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Code Inter-Frequency Biases in GNSS Receivers

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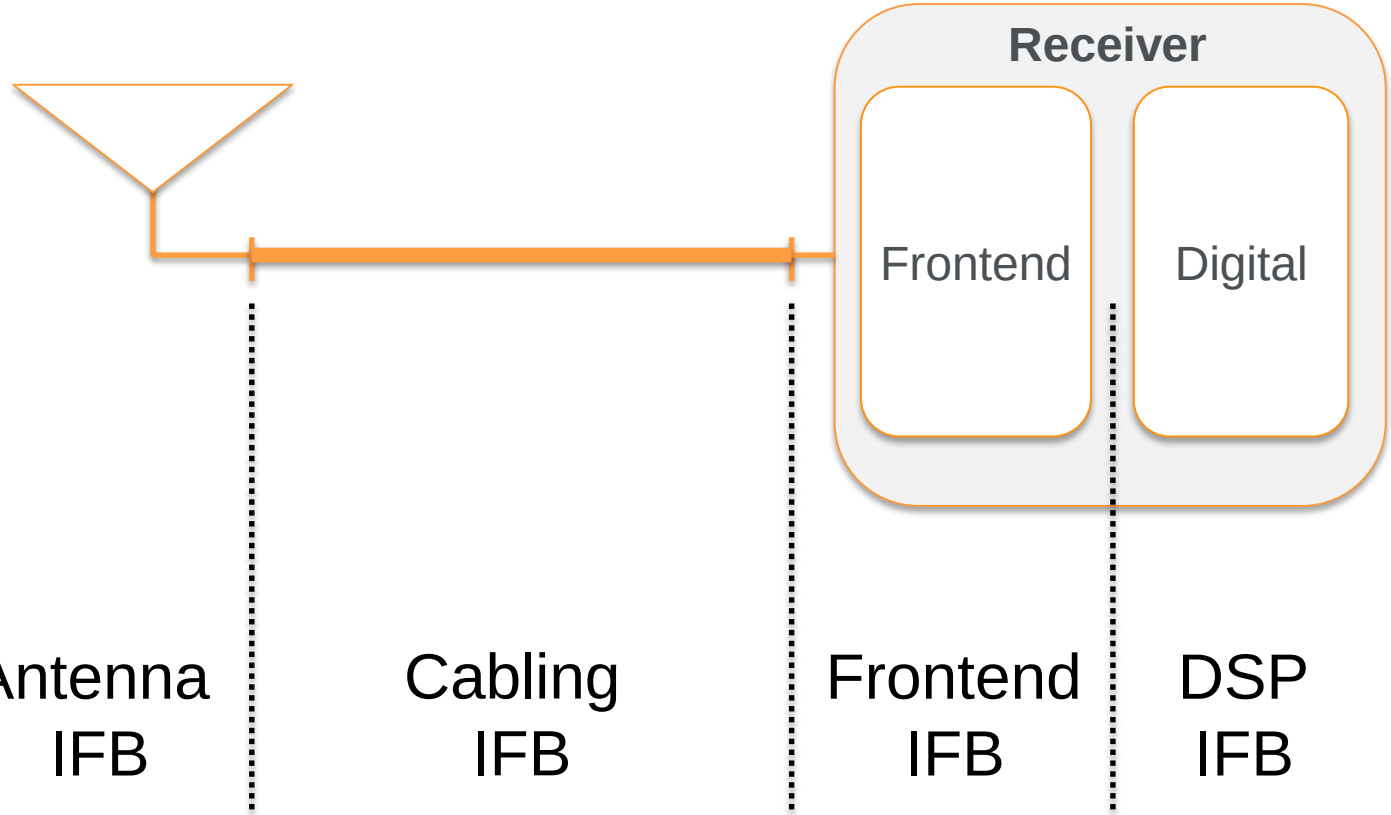
Inter-Frequency Biases in the Reception Chain



