

A Two-Path Bandpass $\Sigma\Delta$ Modulator with Extended Noise Shaping

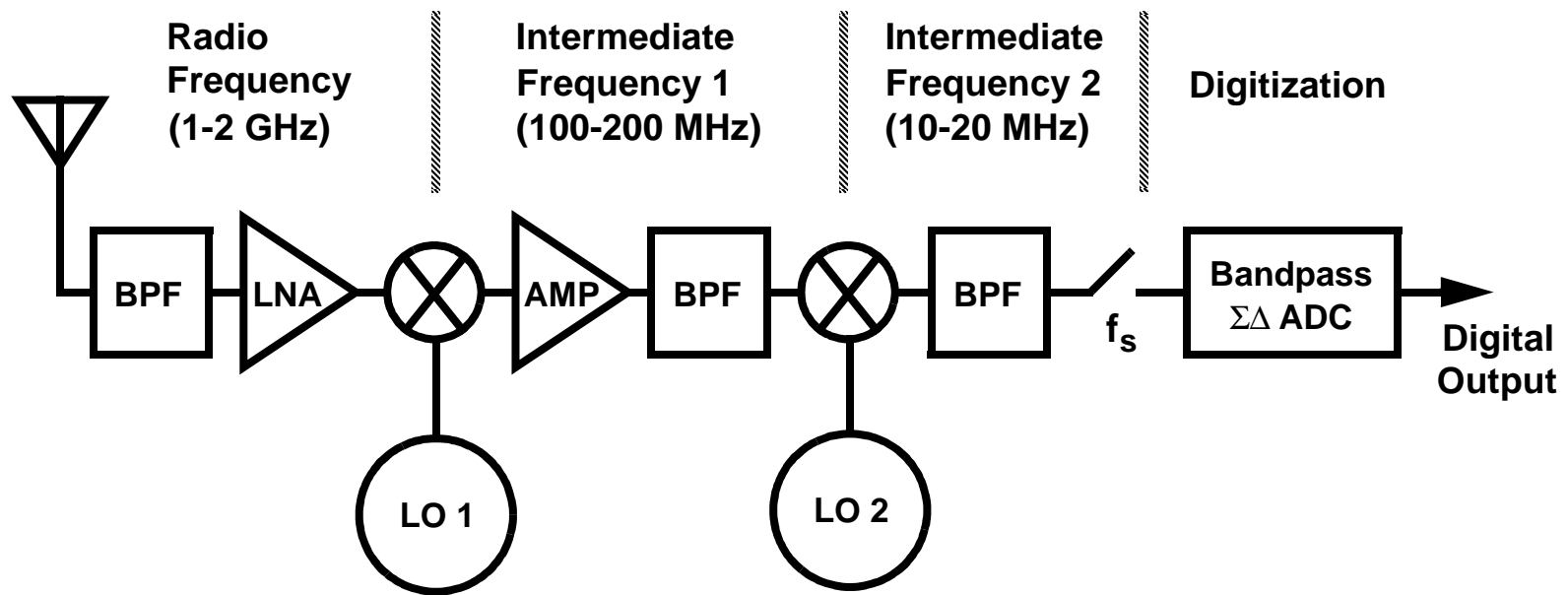
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Outline

- ❑ **Application**
- ❑ **Architecture**
- ❑ **Circuit Details**
- ❑ **Experimental Results**

