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Approach to Solve the AGC API Issue in the Tactical SDR Domain

A Waveform Provider Perspective

Security and mobility in a networked world.

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Scope

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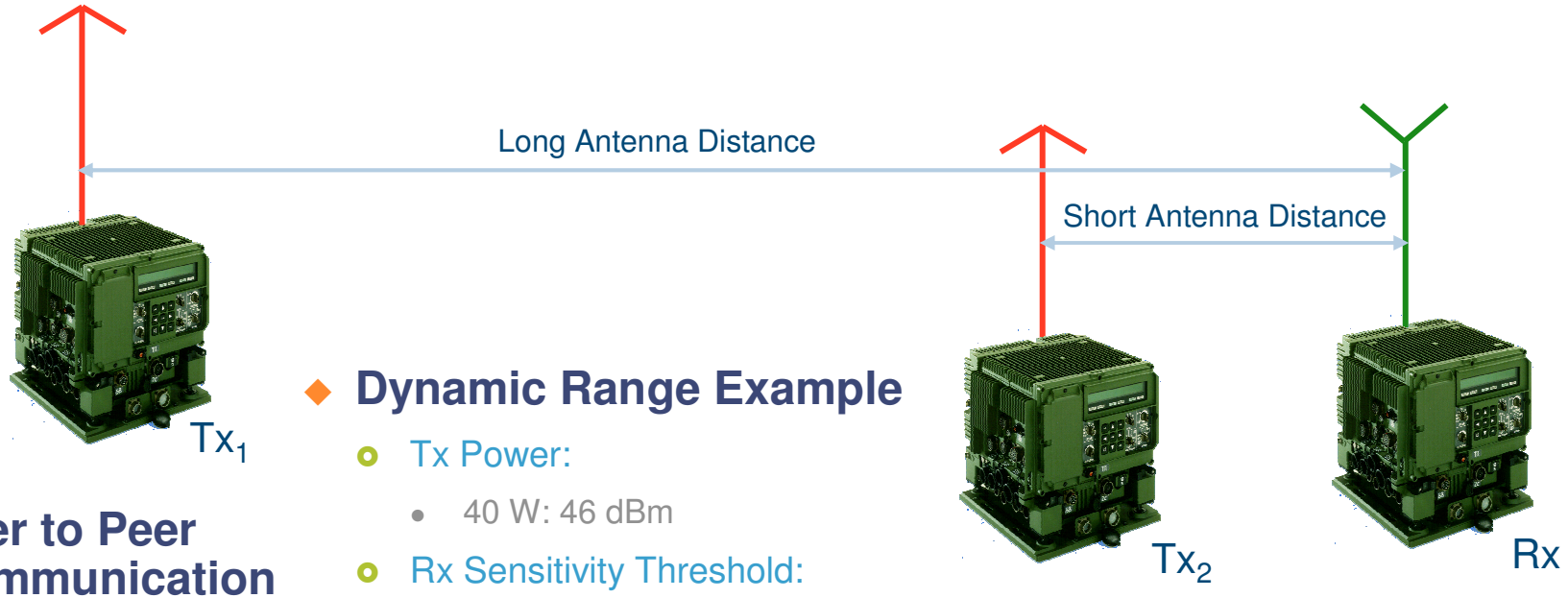
- Tactical Radio Scenario
- AGC Principle in Legacy Receiver
- AGC Principle in SDR Receiver
- SDR AGC Challenges
- WFA View on AGC
- AGC API Concept
- AGC API Summary
- Conclusion

Tactical Radio Scenario

Near-Far Situation



- **Peer to Peer Communication**
  - No uplink/downlink frequency spacing
- **Collocated Transmitters**
  - Minimum distances:
    - few meters

- **Dynamic Range Example**
  - Tx Power:
    - 40 W: 46 dBm
  - Rx Sensitivity Threshold:
    - 0.3 µV: -114 dBm
  - Path Loss at 2 m distance
    - 16 dB
  - Dynamic Range:
    - 144 dB

