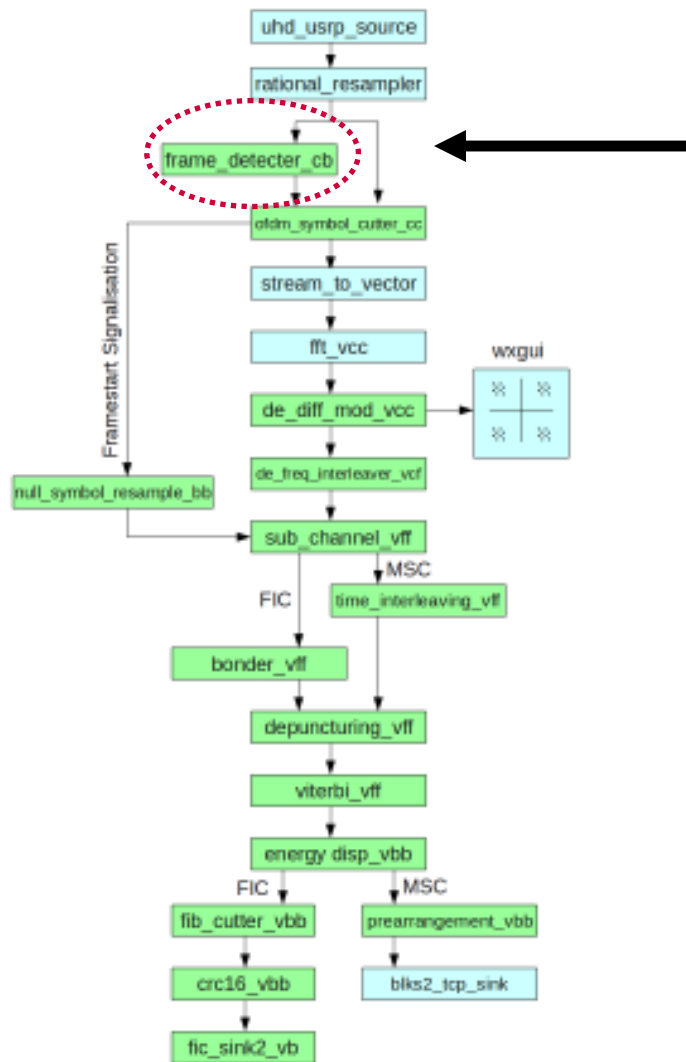
VLC Player

Implementation (Python Flow Graph)



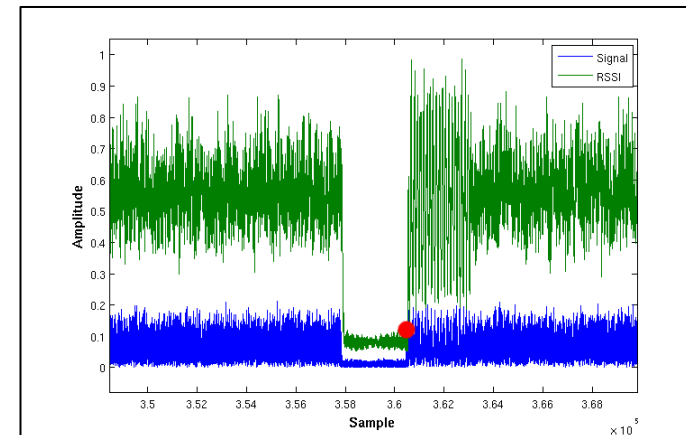
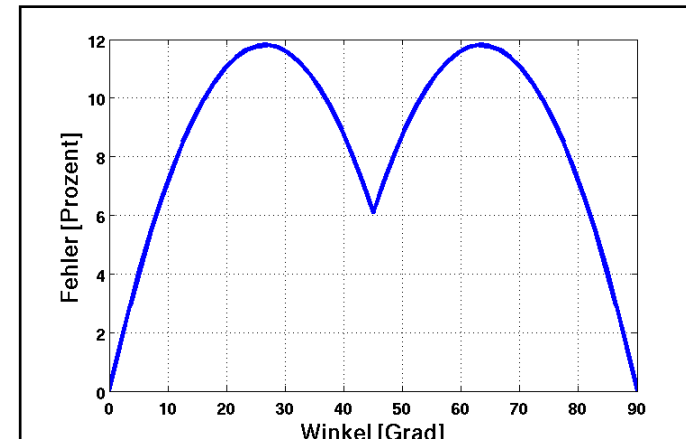
C++ Blöcke

