SDR in Car Radios

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Catena Radio Design

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Car radio

- Analog and digital broadcast standards
  - AM, FM, OIRT, NWR
  - DAB, HD-radio, DRM, CDR
- Digital channels in analog standards
  - RDS, DARC
- Mobile
- High quality requirements
  - Weak Signal Handling
- Reception only
- Large battery ☺
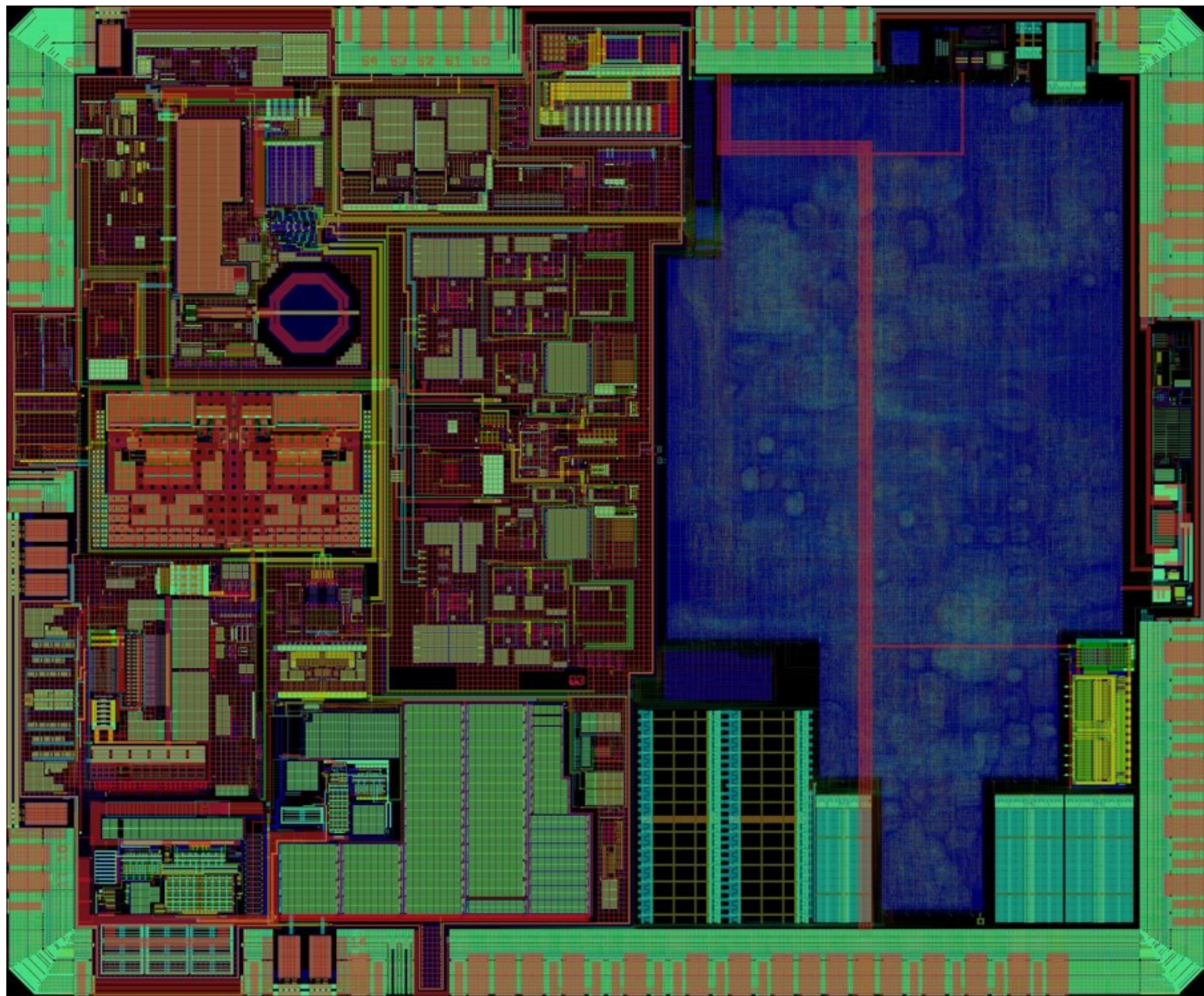 - Power dissipation 1 – 2 W

