Optimizing Wideband Software Radio Performance

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Wide-band RF ⟺ Digital Conversion

- Essential to a seamless air-glass interface
- High Spurious-free Dynamic Range is Key
- Frequency Translator and A/D Converter are the Cornerstones of Performance

Wide-band RF/Digital Conversion Is Essential to a seamless air-glass interface

- Air-Side Signals are modulated on to analog RF carriers (eg 900 MHz)

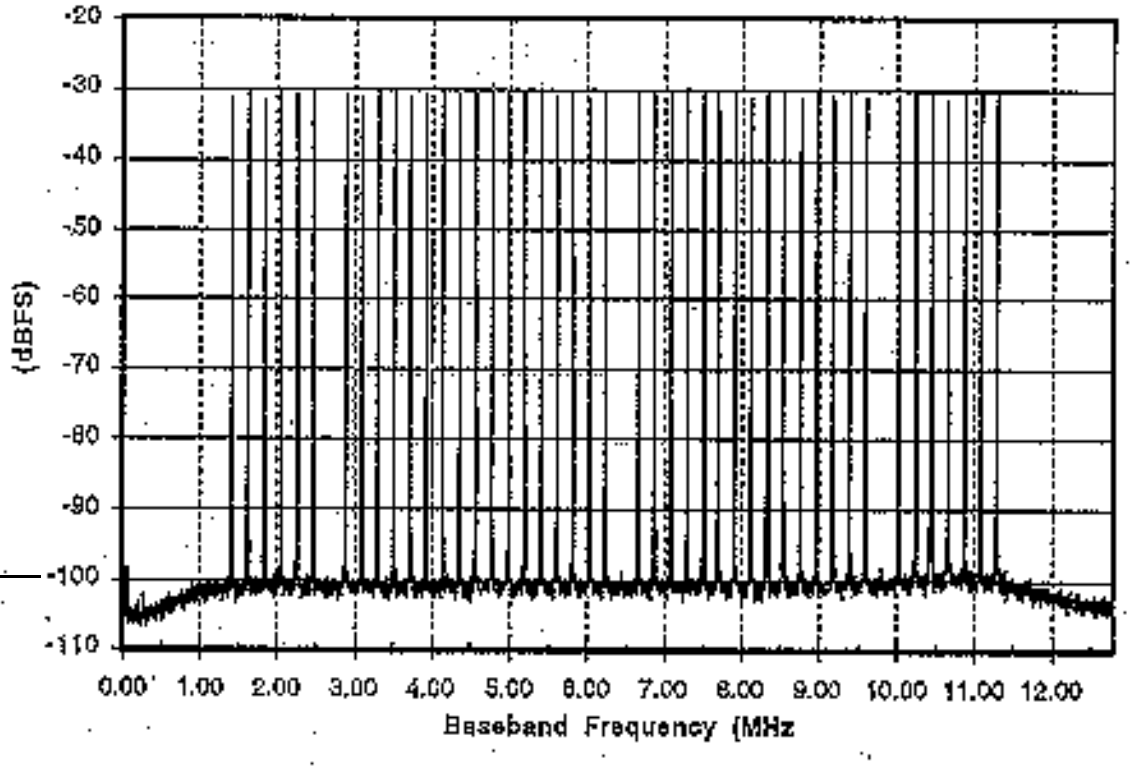
- Glass-side signals are digital and are modulated onto digital carriers(ATM over SONET)

High Spurious-free Dynamic Range is Key

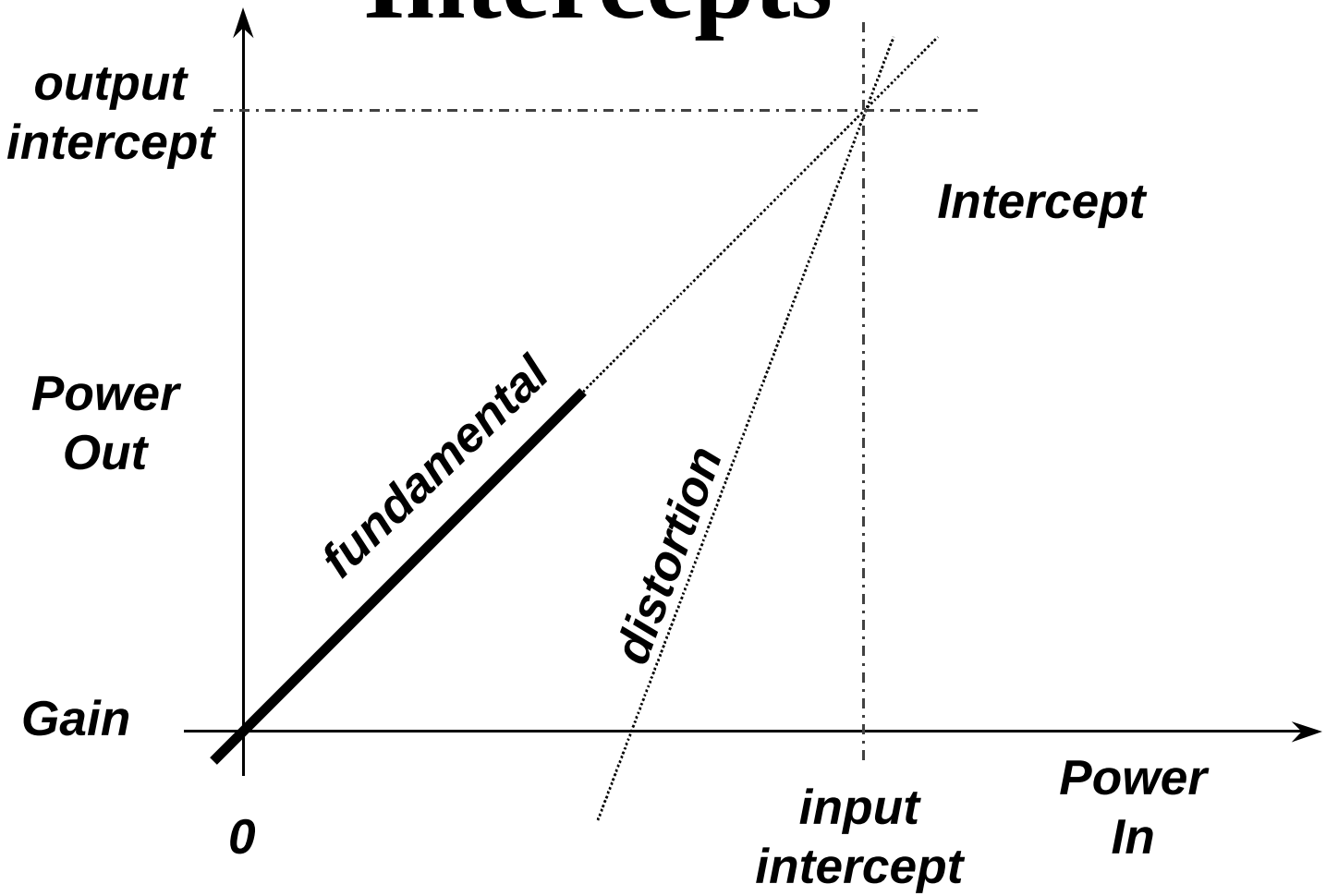
- A typical 12-MHz Cellular Band Needs 70-dB for Signal Dynamic Range plus 30-dB for A/D Converter Headroom
- 70+30 = 100-dB SFDR for continuous full-band operation. (about 16-bits/sample)
- …Unless, of course, you power control