- **Extraordinary Rx Dynamic Range Requirements**

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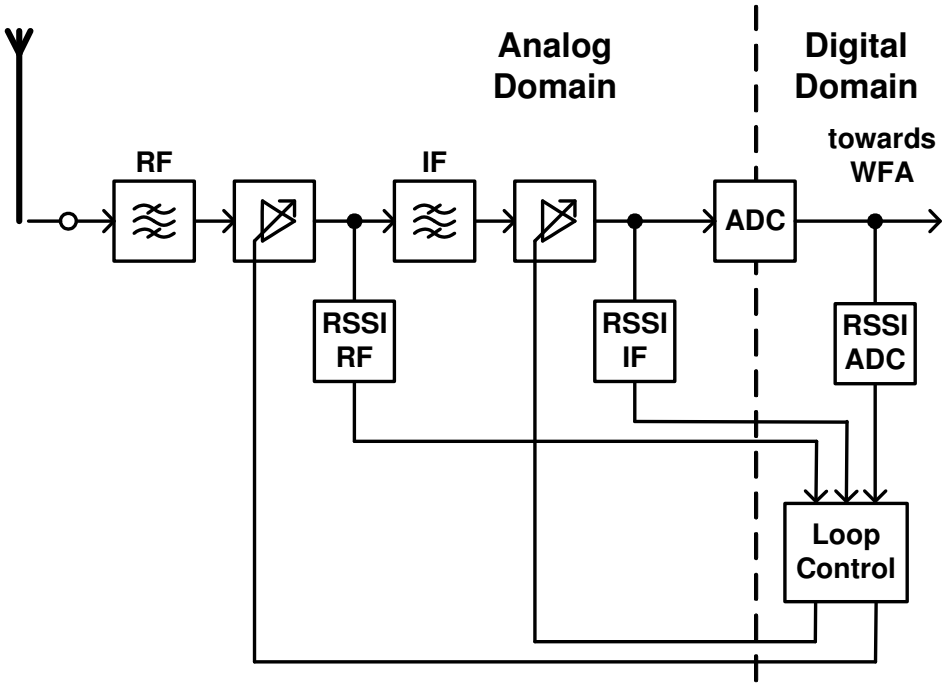
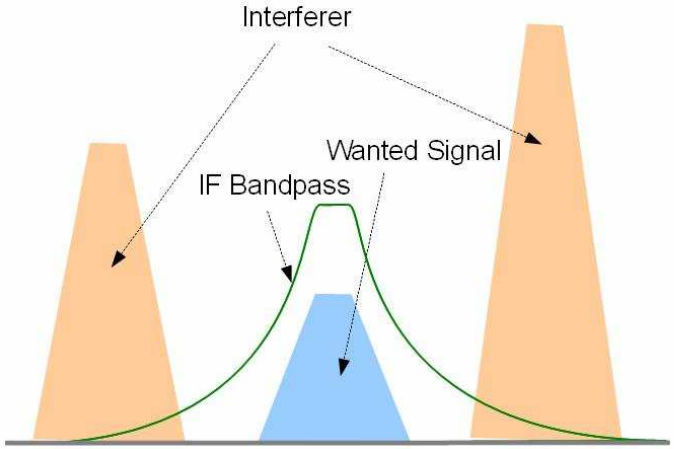
AGC Principle in Legacy Receiver

Generic AGC behavioural model





- **AGC loop dynamic optimized to**
  - waveform dynamic behaviour
  - channel dynamic due to fading
    - dependent on relative Tx – Rx speed
    - and/or reflectors
- **ADC level variation rather limited**