Receiver with IF Digitization



- Relaxed selectivity requirements
- Requires IF sampling

Nyquist vs. Oversampled Converters

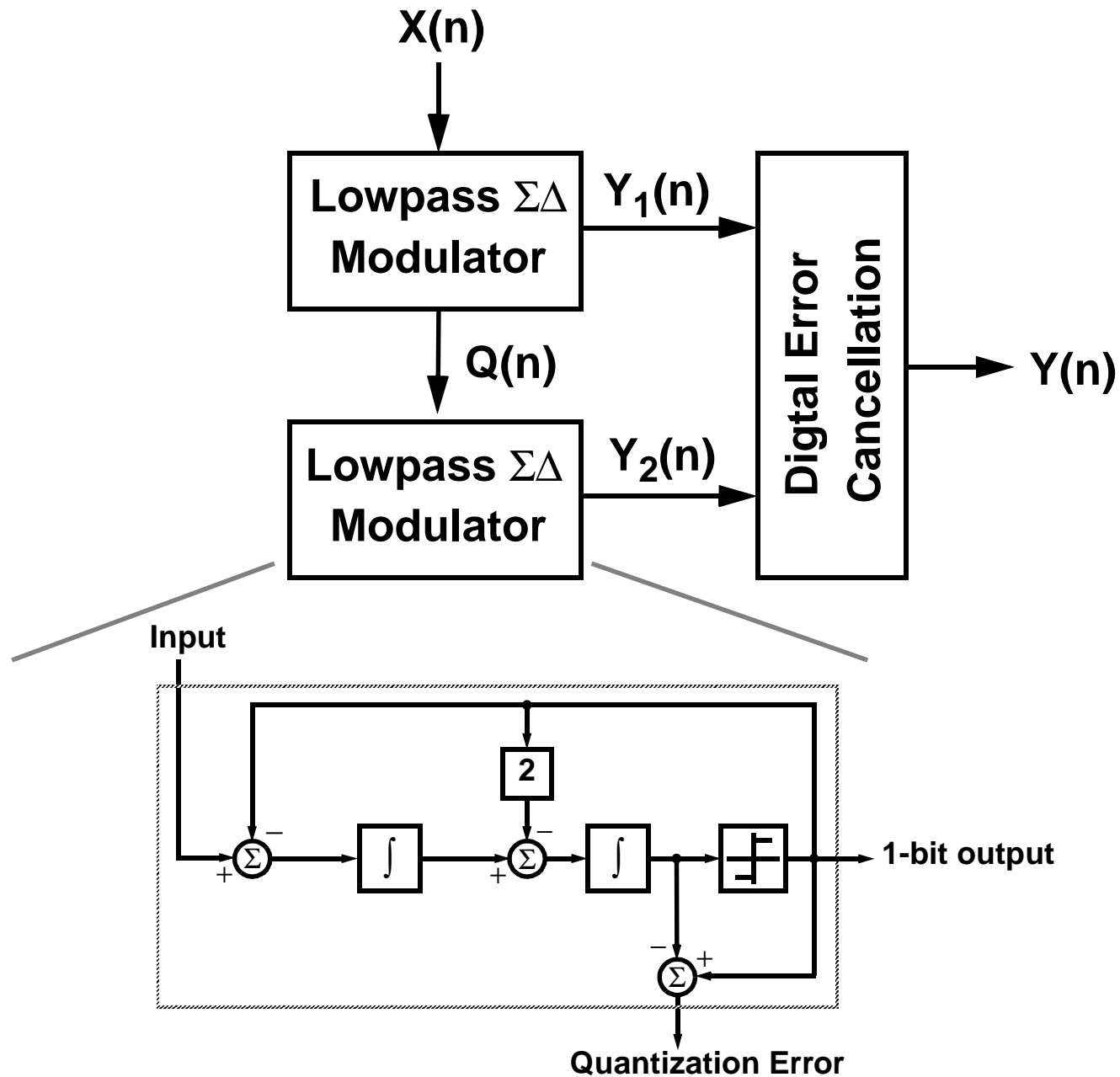
Nyquist A/D converters:

- **Fast conversion rate**
- **Precision limited by component mismatch**

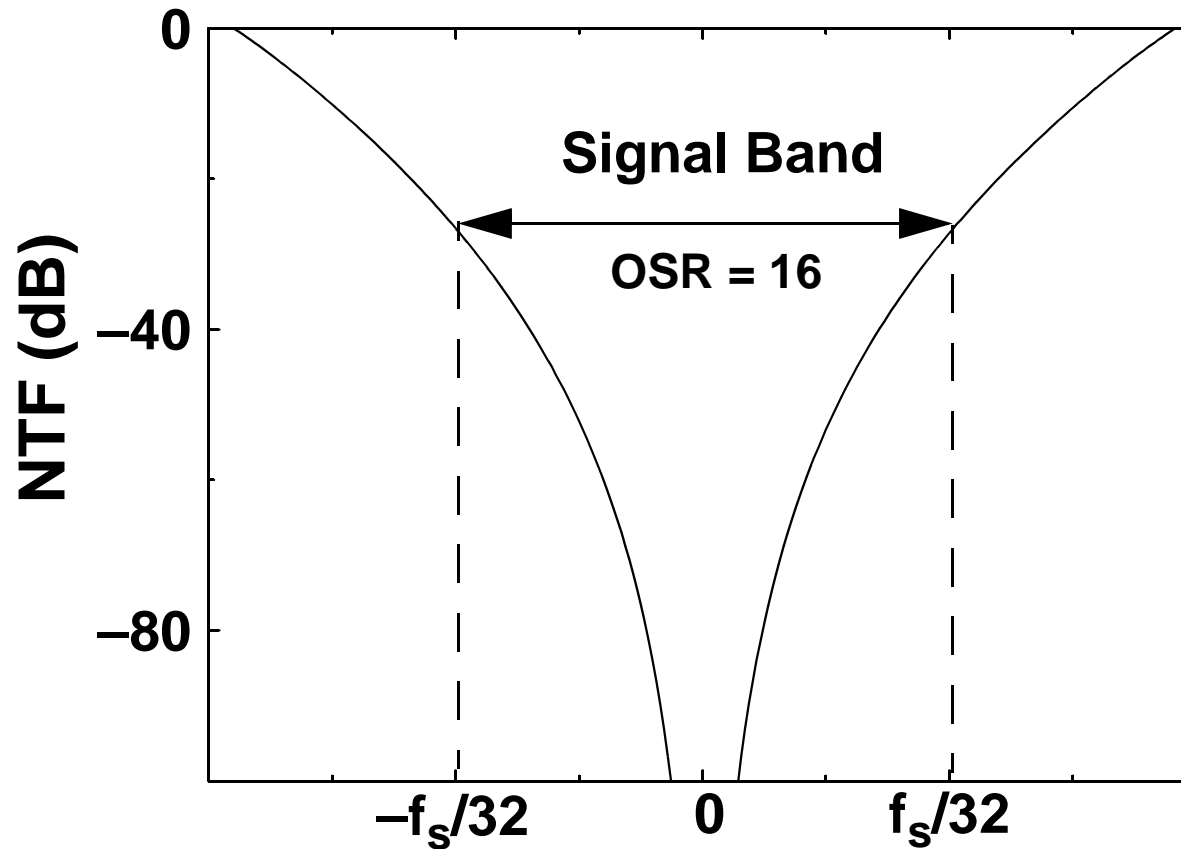
Oversampled converters:

- **Less sensitive to circuit nonidealities**
- **Low conversion rate**

2-2 Cascaded Modulator

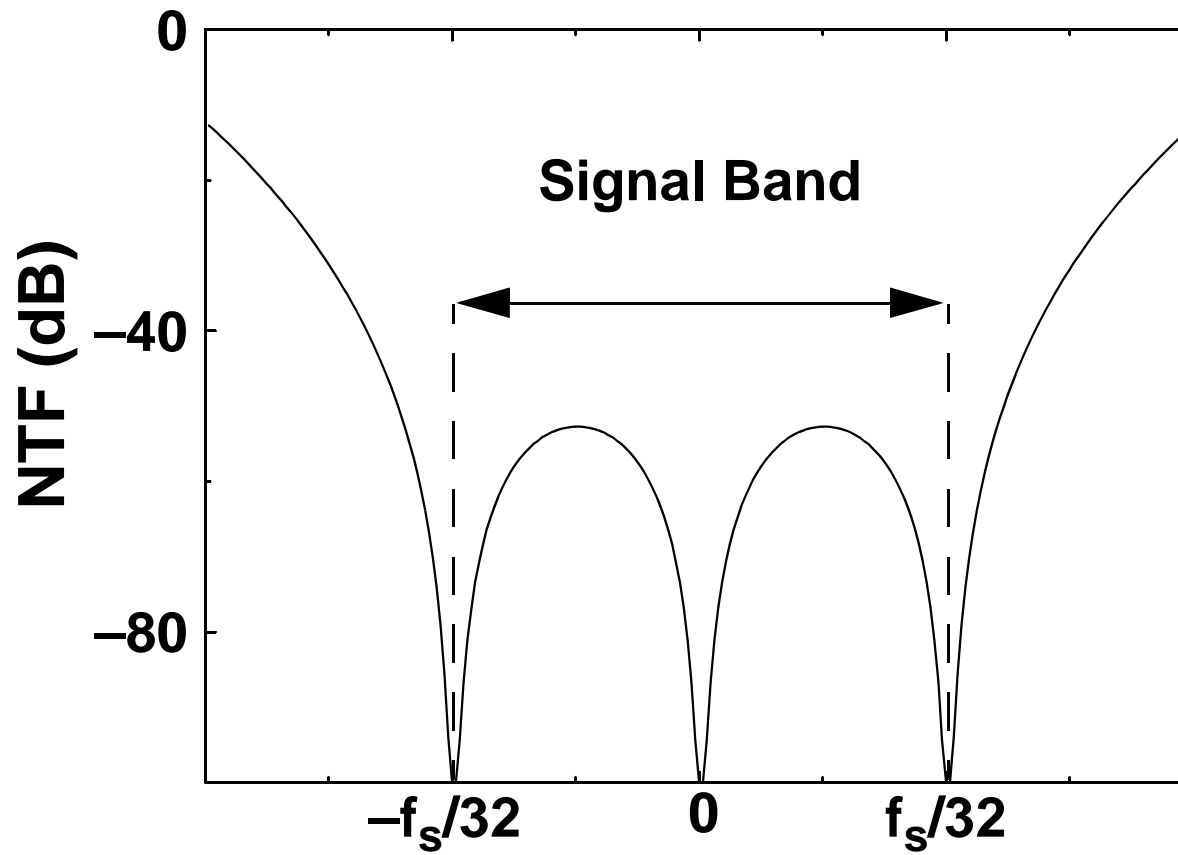


Noise Transfer Function



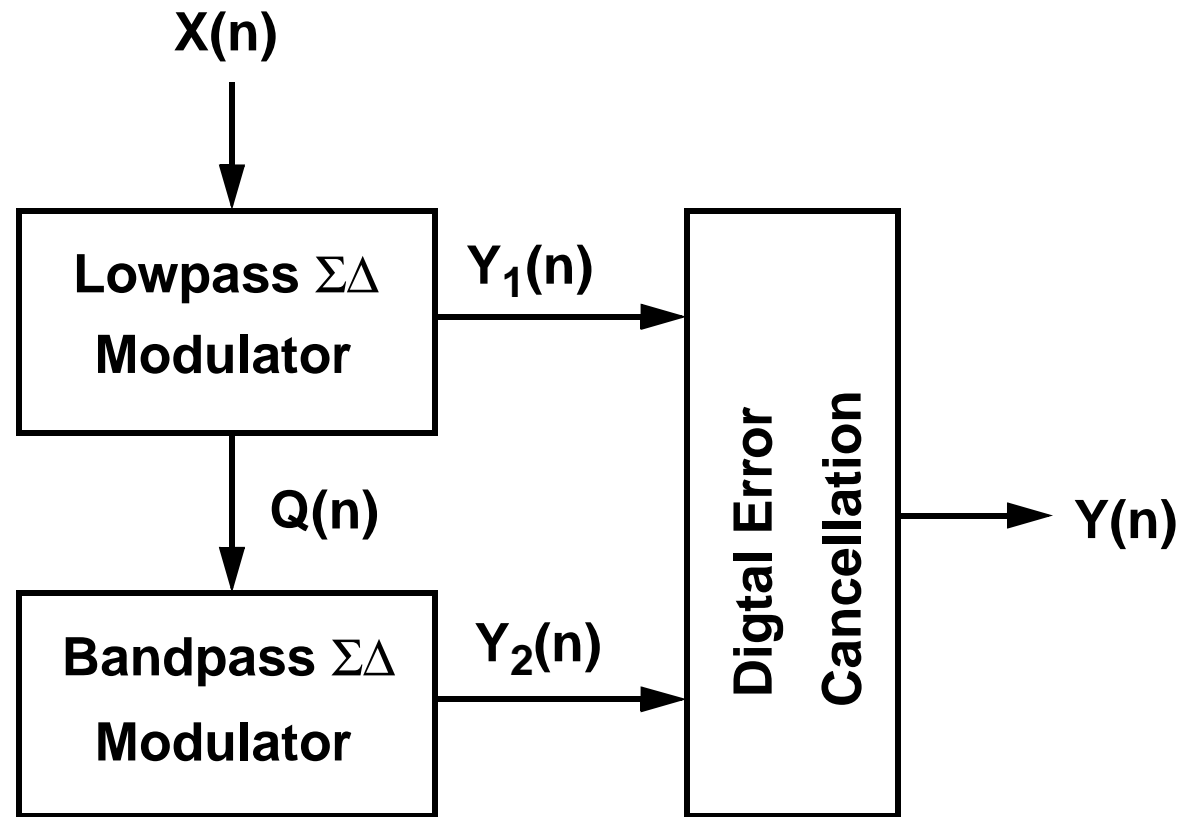
- $NTF = N_1 \times N_2 = (N_{LP})^2$
- $|NTF| > 0$ dB for $OSR < 8$

Move the Notches...