Implementation

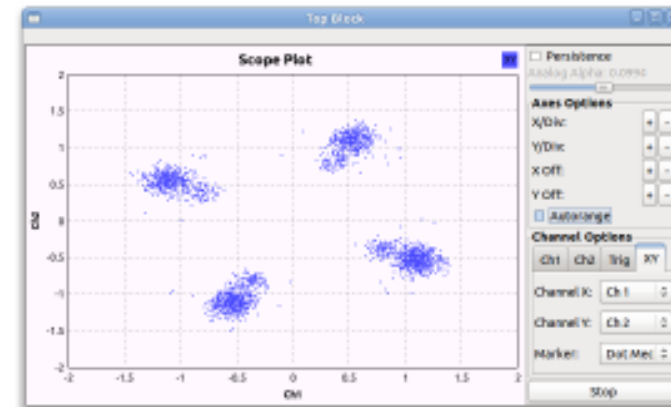
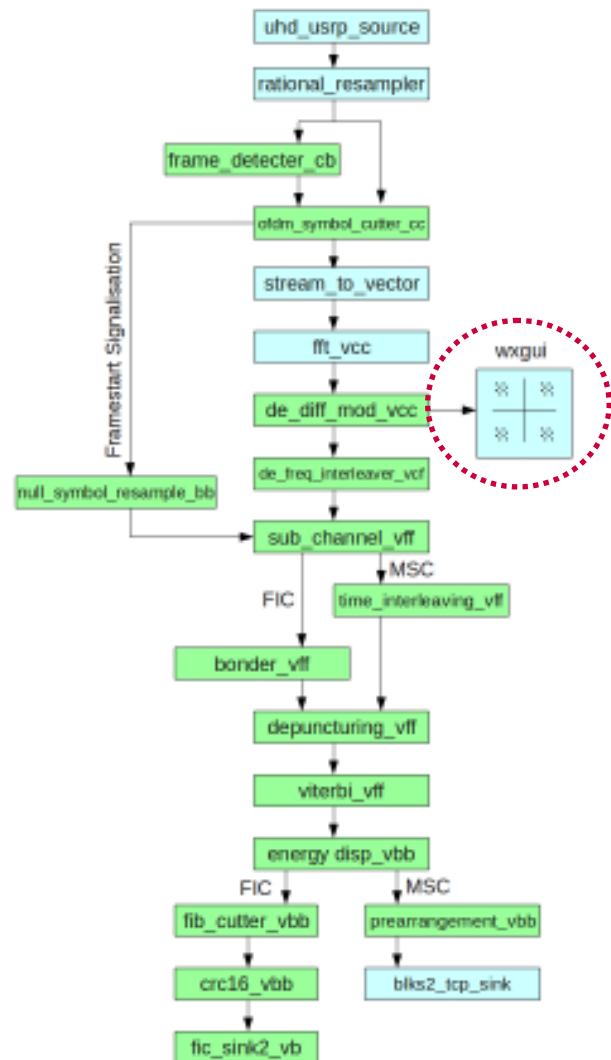


Pythagoras-Näherung:

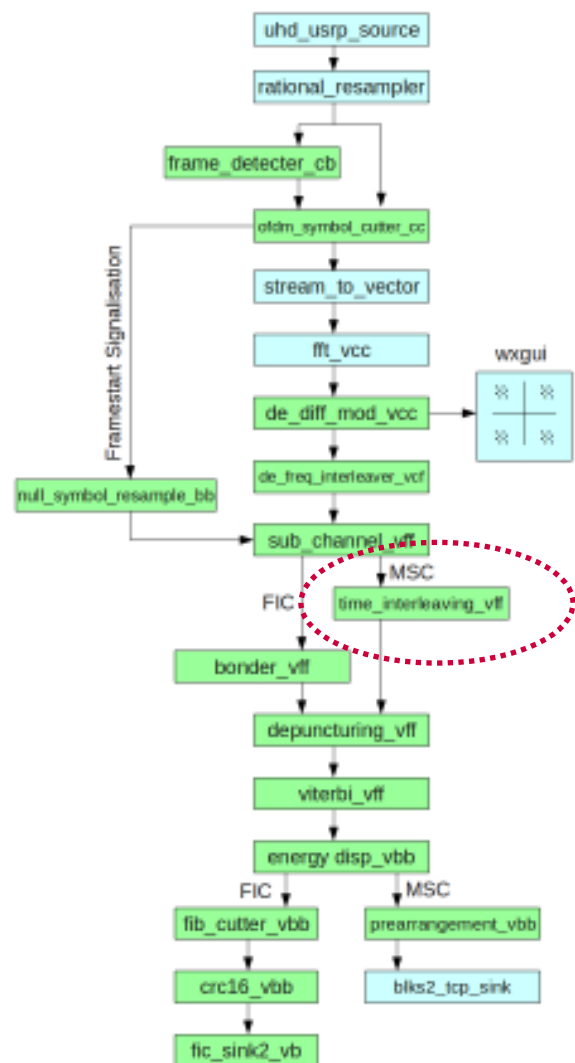
$$\text{Hypotenuse} = \max(\text{Ankathete}, \text{Gegenkathete}) + \min(\text{Ankathete}, \text{Gegenkathete}) / 2$$