48-Tone Test, 10-MHz Band

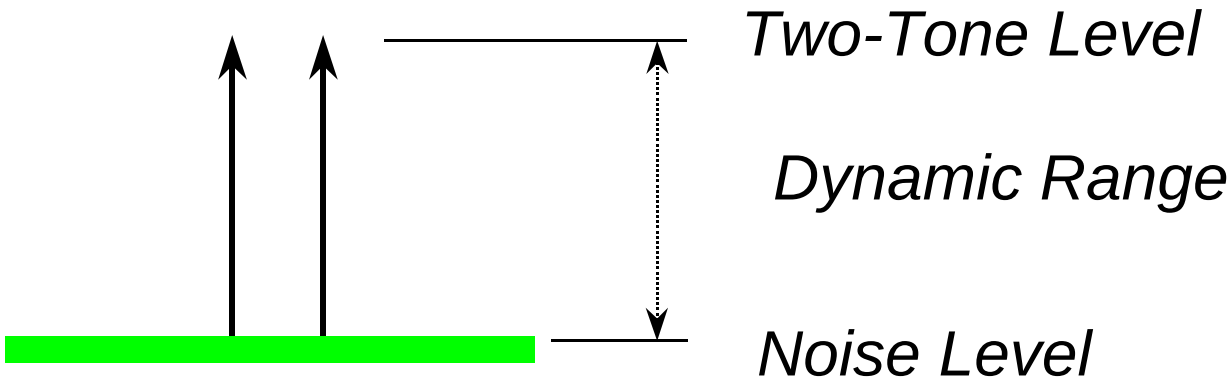
99-dB SFDR



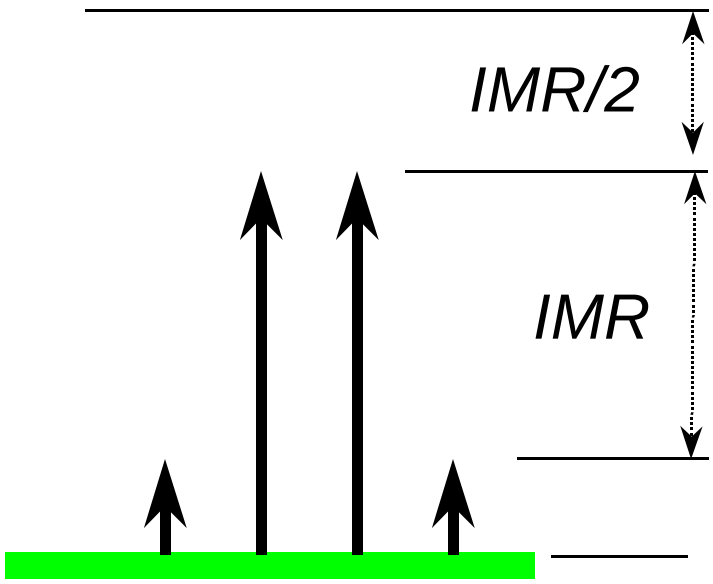
Intercepts



Third-Order Intercept



Third-Order Intercept



Third-Order Intercept

Two-Tone Level

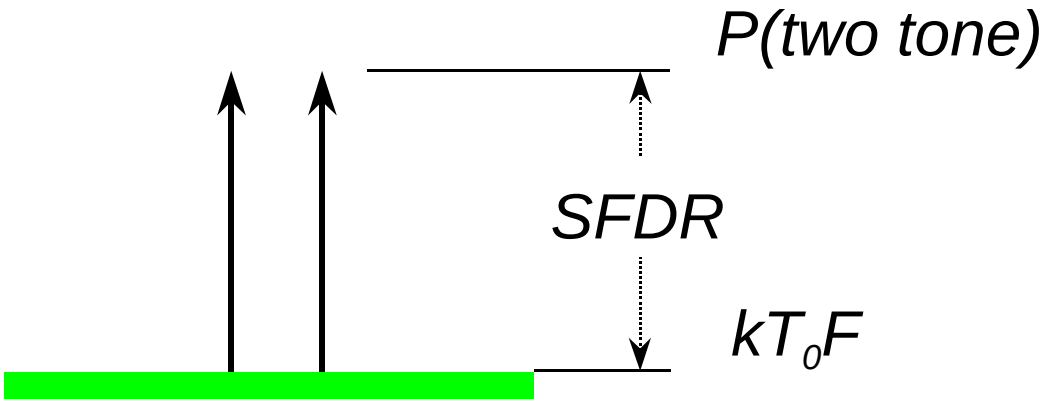
Inter-Modulation Ratio(Db)

Noise Level

Spurious-Free Dynamic Range

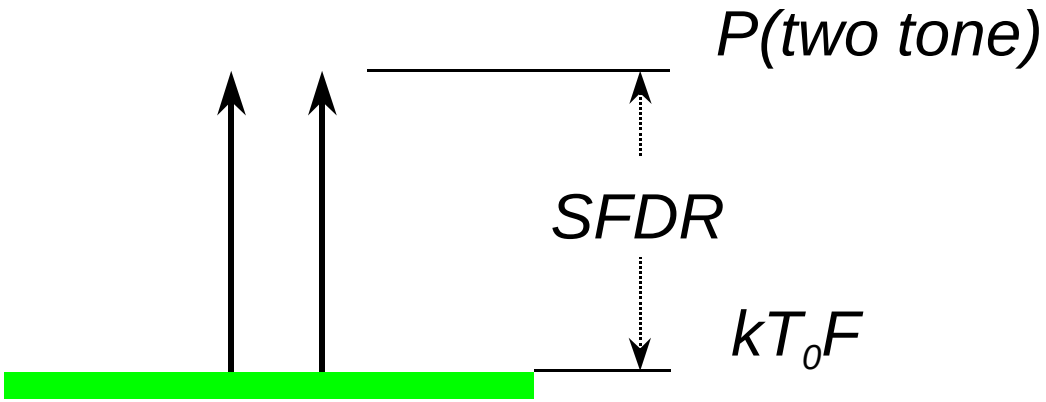
- **SFDR is defined as a power ratio...**
- **The numerator is the power in each tone of a two-tone.....**
- **The denominator is the noise power in a specified bandwidth, usually one Hertz...**
- **The ratio is taken when the power of the largest distortion product produced by system non linearity is just equal to the noise power in the specified band.**

Spurious-Free Dynamic Range



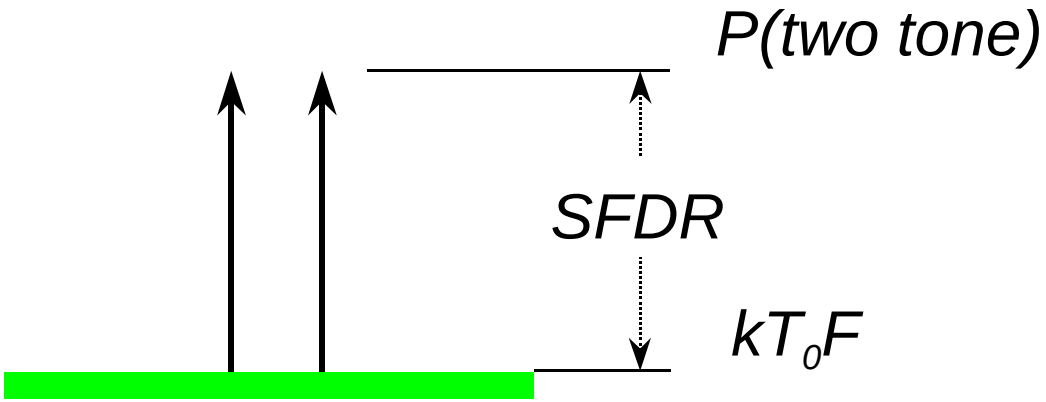
$$P_{third} = \frac{P_{tt}^3}{I_{third}^2} = kT_0F$$