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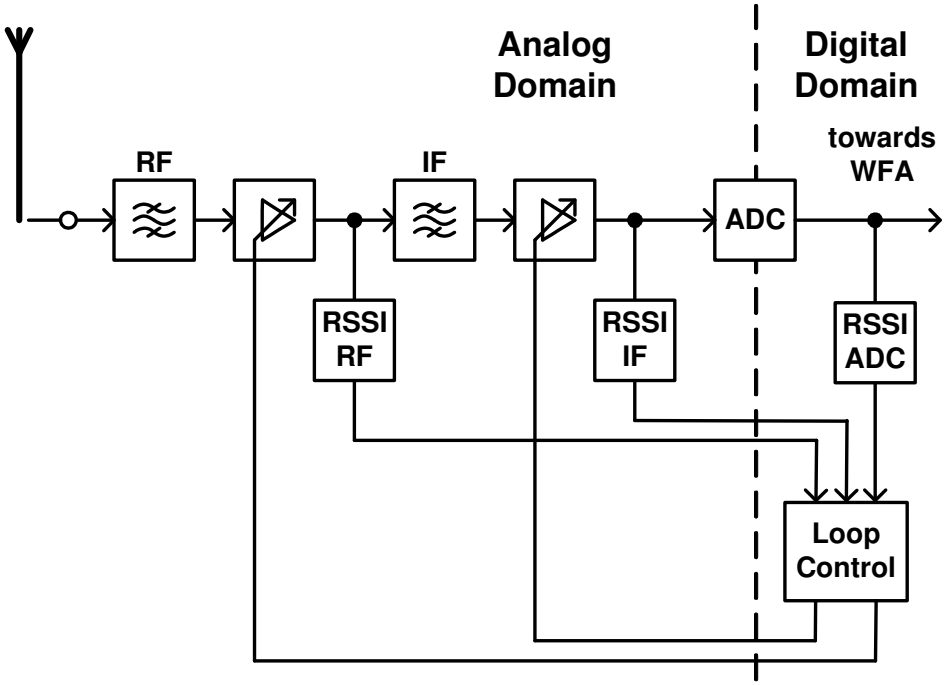
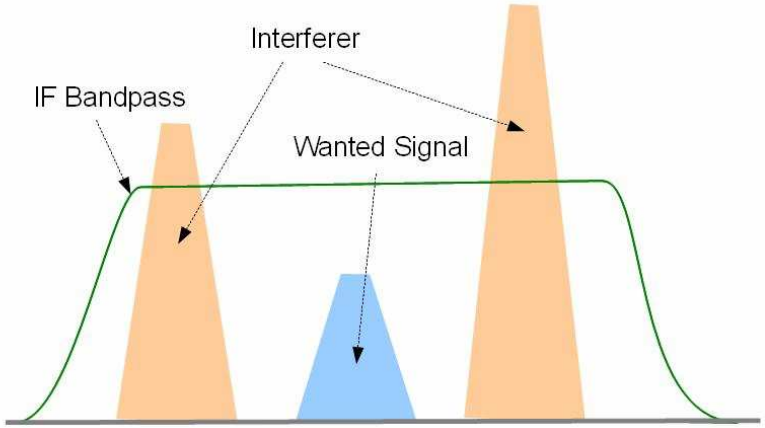
AGC Principle in SDR Receiver

Generic AGC behavioural model





- **AGC loop optimization criteria**
  - dynamic behaviour of unknown transmitters in adjacent channels
  - with unknown channel characteristica
- **ADC level variation dominated by interfering signals**

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SDR AGC Challenges (1)

Transceiver Challenges

- **ADC has to cope with high level difference between**
  - input level of the wanted signal
  - ∑ level of various dominant signals