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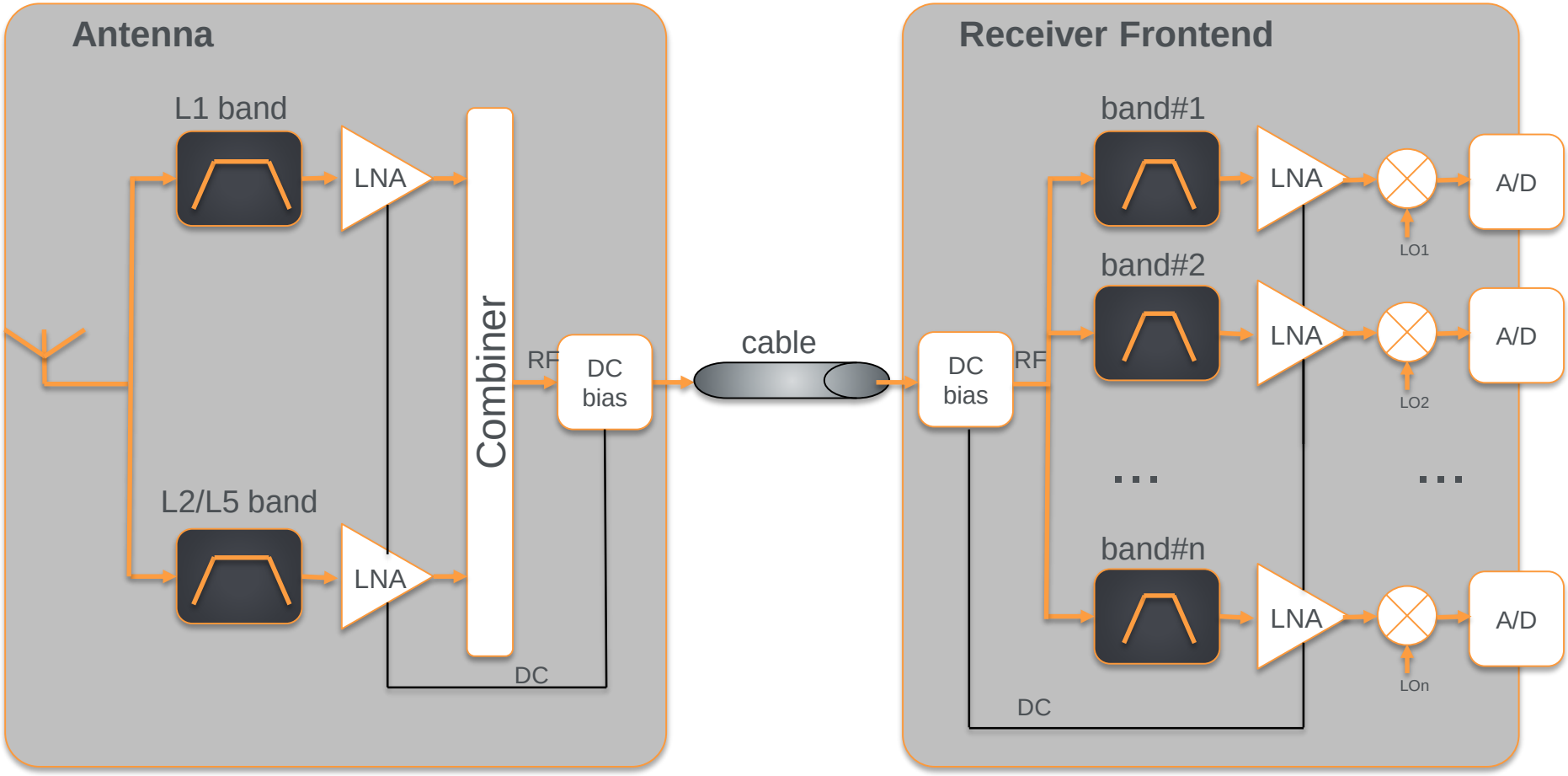