Example: Atomic2

- Single-pipe AM/FM reception
  - Including RDS

- HD-Radio and DRM tuning
  - Base band I2S interface to digital radio decoder

- Contains:
  - Analog circuitry
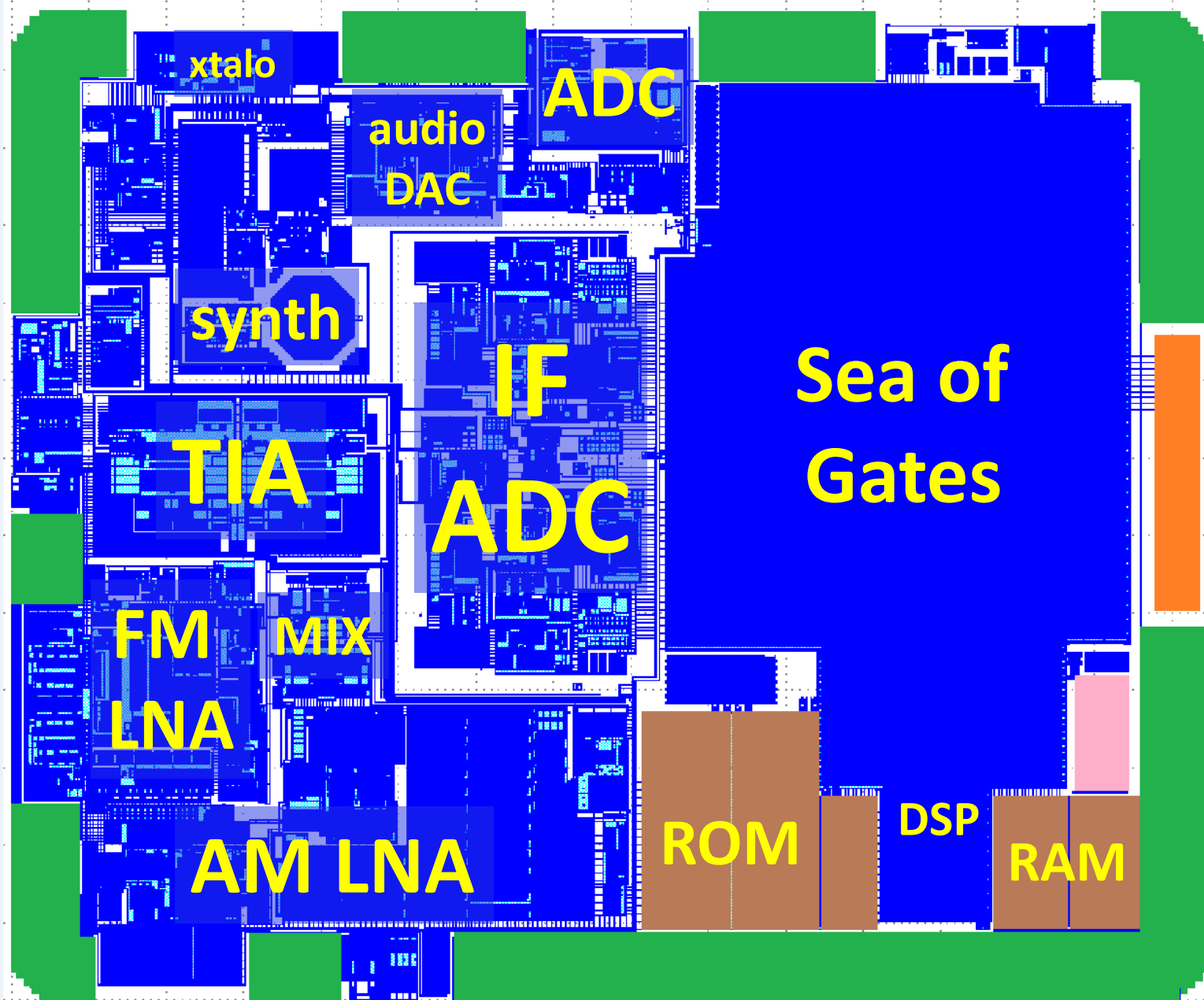 - Digital circuitry