Implementation



Implementation



Input:



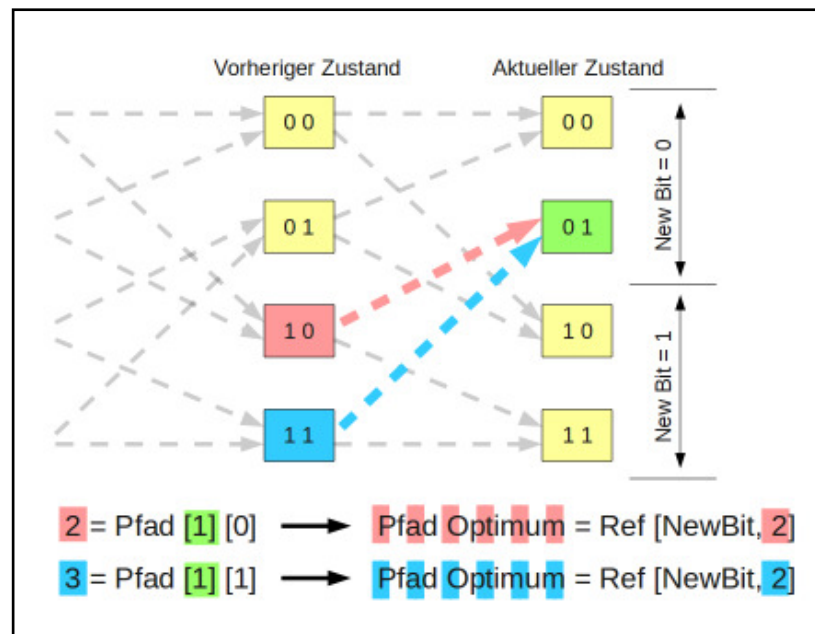
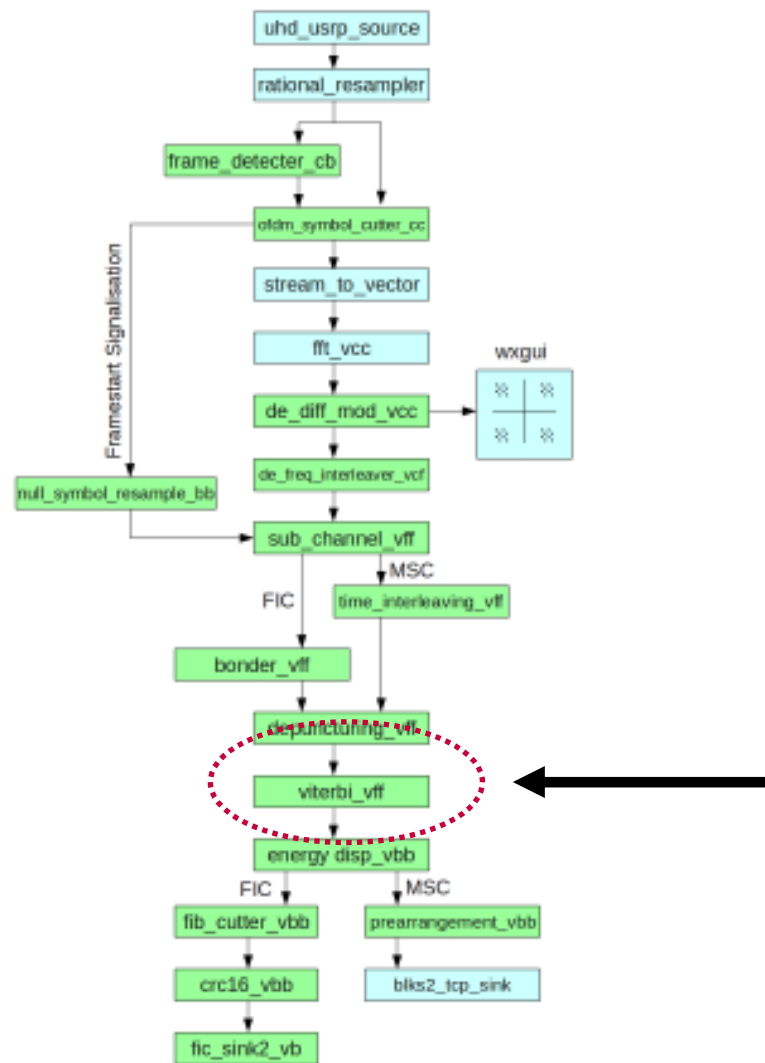
dataArray:



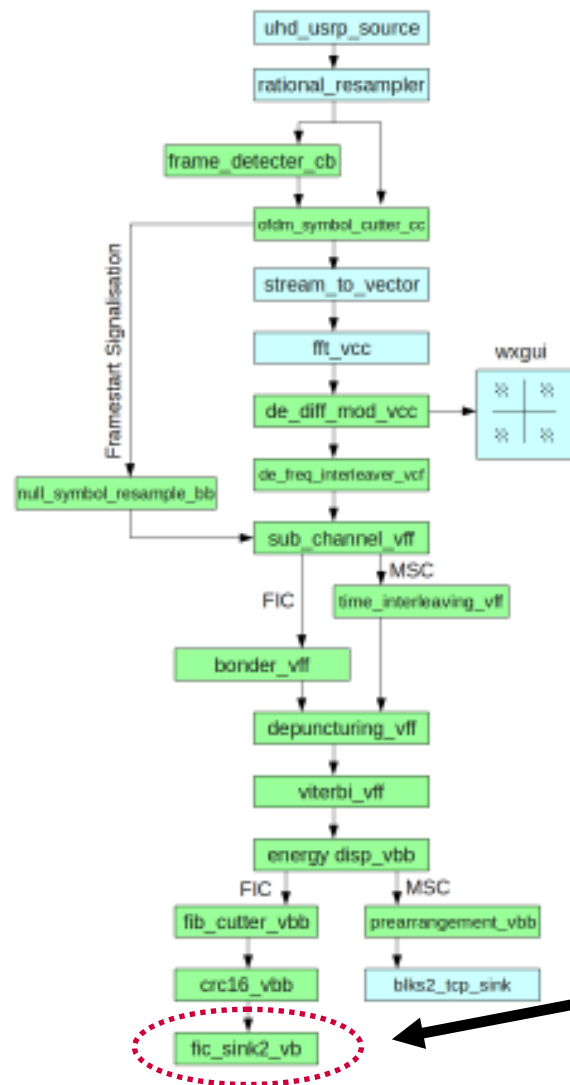
dataArray:
 (Rotiert um 1* CIF , bereit für Daten des nächsten CIFs)