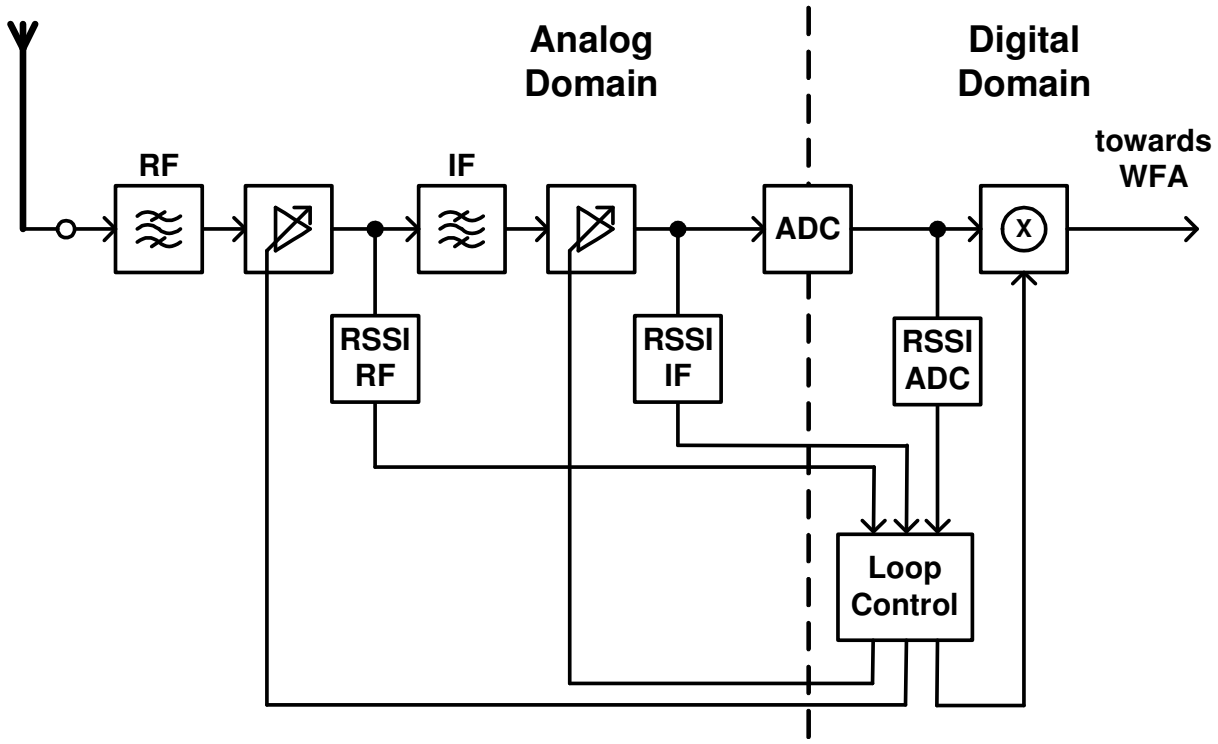
  within IF range

  ⇒ Extraordinary spurious free dynamic requirements to the ADC
- **A properly acting AGC loop will modulate the amplitude level of the wanted Rx signal**
  - inversely to the aggregate receive level of the interfering signal mixture

  ⇒ Level compensation required in transceiver Rx chain

SDR AGC Challenges (2)

Level compensation behavioural model



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SDR AGC Challenges (3)