Spurious-Free Dynamic Range



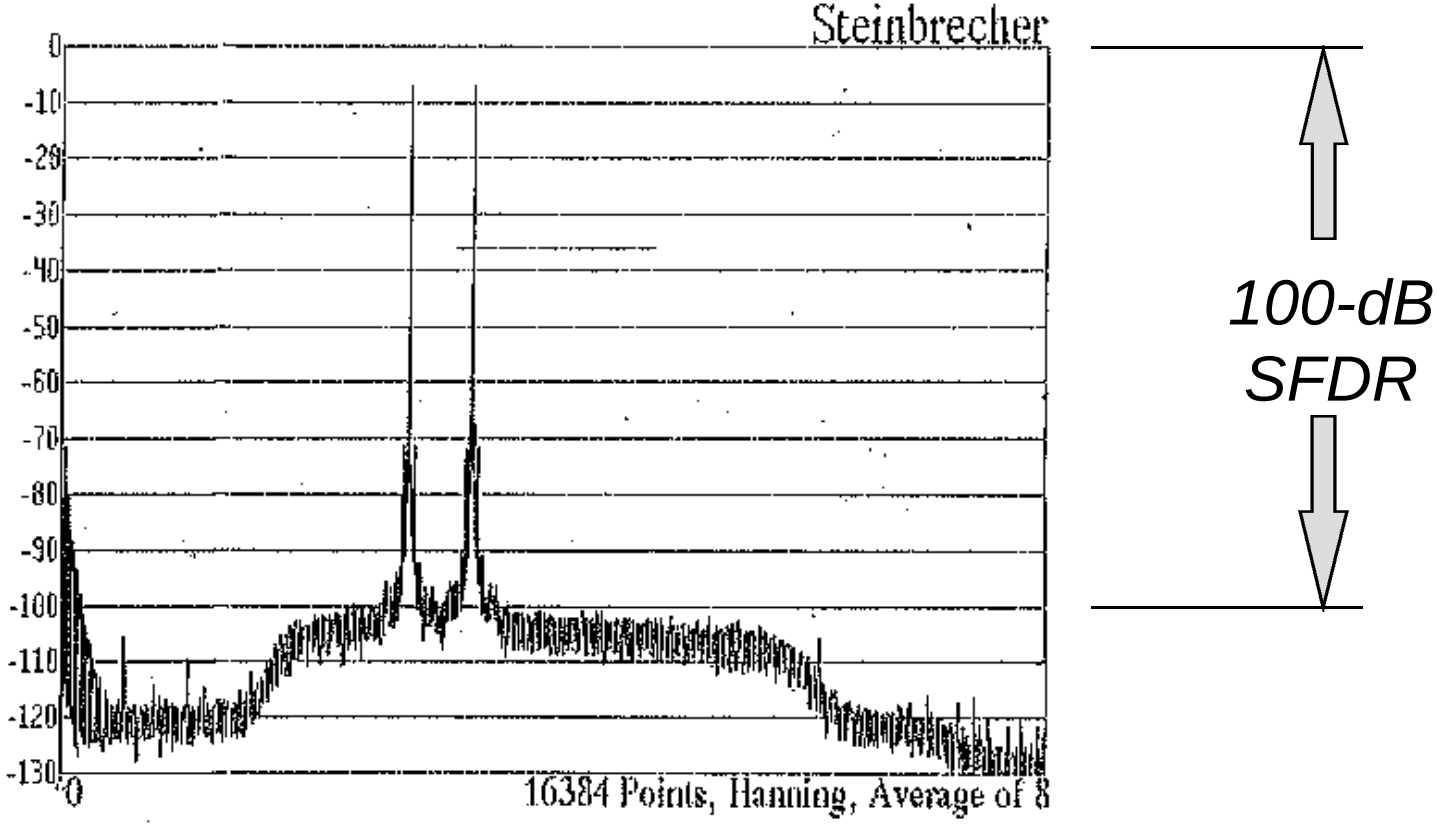
$$\mathrm{SFDR} = \frac{\mathrm{P_{tt}}}{\mathrm{kT_0}F} = \frac{\left(kT_0F\right)^{1/3} I_{third}^{2/3}}{kT_0F}$$

Spurious-Free Dynamic Range

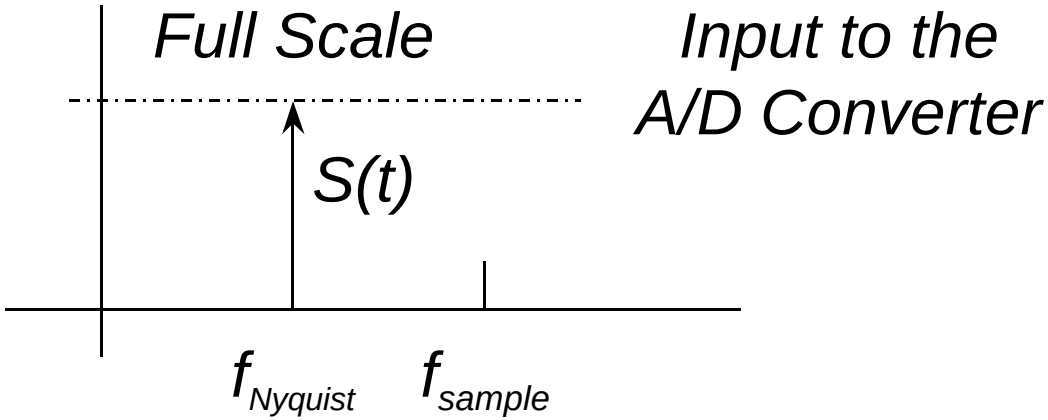


$$\mathrm{SFDR} = \left[\frac{\mathrm{I}_{\mathrm{input}}^{\mathrm{third}}}{\mathrm{kT}_0 F} \right]^{2/3}$$