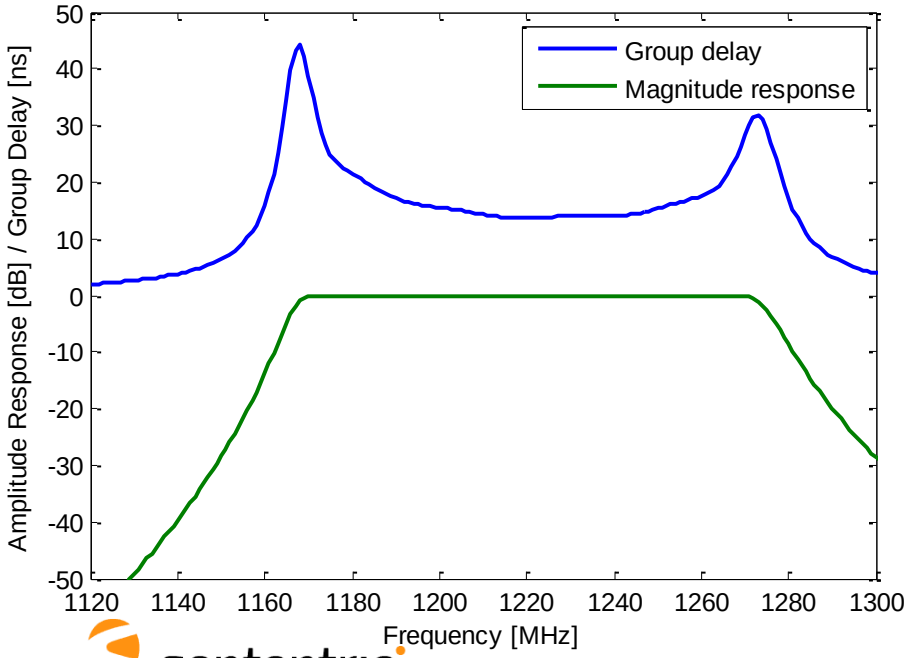
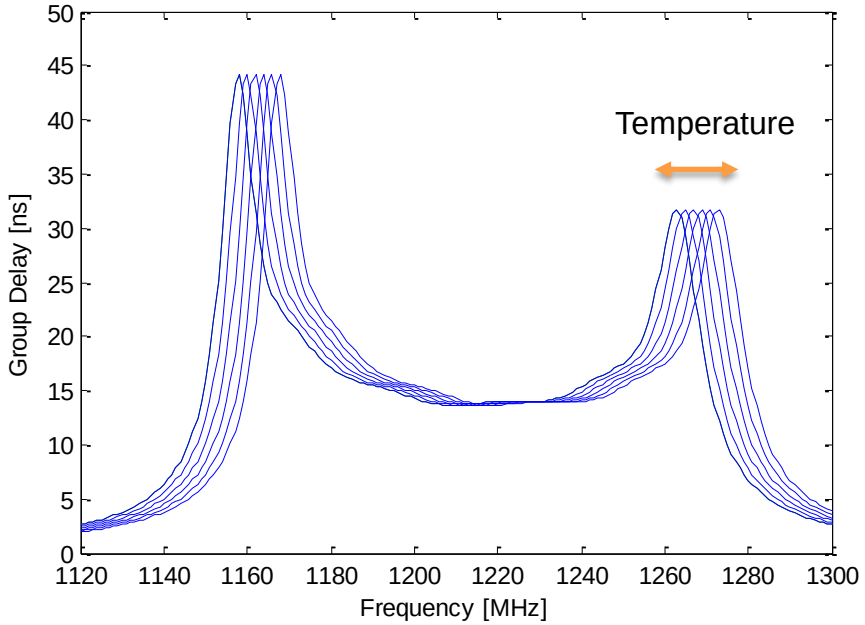
Analog Chain