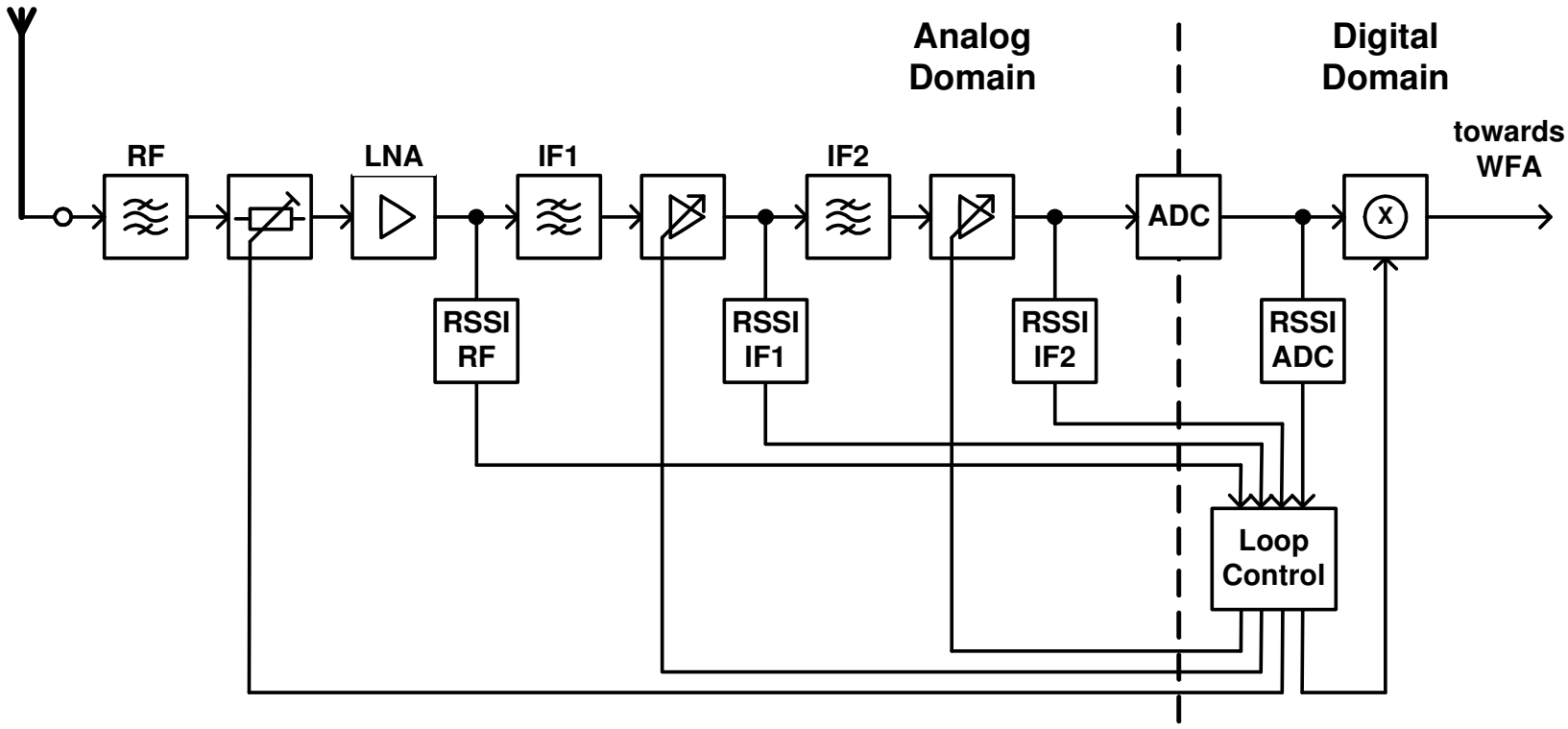
Waveform Application (WFA) Challenges

- **WFA dealing with the sampled receive signal will have to**
  - compensate the signal variations of the wanted signal by WFA internal AGC methods
  - cope with distortion effects caused by gain variations within Rx chain
  - properly control the AGC behaviour in real time
    - to minimize distortion effects impact on received information quality:
      - BER: Bit Error Rate
      - Voice intelligibility
- **WFA dealing with the sampled receive signal will not have to**
  - **deal with the internal design of the transceiver Rx chain!**

WFA View on AGC

Multi stage gain variation

- to be hidden at the platform API towards WFA



AGC API shall be intellegible from WFA designer's point of view!

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AGC API Concept (1)

Waveform Application (WFA) Challenges

- **WFA dealing with the sampled receive signal will have to**
  - compensate the signal variations of the wanted signal by WFA internal AGC methods
  - cope with distortion effects caused by gain variations within Rx chain
  - properly control the AGC behaviour in real time
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      - BER: Bit Error Rate
      - Voice intelligibility
- **WFA dealing with the sampled receive signal will not have to**
  - **deal with the internal design of the transceiver Rx chain!**

AGC API Concept (2)

Waveform Application (WFA) Challenges

- **WFA dealing with the sampled receive signal will have to**
  - compensate the signal variations of the wanted signal by WFA internal AGC methods
    - requires Software AGC within WFA
      - but no particular impact on AGC API
    - WFA issue only

AGC API Concept (3)