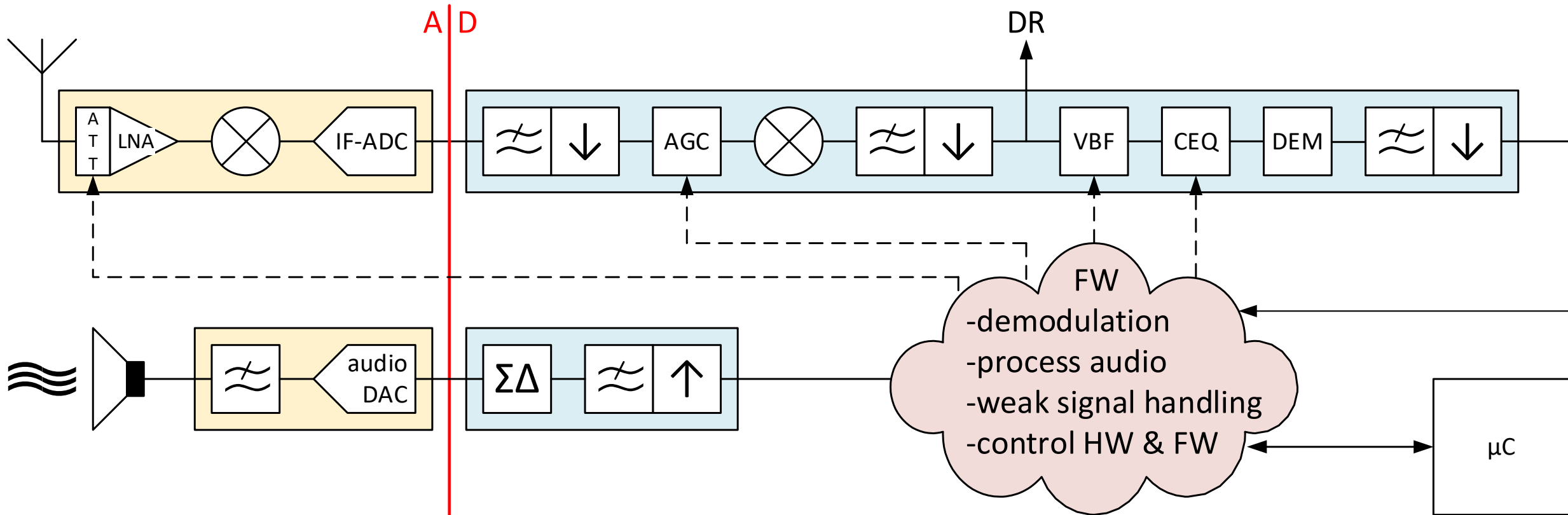 - Firmware
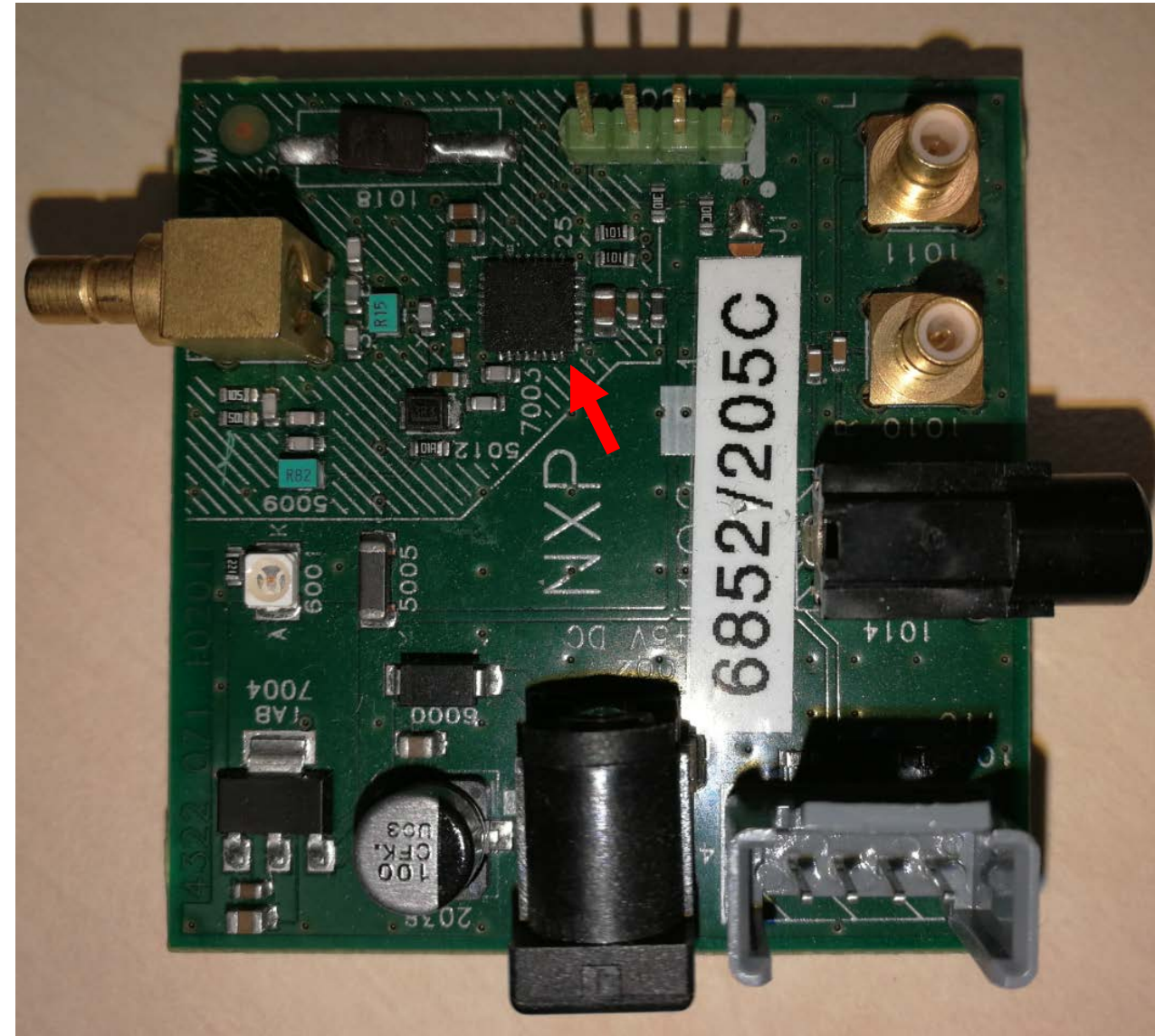