Implementation



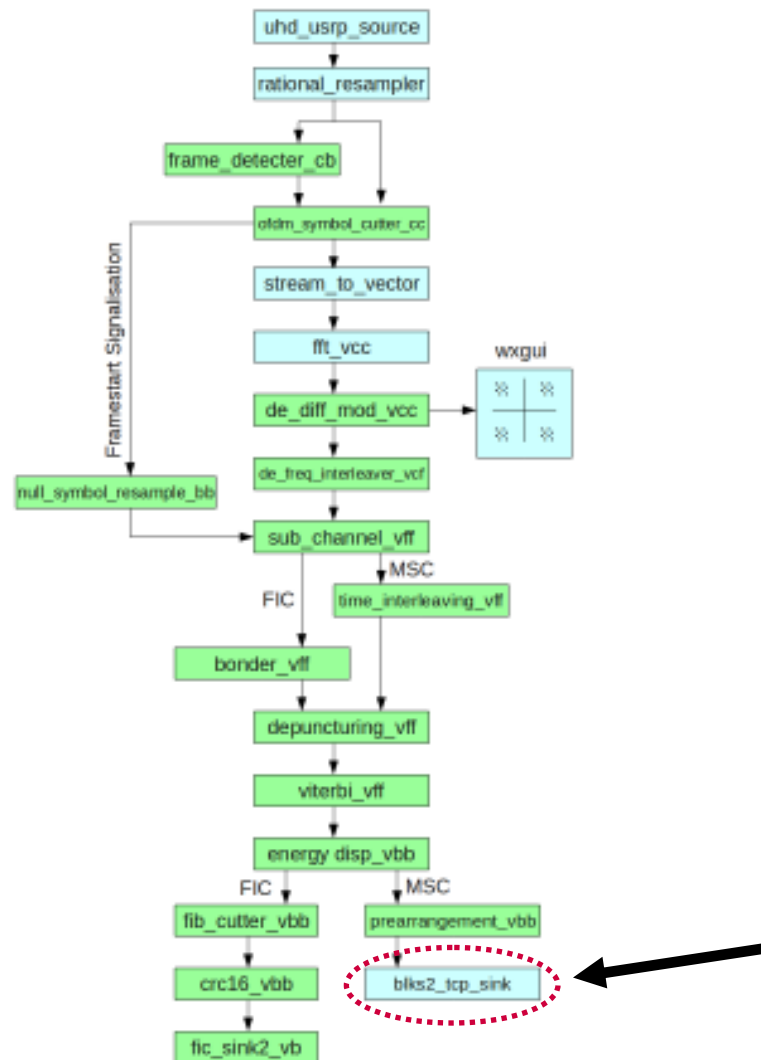
Implementation



```
holm@holm-OptiPlex-750: ~/NewWorkDAB
File Edit View Search Terminal Help
Ensemble-Time: 2011/07/28 15:16:04 +02:00
DRS 1 SubChan: 1 SID: 17329 StartAdr: 0 Size: 84 EEP: 0 Level: 4 kbit/s: 128 ASCTy: 0
DRS 2 SubChan: 2 SID: 17330 StartAdr: 84 Size: 104 EEP: 0 Level: 4 kbit/s: 160 ASCTy: 0
DRS 3 SubChan: 3 SID: 17331 StartAdr: 188 Size: 84 EEP: 0 Level: 4 kbit/s: 128 ASCTy: 0
DRS MUSIKMELLE SubChan: 4 SID: 17332 StartAdr: 272 Size: 96 EEP: 0 Level: 3 kbit/s: 128 ASCTy: 0
DRS Virus SubChan: 5 SID: 17333 StartAdr: 368 Size: 96 EEP: 0 Level: 3 kbit/s: 128 ASCTy: 0
CH-POP SubChan: 6 SID: 17137 StartAdr: 464 Size: 84 EEP: 0 Level: 4 kbit/s: 128 ASCTy: 0
CH-CLASSIC SubChan: 7 SID: 17138 StartAdr: 548 Size: 84 EEP: 0 Level: 4 kbit/s: 128 ASCTy: 0
CH-JAZZ SubChan: 8 SID: 17139 StartAdr: 632 Size: 70 EEP: 0 Level: 4 kbit/s: 112 ASCTy: 0
RSR-1ERE+ SubChan: 9 SID: 17369 StartAdr: 702 Size: 24 EEP: 1 Level: 3-A kbit/s: 32 ASCTy: 63
RETE UNO+ SubChan: 10 SID: 17385 StartAdr: 726 Size: 24 EEP: 1 Level: 3-A kbit/s: 32 ASCTy: 63
RR-SRG SubChan: 11 SID: 17313 StartAdr: 750 Size: 35 EEP: 0 Level: 4 kbit/s: 56 ASCTy: 0
DRS 4 NEWS SubChan: 12 SID: 17334 StartAdr: 785 Size: 42 EEP: 0 Level: 3 kbit/s: 56 ASCTy: 0
MRS+ SubChan: 13 SID: 17373 StartAdr: 827 Size: 24 EEP: 1 Level: 3-A kbit/s: 32 ASCTy: 63

.....
Choose a DAB subchannel (DAB+ not allowed): 3
```