Waveform Application (WFA) Challenges

- **WFA dealing with the sampled receive signal will have to**
  - compensate the signal variations of the wanted signal by WFA internal AGC methods
  - cope with distortion effects caused by gain variations within Rx chain
  - properly control the AGC behaviour in real time
    - to minimize distortion effects impact on received information quality:
      - BER: Bit Error Rate
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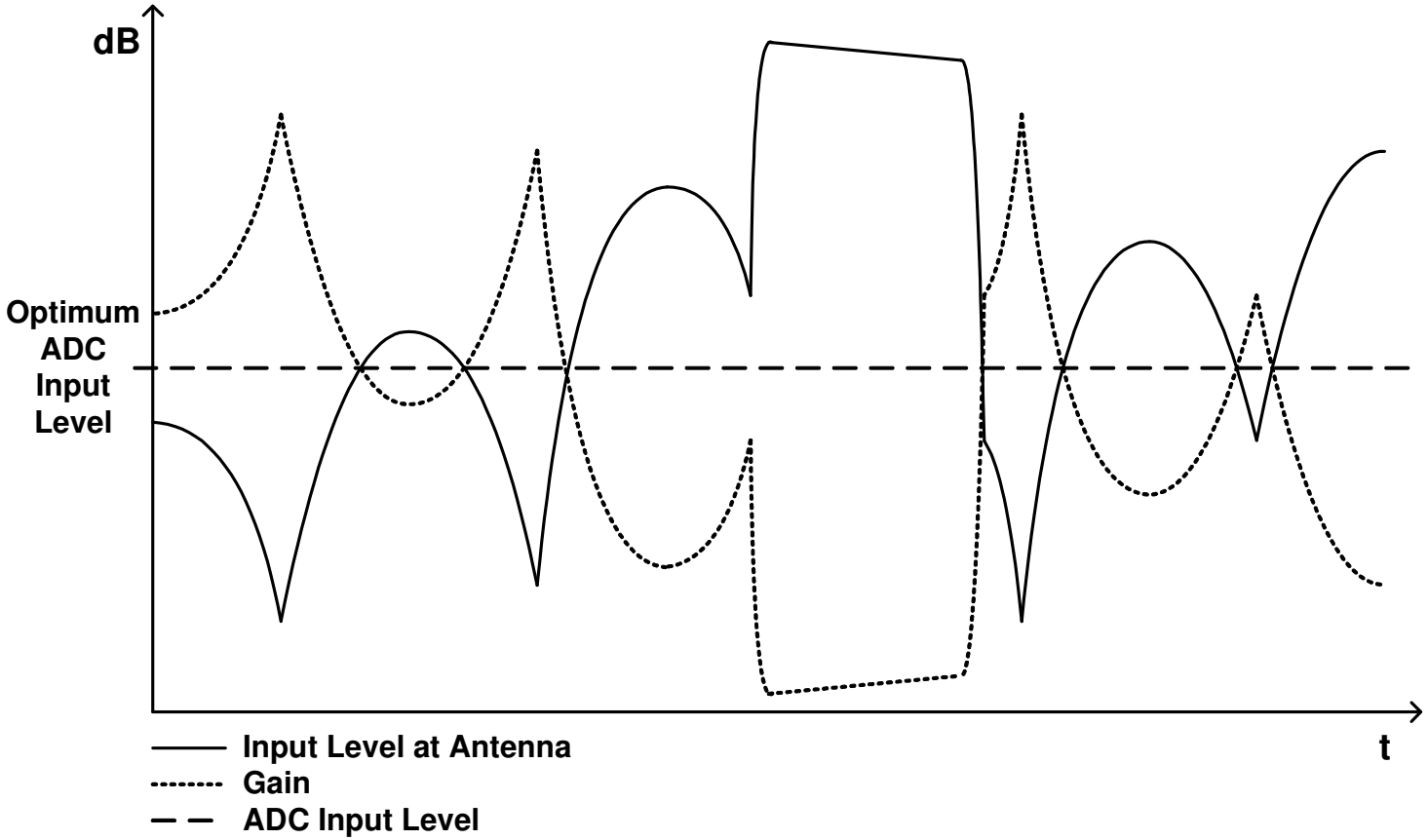
AGC API Concept (4)

Constant level behaviour



- causes rather continuous (slope dependent) distortion on receive signal
- Distortion may be limited by limitation of gain slope
  - preferably independently for gain increase and gain decrease slopes