Spurious-Free Signals, 30-KHz Band

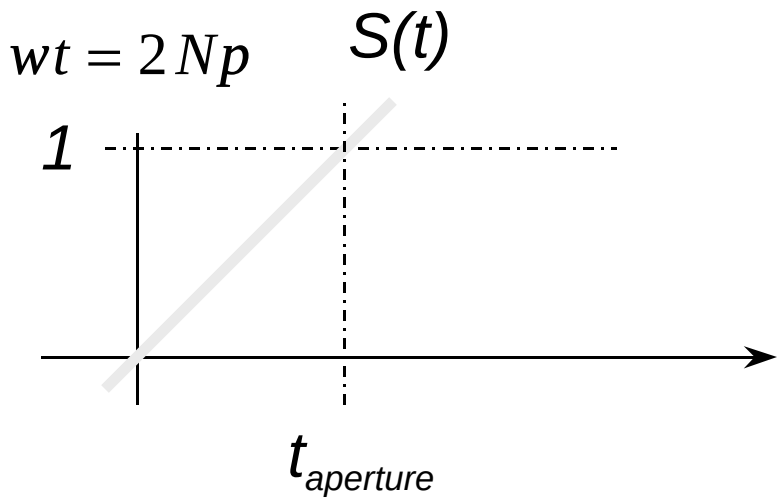


The A/D Aperture Constraint



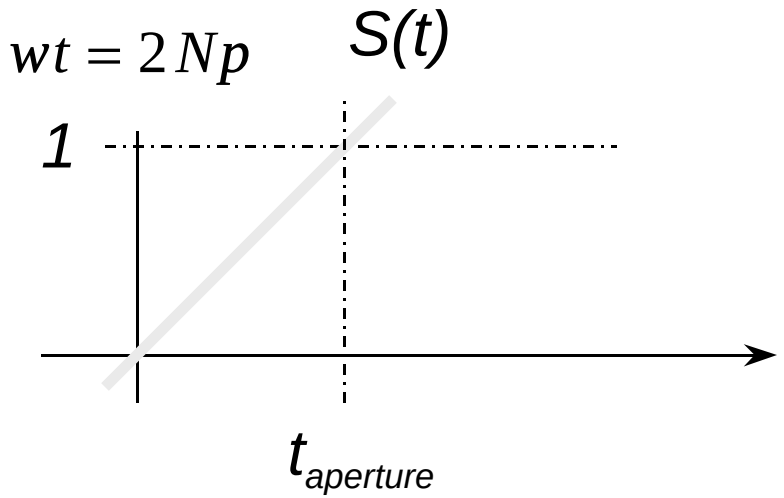
$$S(t) = 2^{N-1} \sin(2pf_{Nyquist}t)$$

The A/D Aperture Constraint



$$1 = 2^{N-1} \sin(2pf_{Nyquist} t_{aperture})$$

The A/D Aperture Constraint



$$1 = 2^{N} p f_{Nyquist} t_{aperture}$$

The A/D Aperture Constraint

$$N = N_A - Log_2\left(f_{Nyquist} \right)$$

$$N_A = \frac{1}{2^{N_{eff}}\, pt_{aperture}}$$

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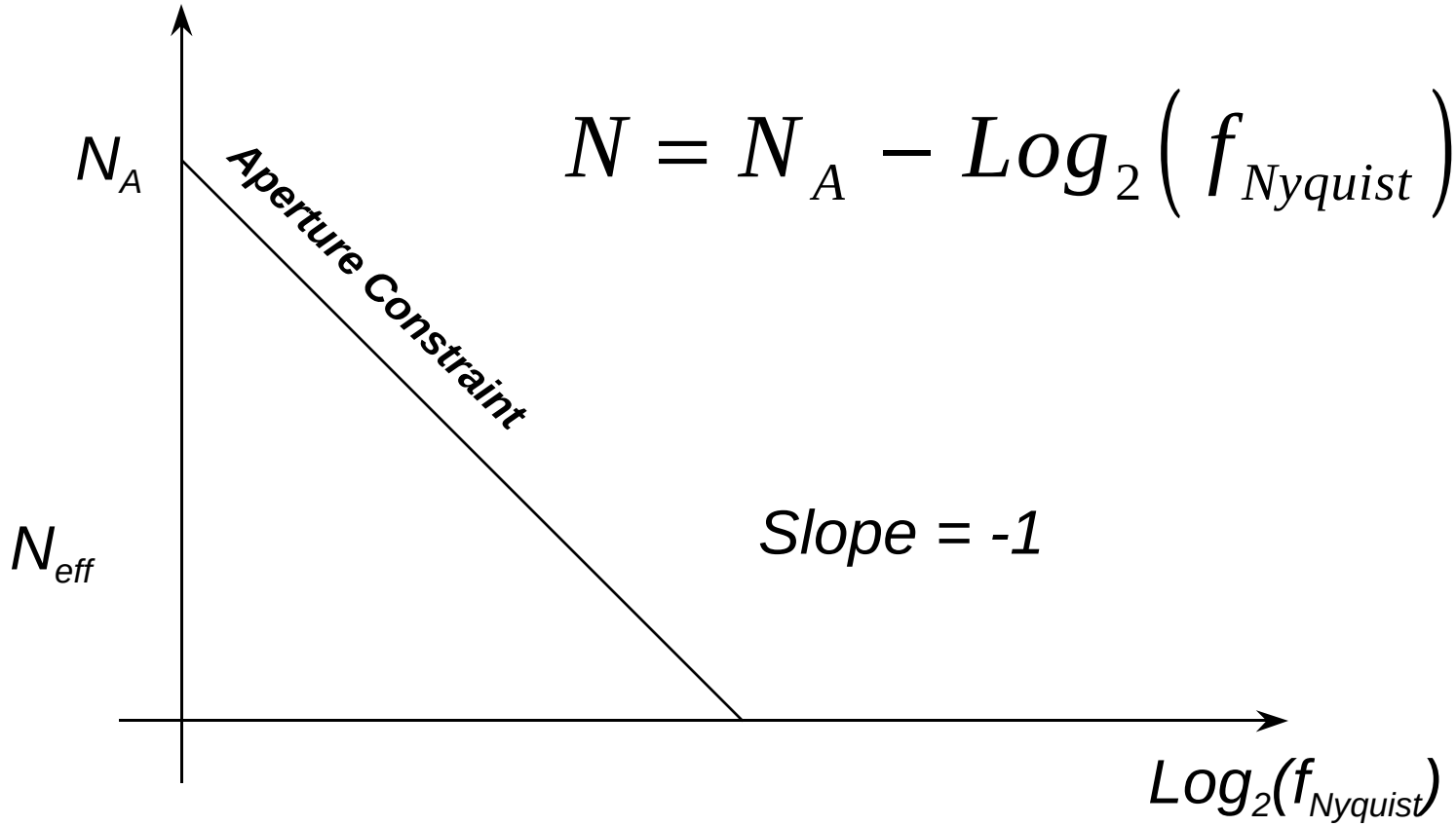
Optimum Design



$$N = N_A - Log_2\left(f_{Nyquist} \right)$$

The Speed of Light...