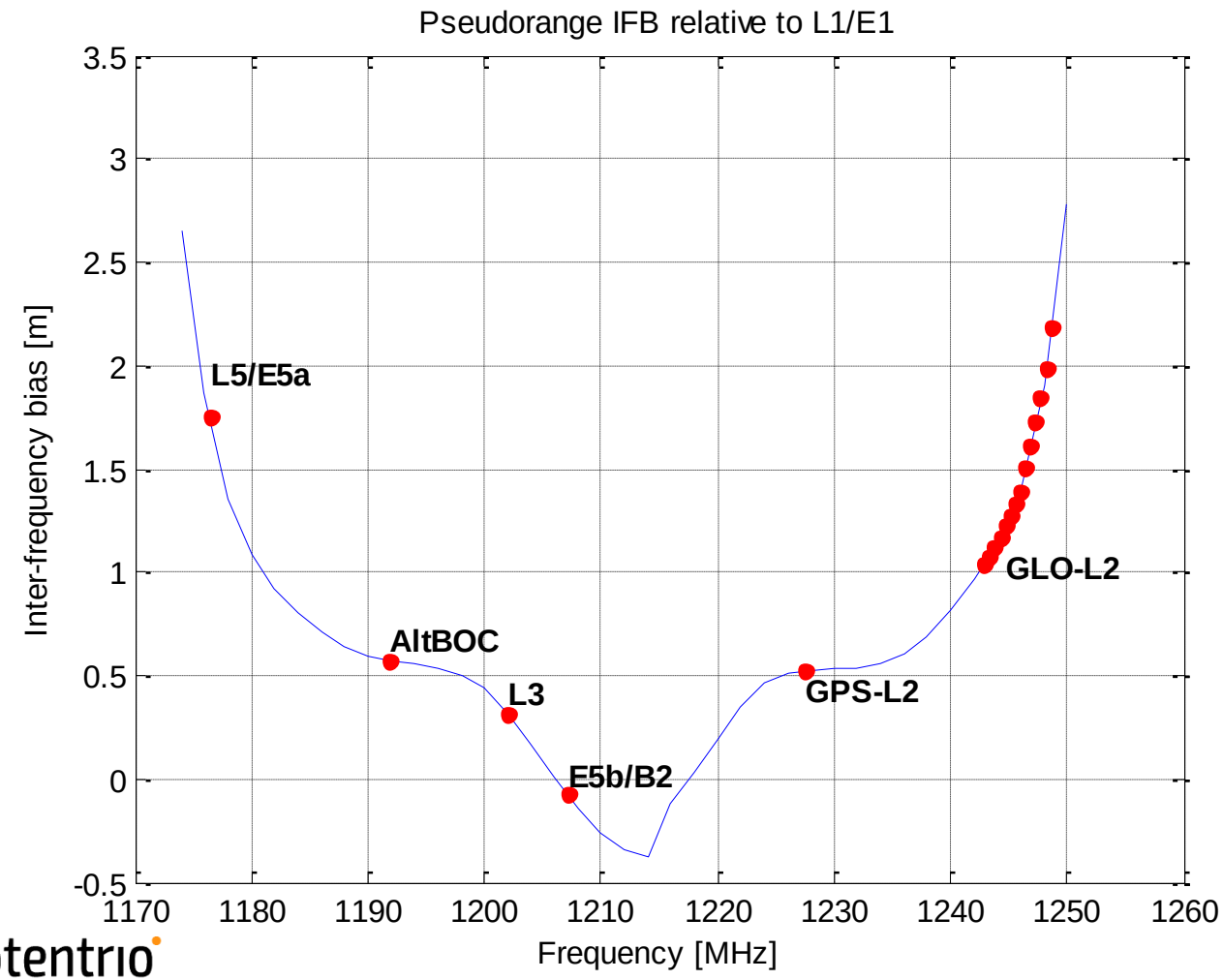
Typical IFB Effects in Analog Filters

- Analog IFBs caused by:
  - Group delay differences between filters
  - Group delay variation in passband
- Main effect of temperature is a frequency shift. Effect larger on band edges.