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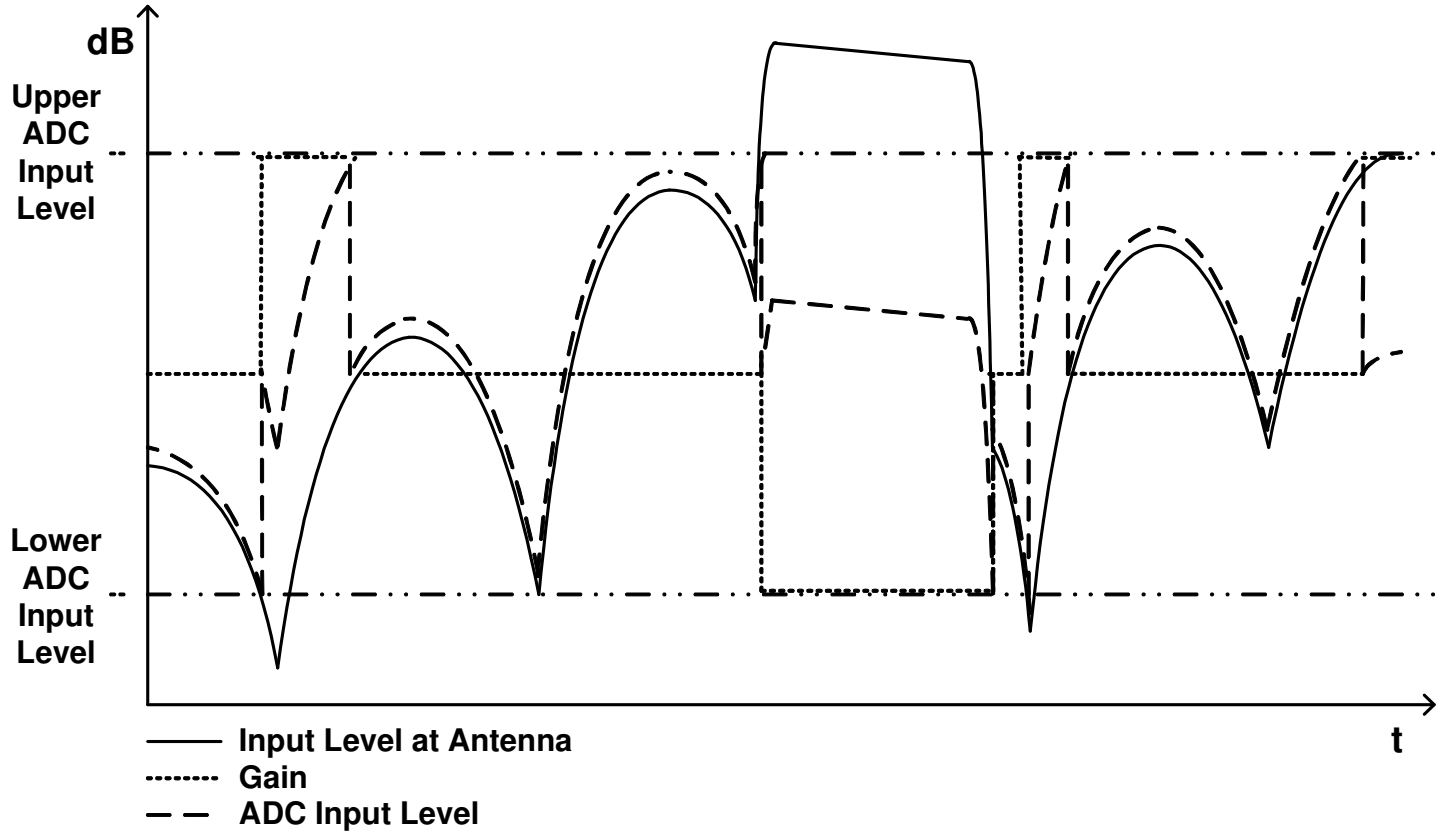
AGC API Concept (5)

Floating level behaviour



- causes impulsive distortion on receive signal
  - at quasi-random instants

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AGC API Concept (6)

Waveform Application (WFA) Challenges

- **WFA dealing with the sampled receive signal will have to**
  - compensate the signal variations of the wanted signal by WFA internal AGC methods
  - cope with distortion effects caused by gain variations within Rx chain
  - properly control the AGC behaviour in real time
    - to minimize distortion effects impact on received information quality:
      - BER: Bit Error Rate
      - Voice intelligibility
    - Utilizing the knowledge about the (most) vulnerable phases of the waveform
    - Disable gain variation in such phases
      - Real time control towards transceiver Rx chain

AGC API Summary (1)

Case: Constant Level

- ***setOptimumLevel***
  - specifies the optimum ADC input level [dB_{FS}]
    - i.e. the ADC level to be quasi fixed (= constant) by the AGC algorithm
- ***setSensitizationSlope***
  - specifies the maximum gain increase speed [dB/s]
- ***setDesensitizationSlope***
  - specifies the maximum gain decrease speed [dB/s]
- ***enableSensitization***
  - snables/disables gain increase
- ***enableDesensitization***
  - snables/disables gain decrease

AGC API Summary (2)