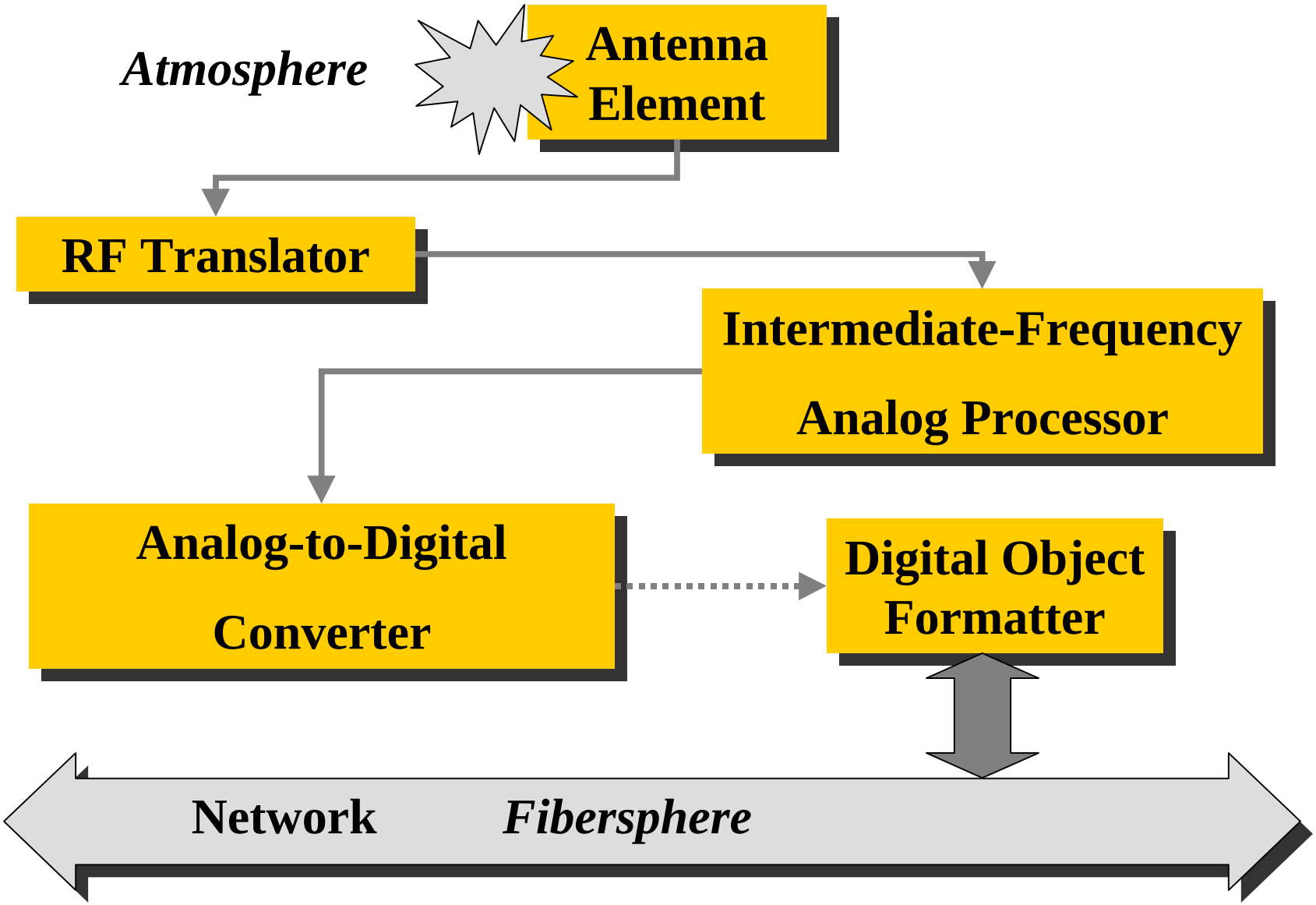
16-Bit Quantizer, 15-MHz Sinusoid

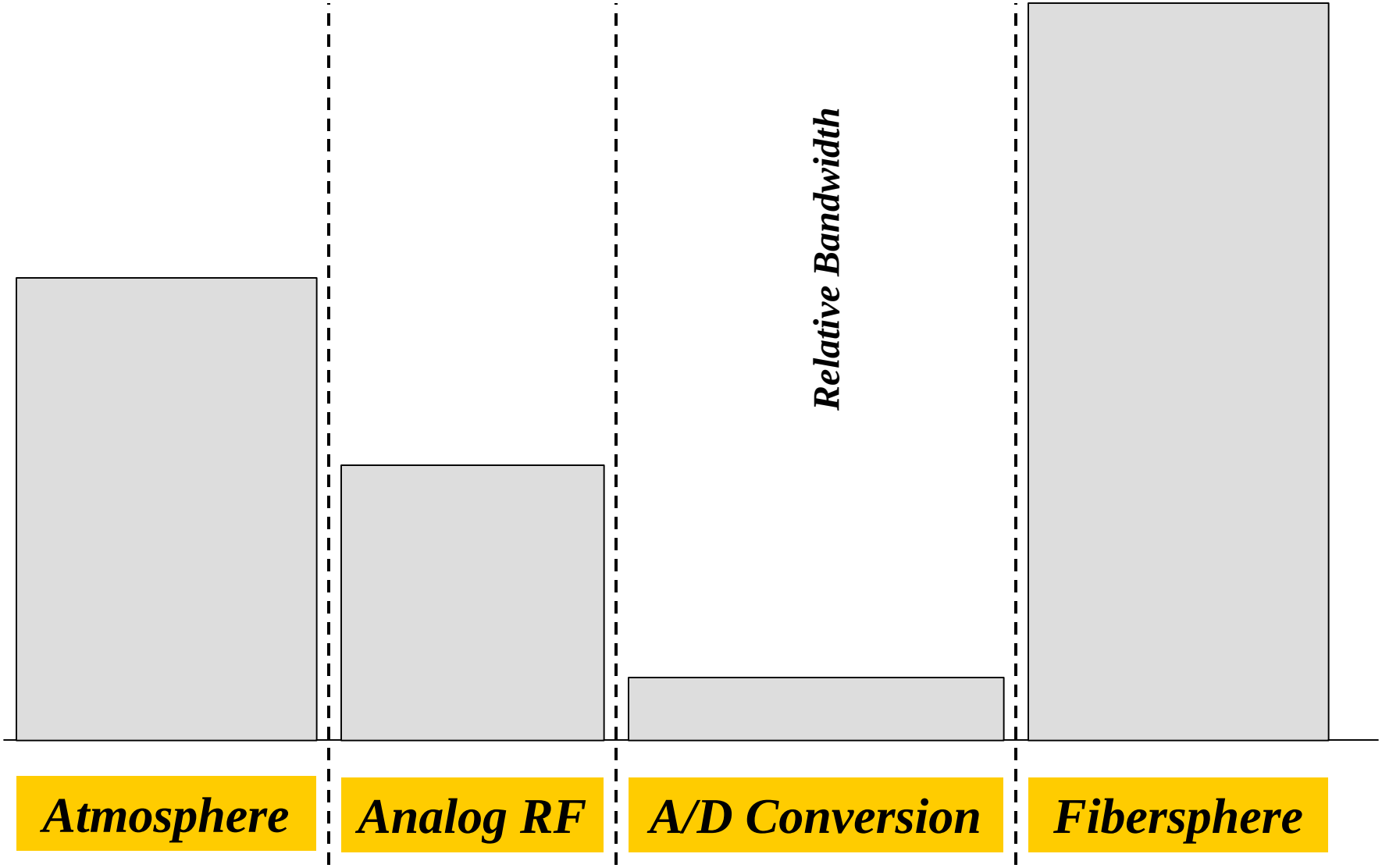
1-LSB Occurs in

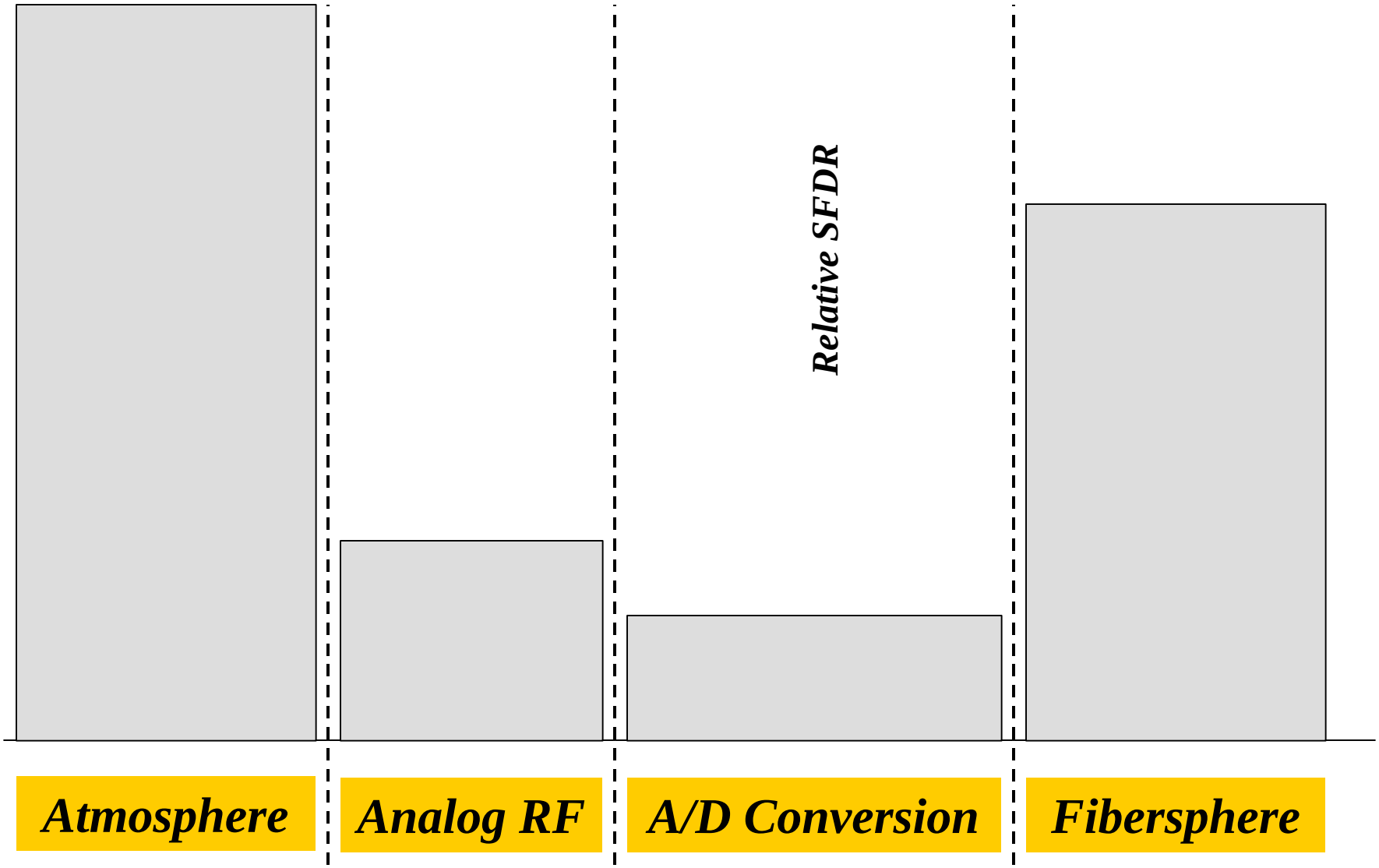
3.24×10^{-13} Second

Light Travels About

100 microns

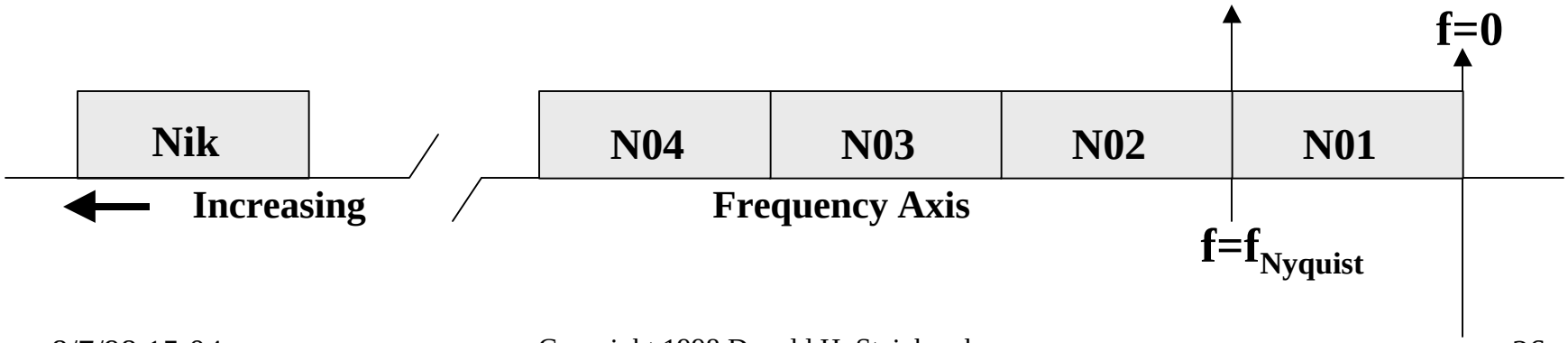