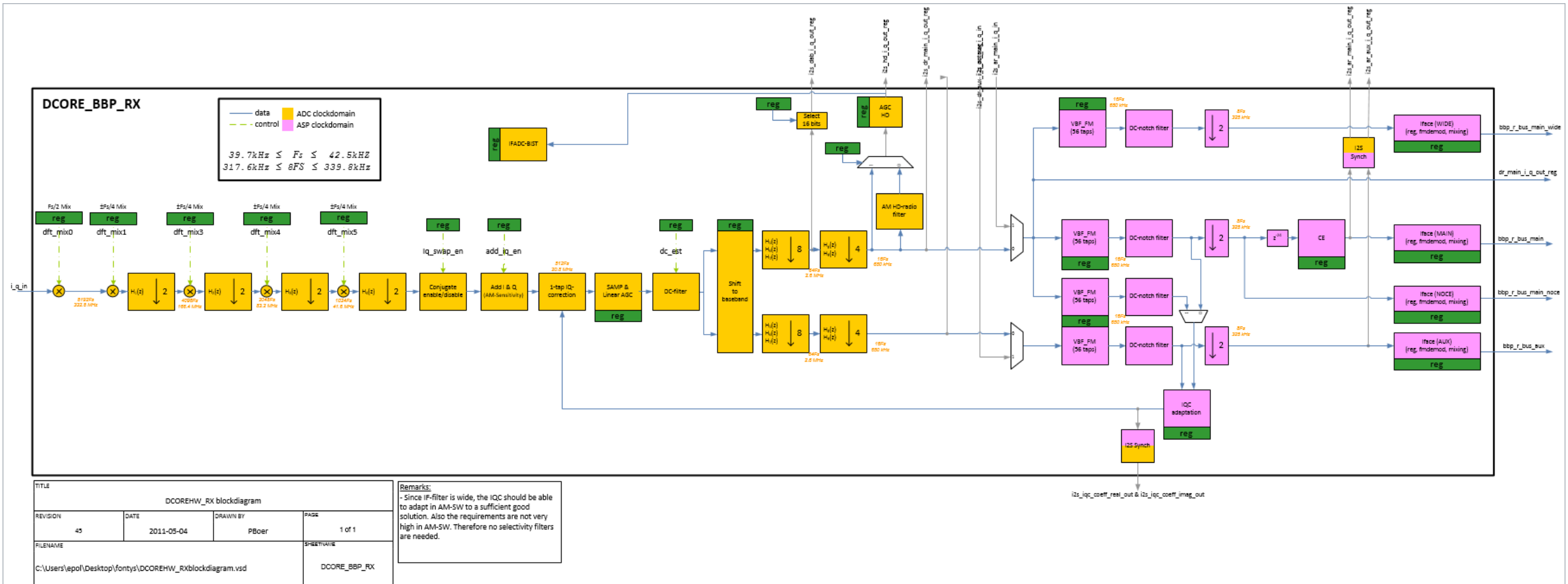# Functional system overview
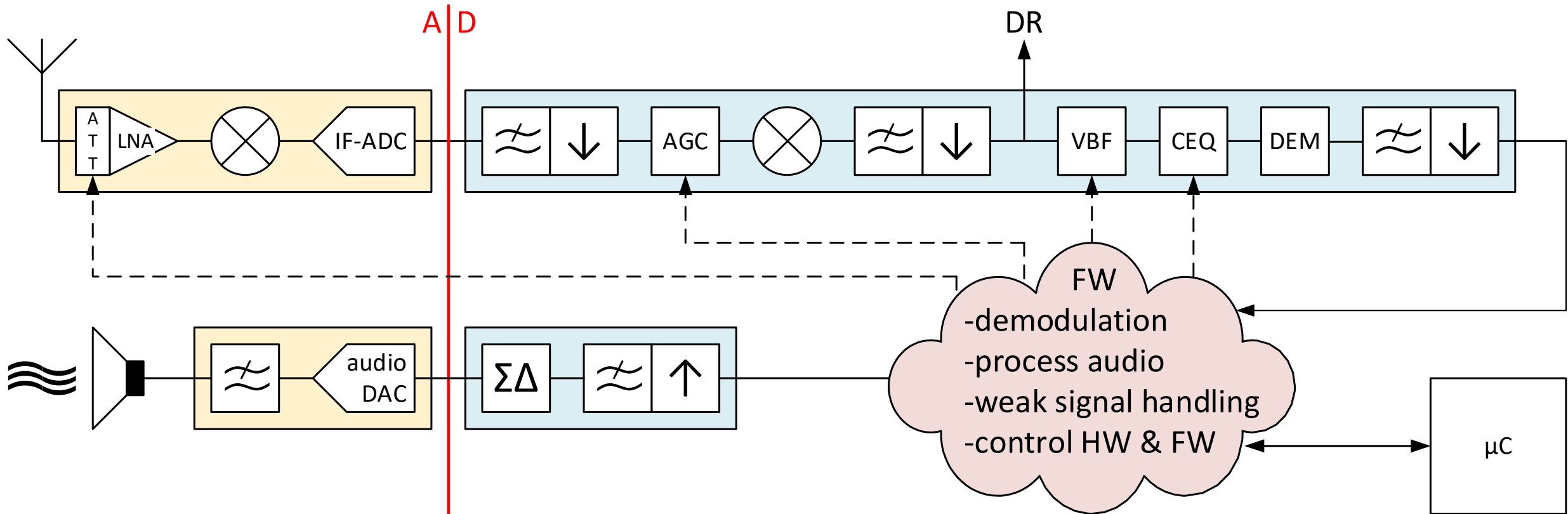
Die layout (I)