Example of Receiver Analog Filter IFBs



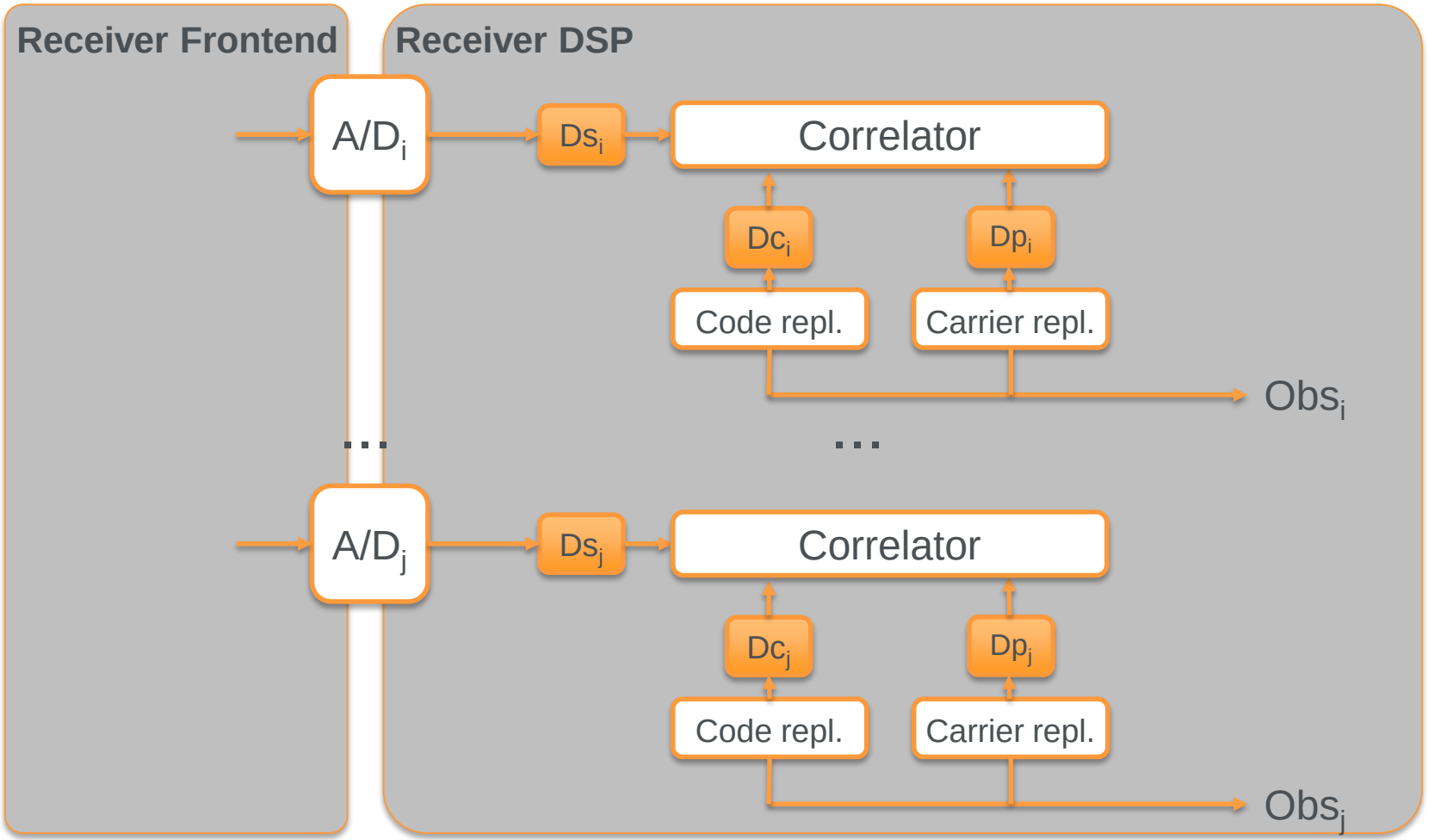
IFBs in Analog Filters

- Typical IFB values:
  - Antenna: 5 to 10ns
  - Receiver: 5 to 100ns depending on frequency plan

- Temperature sensitivity:
  - Antenna: <10ps/°C
  - Receiver: up to 50-100ps/°C

- Notes:
  - Analog IFBs can depend on firmware version (frequency plan may be SW-defined)
  - Analog IFBs can be compensated for in firmware