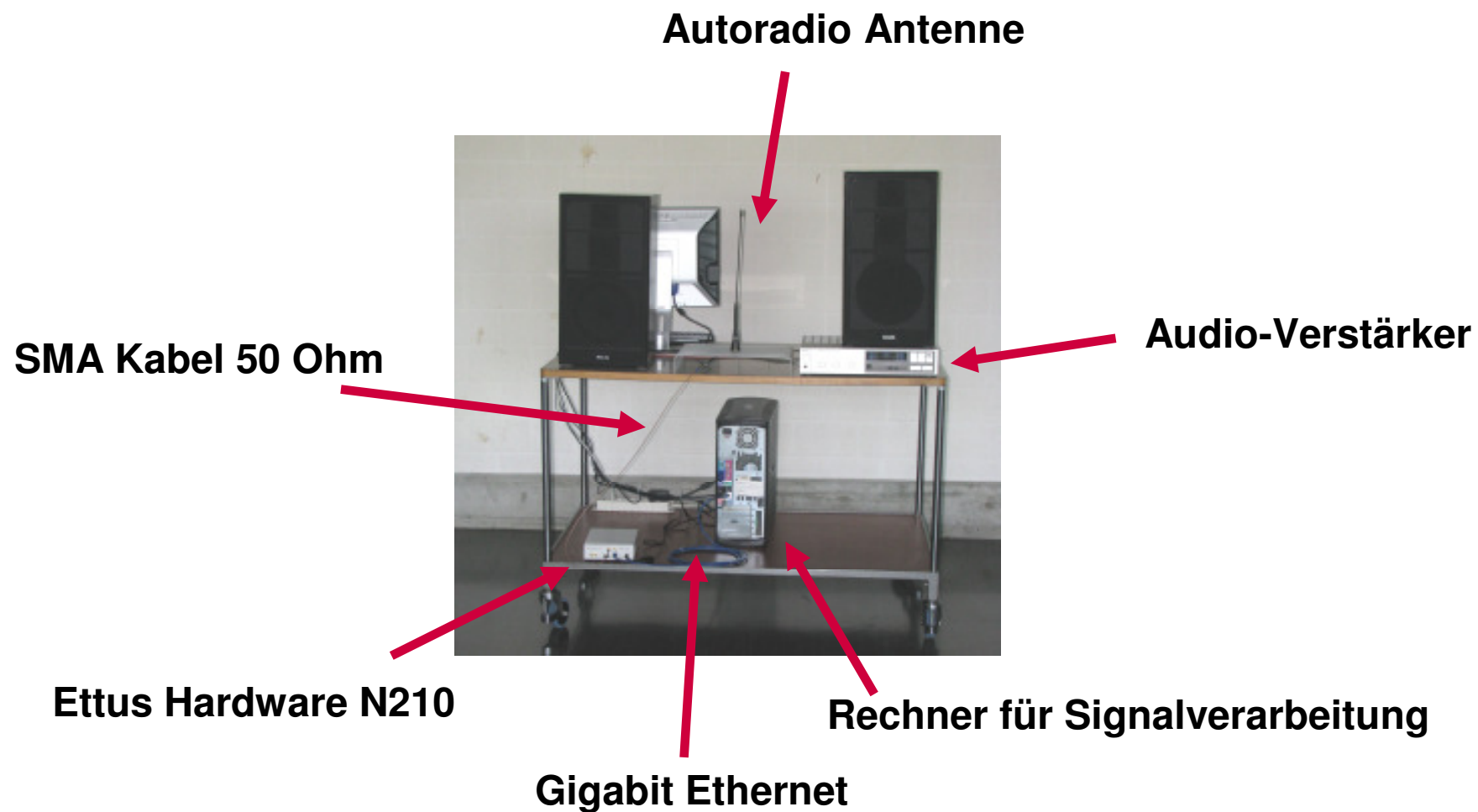
Implementation



Netzwerk, VLC Player

- DAB Matlabsimulation (Laborversuch)
- Realtime GNU DAB Radio
- Drei Vorführungsprogramme
- 19 Blöcke, die jederzeit wieder eingesetzt werden können
- Erkenntnisse über Einsatzbereiche von GNU Radio für das ZSN

- Alle Radiostationen gleichzeitig im Internet broadcasten
- Zusatzinformationen (Songtitel, Trafficinformationen) anzeigen
- Datenservices implementieren
- DAB Analysetool erstellen
- DAB Sender
- Realtime DAB Empfänger in Simulink
- (DAB+ implementieren)



Vorführung

Fragen?