Die layout (II)

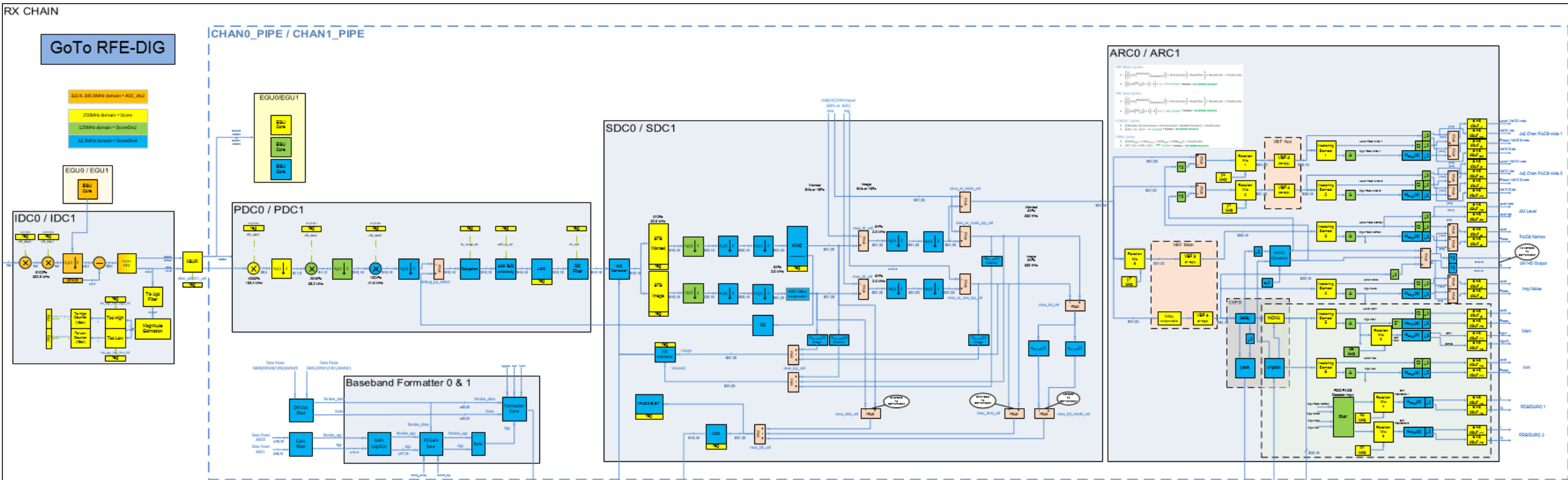# Functional system overview

Hardwired signal processing (I)

Hardwired signal processing (II)

Design complexities

- Analog Design:
  - Performance requirements
    - Noise, linearity, area, power consumption

- Digital Design:
  - Signal processing accuracy & functionality

- Firmware Design:
  - Adaptive signal processing
  - Control of signal processing in HW and FW
  - Real-Time operation