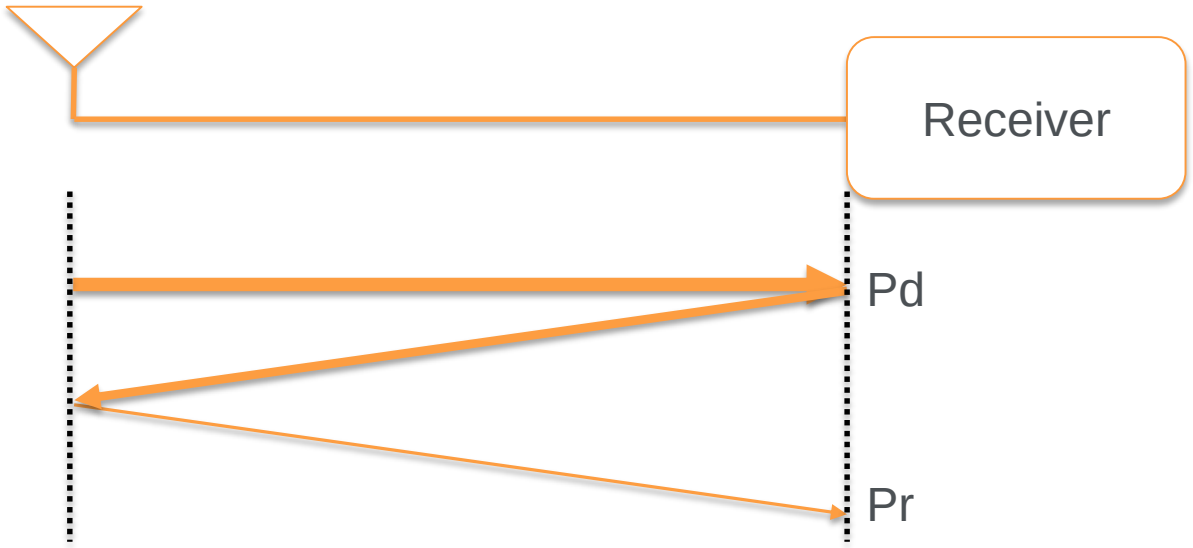
Delays in Digital Processing



DSP IFBs

- Typical DSP IFBs: up to several µs
- Strongly dependent on modulation type (e.g. GPS P1 vs GPS CA)
- Absolutely independent on temperature
- Code IFBs usually well known by manufacturer and compensated for in firmware
  - ! This can lead to code-carrier biases if the compensation is not aligned on code and phase

Effect of Cable Reflection



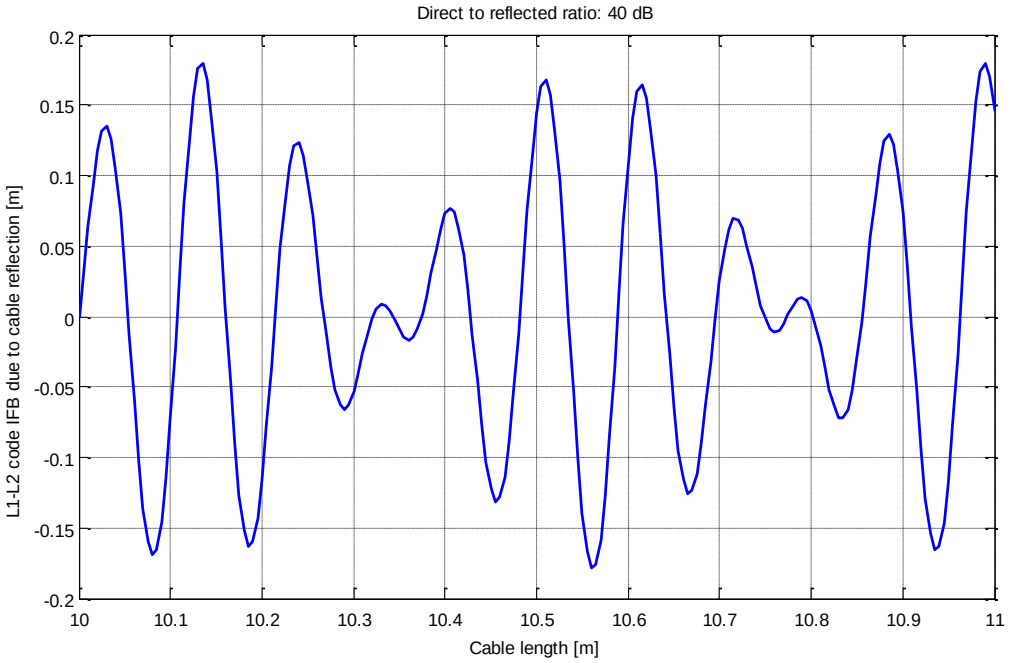
Reflected to Direct ratio [dB]:

$$Pd\text{-}Pr = ReturnLoss_{Rx} + ReturnLoss_{ant} + 2*Loss_{cable}$$

e.g. *15dB* + *15dB* + *2*5dB* = *40dB*

IFBs from Cable Reflection

- Order of magnitude: a few nanoseconds
- Dependent on temperature (return loss is temperature dependent)



Cable Cross Talk…

Summary of main IFB Sources

Component	IFB size	Temperature dependence?	Compensated in firmware?
Antenna	~5ns	yes, limited	usually no
Rx Frontend	5 to 100ns	yes, potentially significant	vendor specific
Rx DSP	up to a few µs	no	usually yes
Cabling	a few ns	yes, limited	no

… and also PRN-dependent effects (~ns level)

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