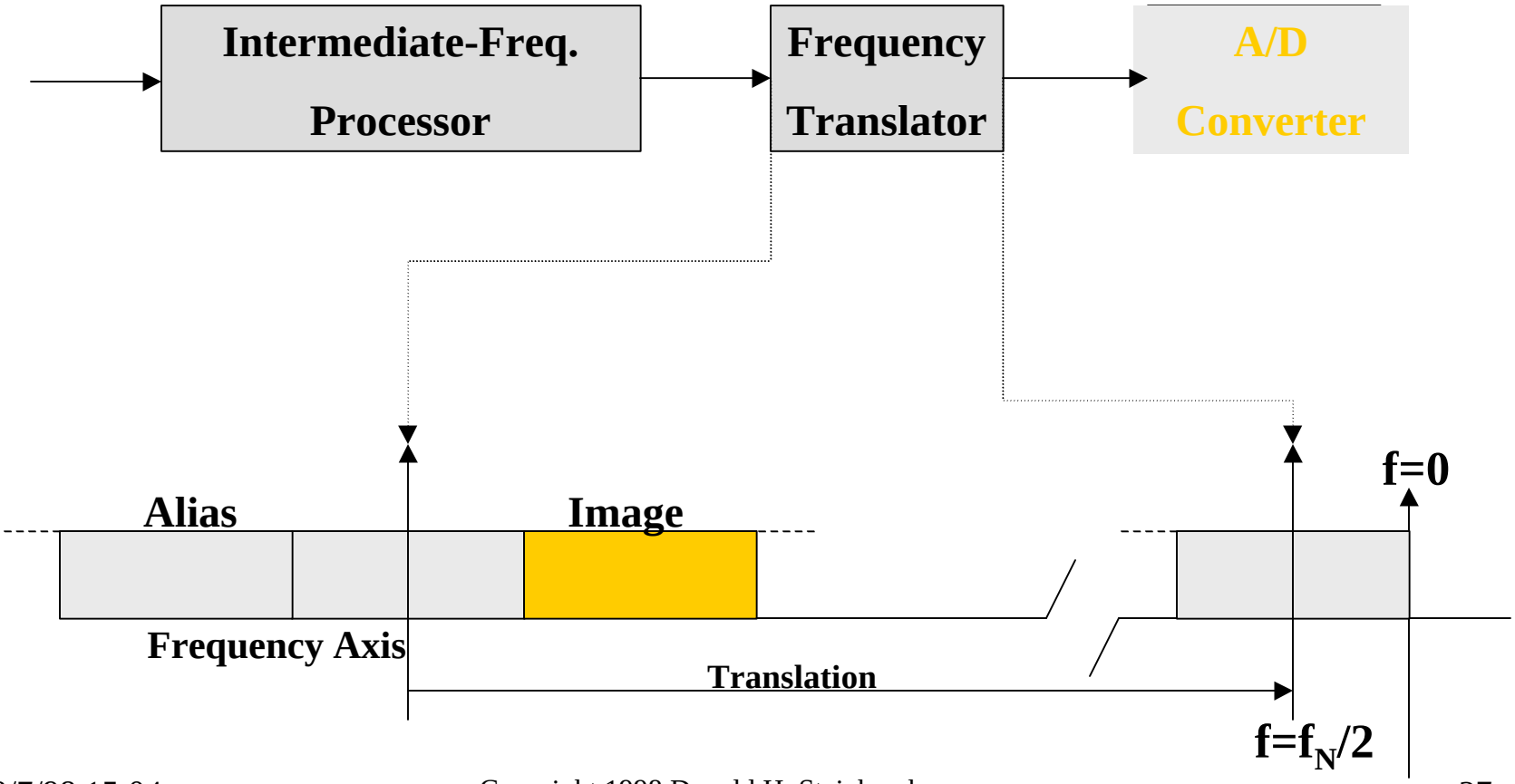


Wide-Band Software Radio Design is Driven by the Properties of the Chosen A/D Converter

Nyquist zones of a periodically driven A/D converter. The zone most often used as the signal band is N01



The basic analog elements of a software radio.