FW architecture

- Main FW modules:
  - Command processing
  - Resource management
  - Event handling
  - Signal processing
  - Drivers
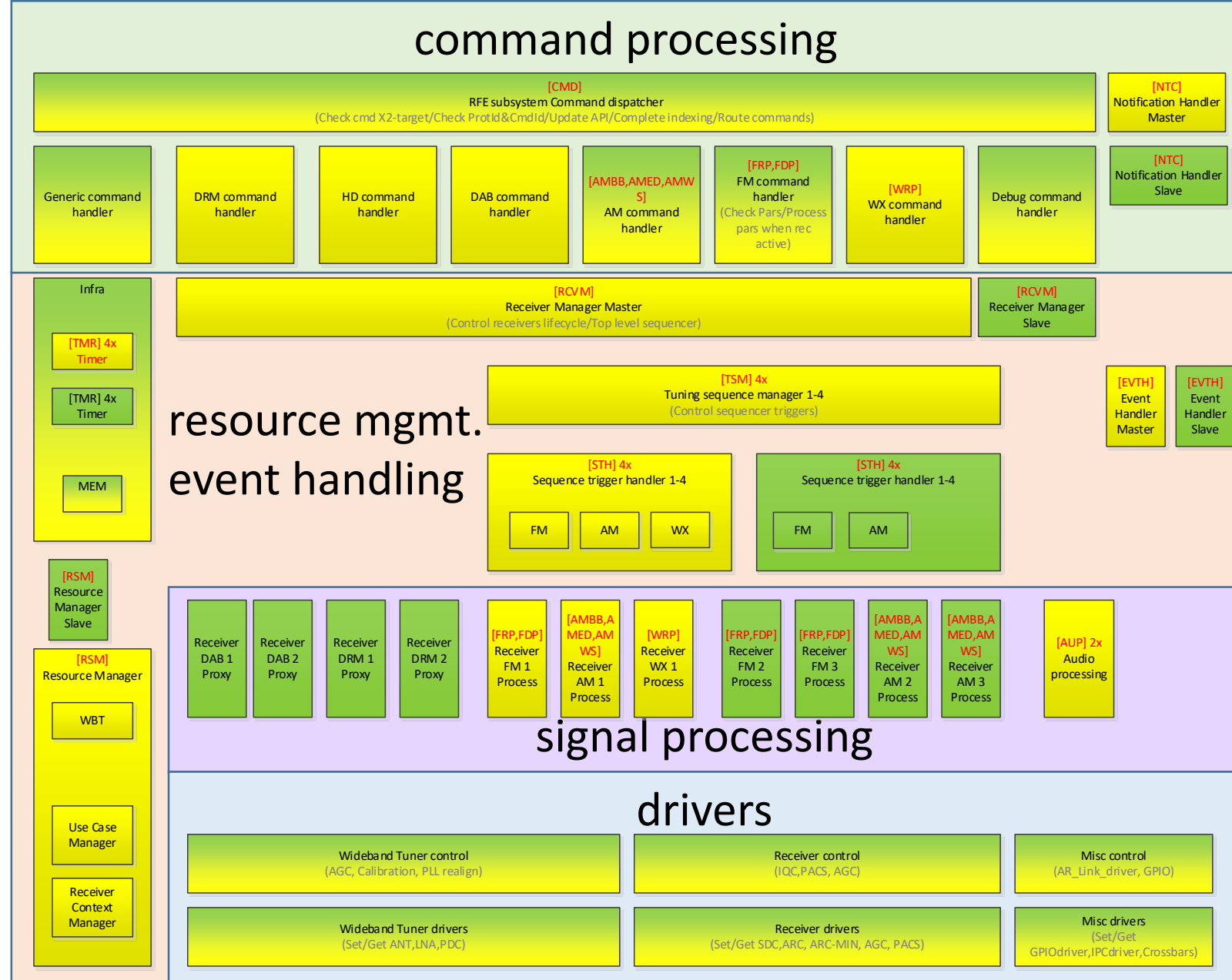
Timeline diagram for "tune" command
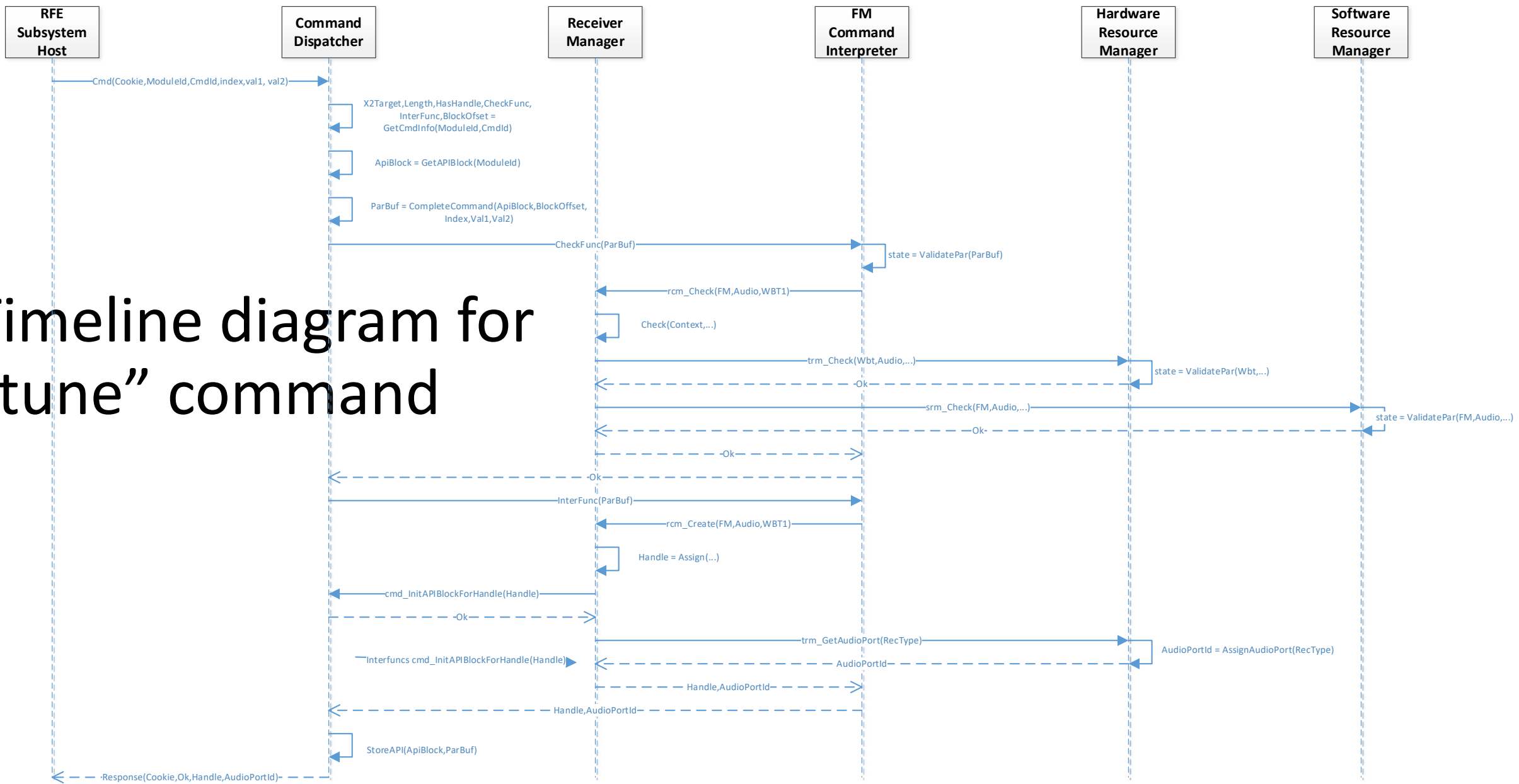
SDR in Digital Radio reception

- Some baseband processing is done in HW
  - E.g, DAB base band sample rate is 2 Msamples/s
  - Some Sample Rate Conversion (SRC) is required to lock onto transmitter
  - Locking onto transmitter is needed in order to obtain useful spectra
- After SRC, the baseband signal is analyzed in the spectral domain
  - Fourier transform is executed in FW on a powerful DSP
  - SRC is adjusted based on results of spectral transform
- Two independent signals may be combined at this point
  - Option if the car has two physically separated antennas
  - FW Algorithm deployed is called Maximum Ratio Combining (MRC)
- Then, fully FW-based decoding of multiple data streams can proceed

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Development of new features

- Development platforms need to be programmable
  - MatLab on PC for off-line simulation
    - Feasibility studies
  - FPGA implementation for real-time execution
    - Long settling/measurement time intervals
    - Field tests

- Sometimes previous products can be used to develop new features

Conclusion

- Car radio products contain analog and digital circuitry, and firmware
- The analog and digital parts make a (very) good stationary radio
- The firmware content makes the product a great car radio

- Firmware deals with
  - Dynamic circumstances
  - Weak signals
- Firmware needs to cooperate closely with hardware
  - Lots of interfaces for measurement and control
- Programmability is crucial for products and development