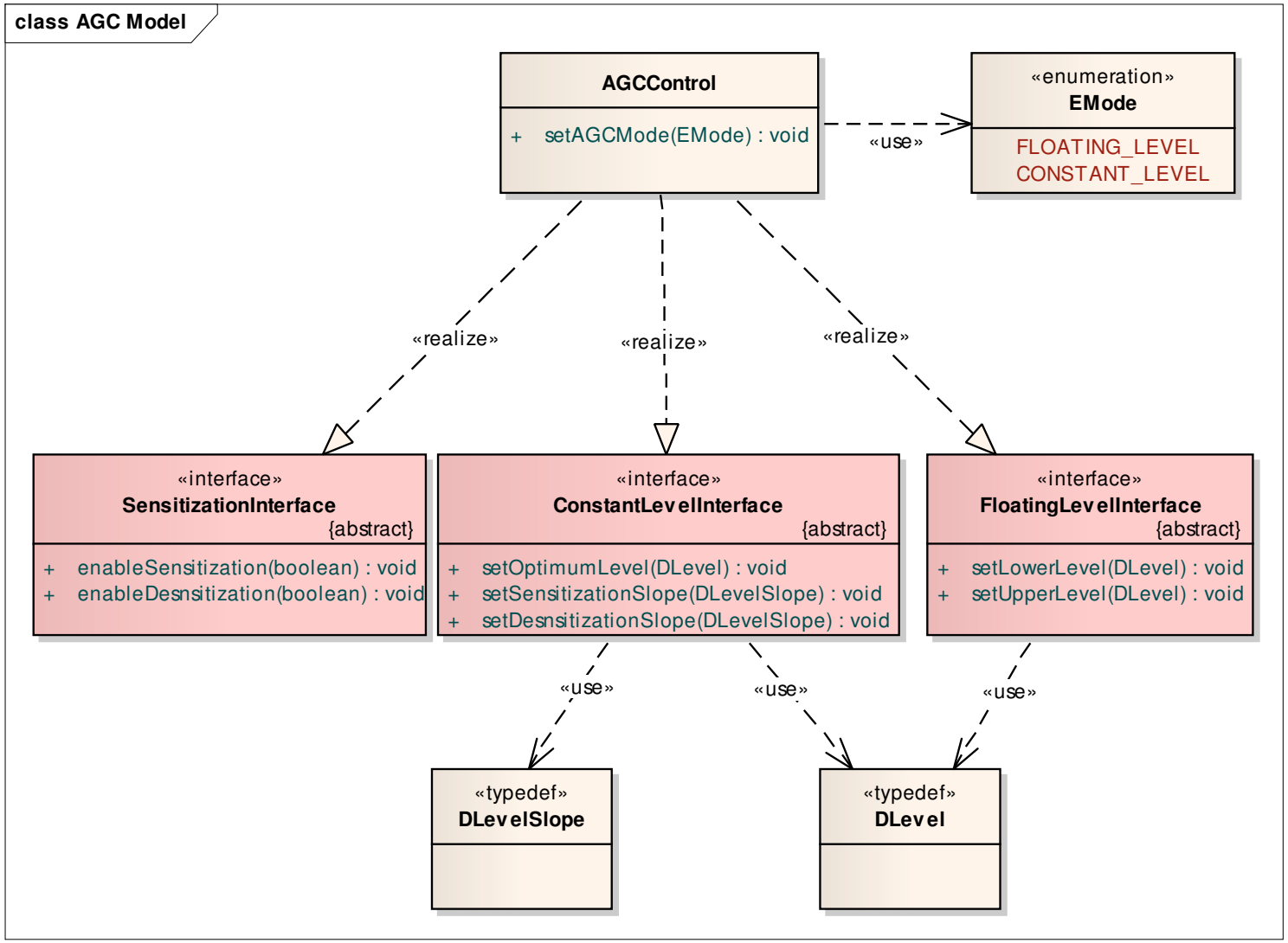
Case: Floating Level

- ***setUpperLevel***
  - specifies the upper boundary of the floating ADC input level [dB_{FS}]
- ***setLowerLevel***
  - specifies the lower boundary of the floating ADC input level [dB_{FS}]
- ***enableSensitization***
  - enables/disables gain increase
- ***enableDesensitization***
  - enables/disables gain decrease

Remark: In case of Floating Level, gain in/decrease speed shall be as fast as possible.

AGC API Summary (3)

UML Diagram



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Conclusion

Platform API

- suited for configuration and real time control of the AGC located within any tactical SDR receiver
- takes into account that even decades of adjacent channels may pass the IF analog filter in front of the ADC
- provides a flexible, but transparent AGC loop dynamic behaviour control adaptable to the dynamic behaviour of the receive scenario
- allows a WFA supplier to control the impact on the receive signal distortion according to
  - *continuous* noise model
  - *impulsive* noise model
- requires no knowledge of the individual receiver design
- ensures waveform application portability onto any tactical SDR platform

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