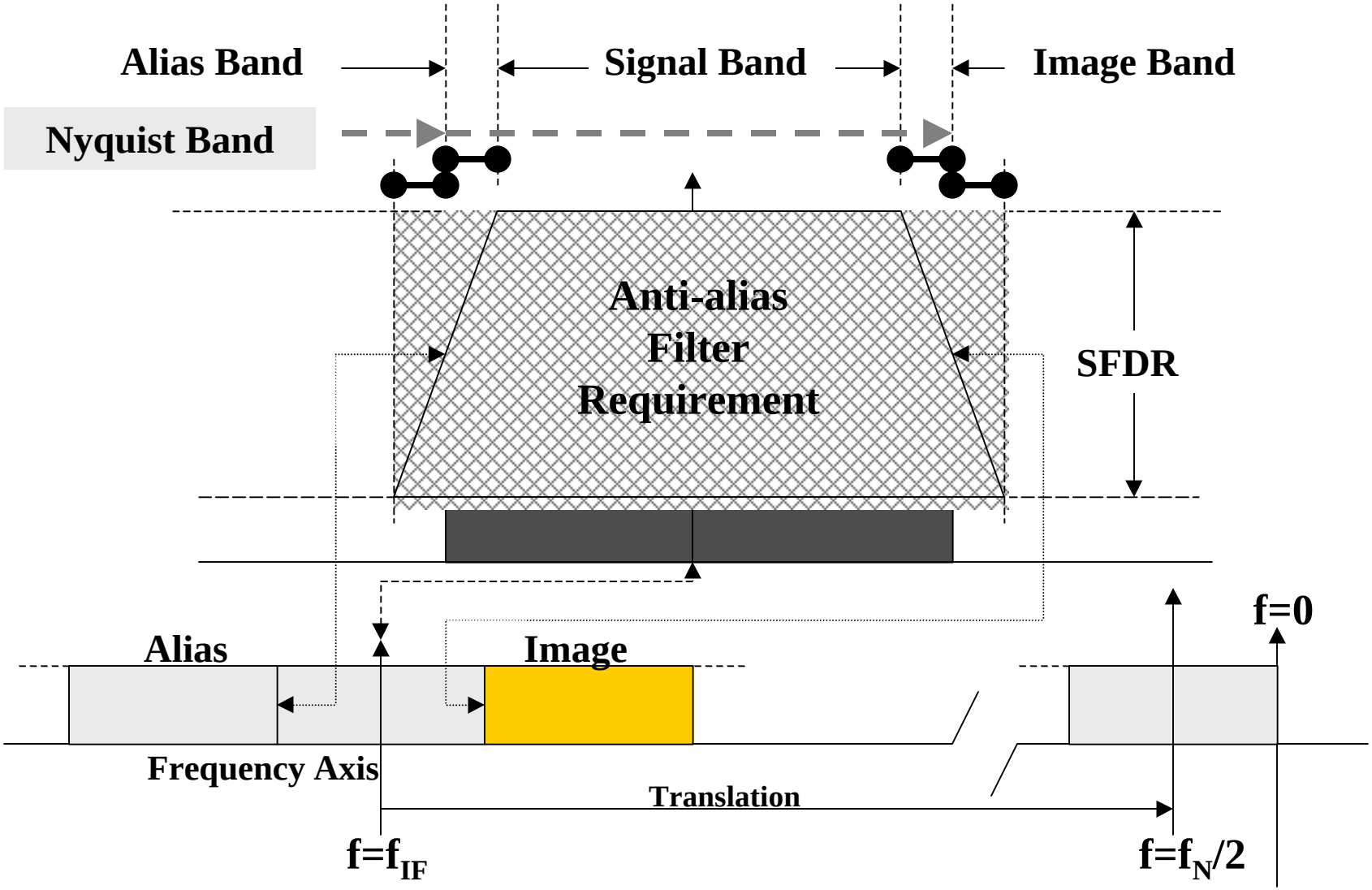
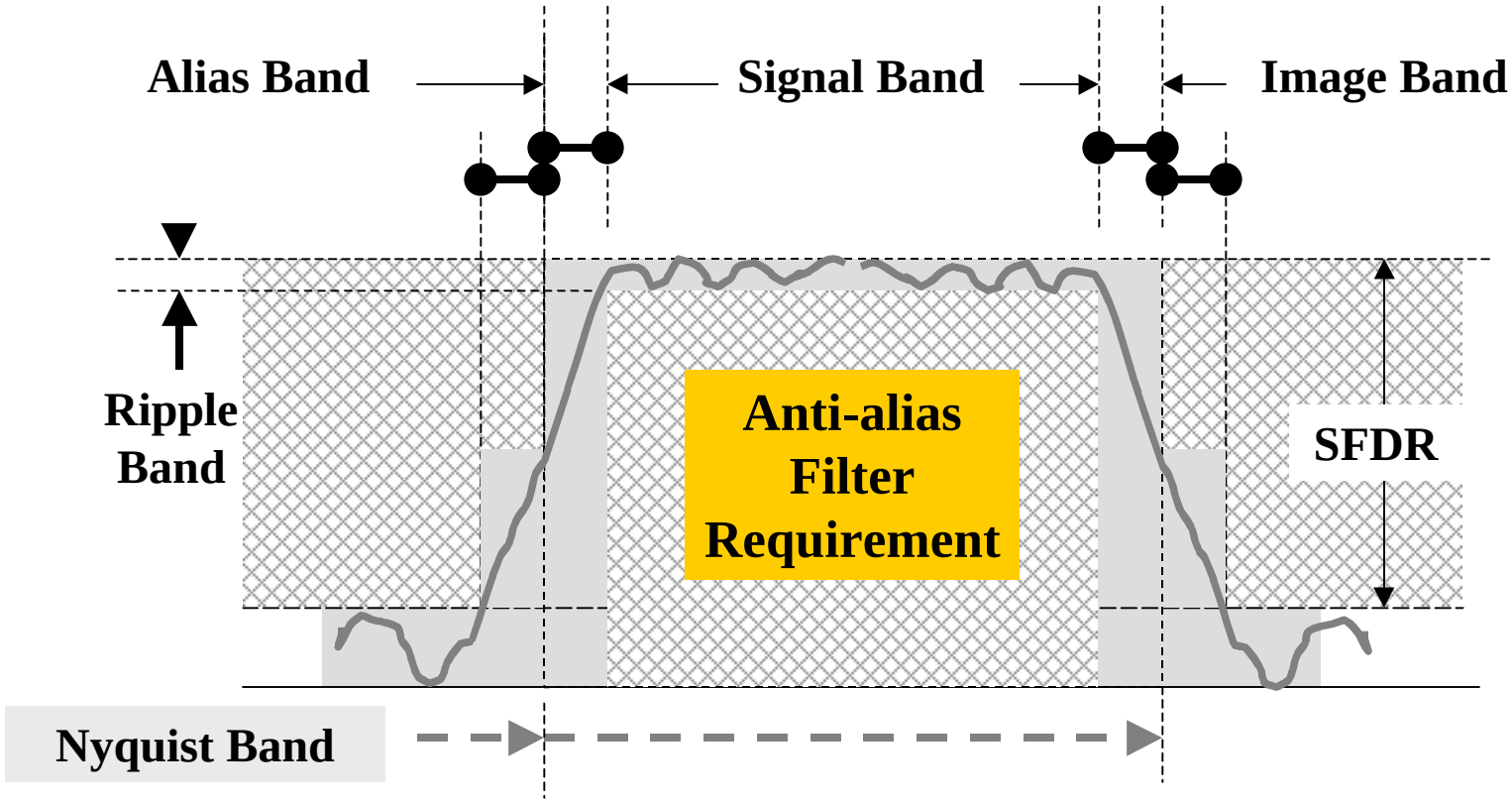
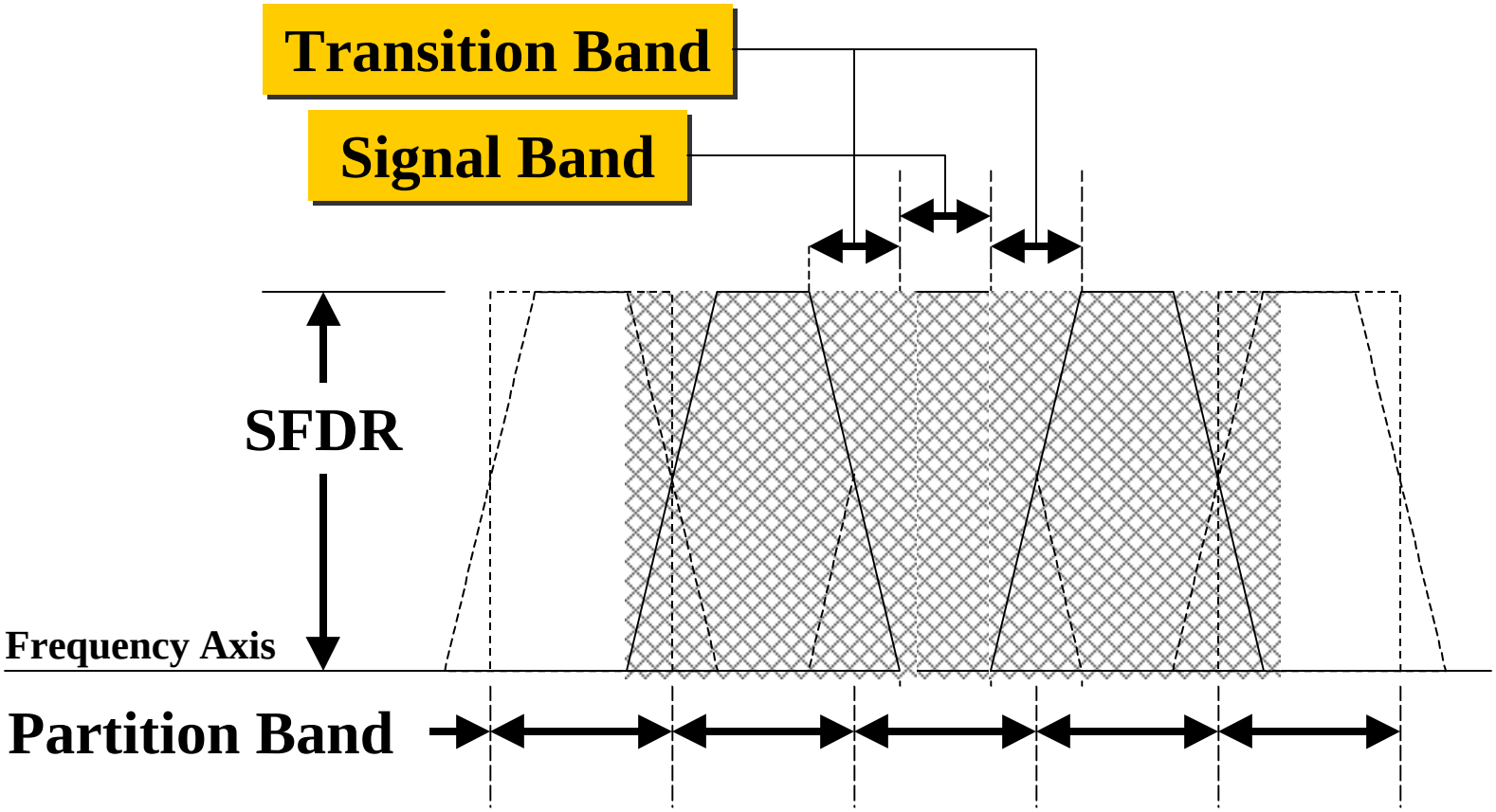


Figure 3. The anti-aliasing filer requirement is determined by the properties of the A/D converter.

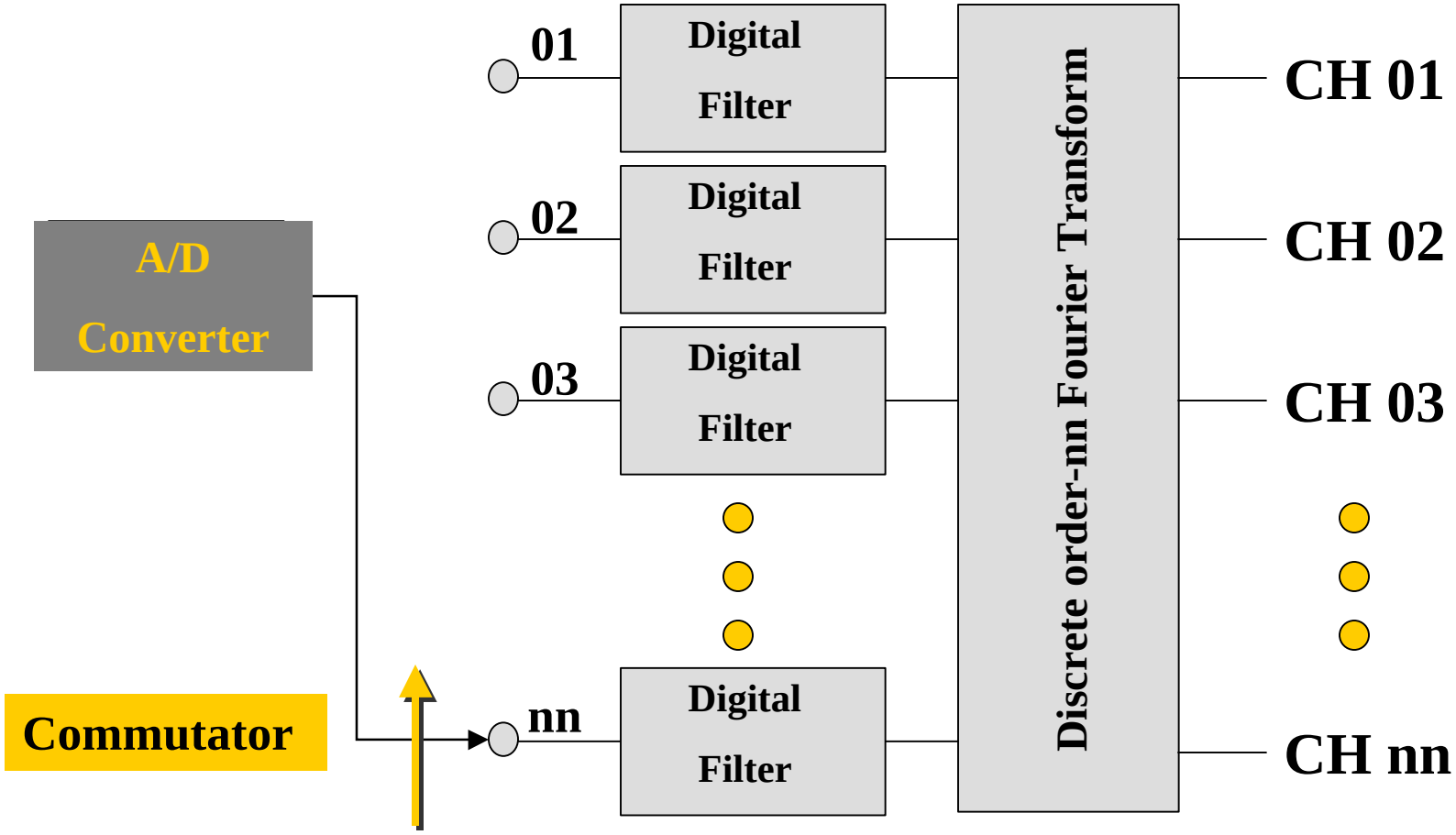


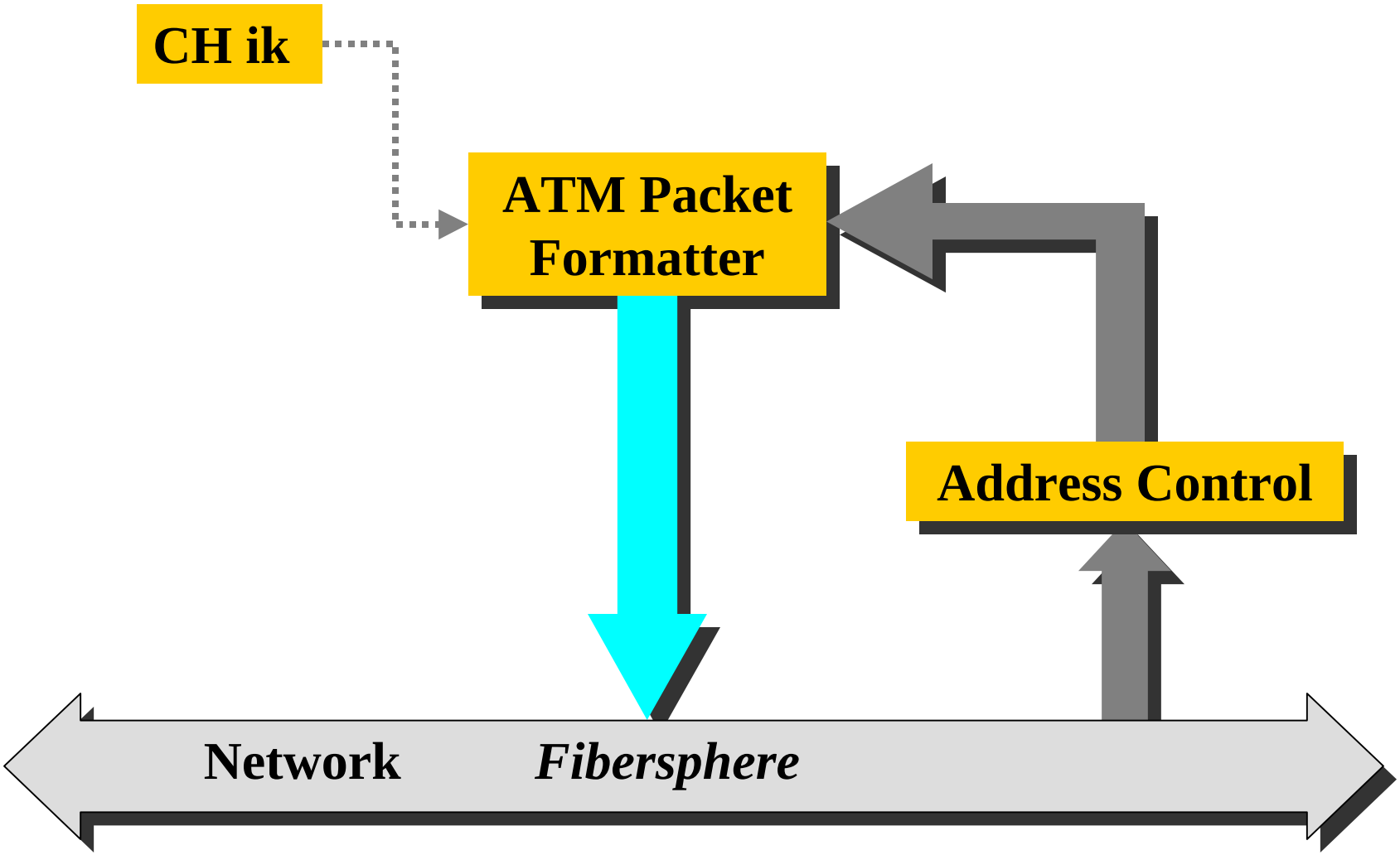
The anti-aliasing filer requirement is determined by the properties of the A/D converter.

The digital filter characteristics of the signal band partitioner.



A digital partitioner separates the Nyquist band into nn equal sub bands.





Summary

- A/D Converter drives design of Software Radio.
- Opportunity for developing a core radio component suitable for all software radios using a particular A/D Converter.
- Opportunity for developing a network interface device suitable for a wide variety of software radio applications.