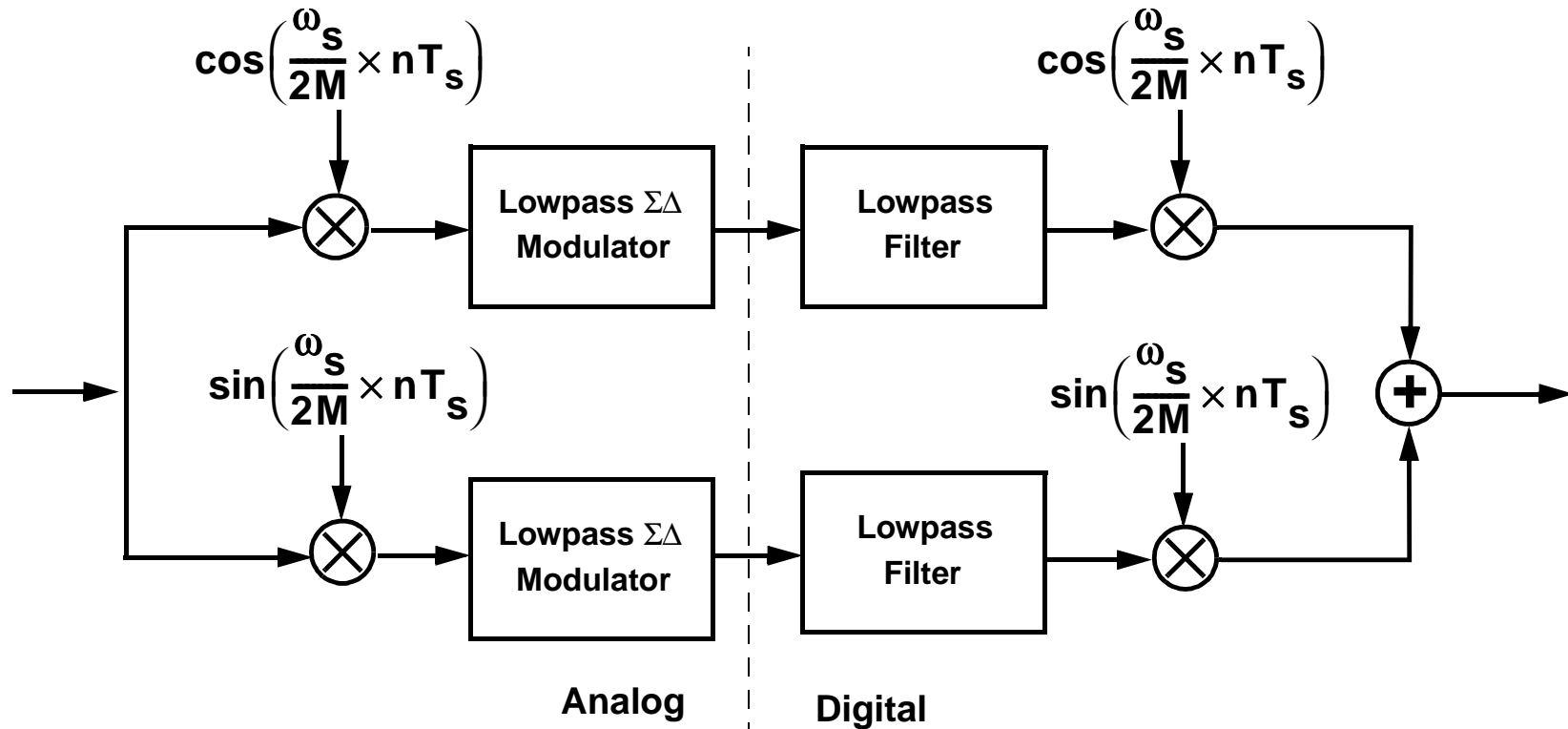
- $|NTF| < 0$ dB

Lowpass-Bandpass Cascaded Modulator

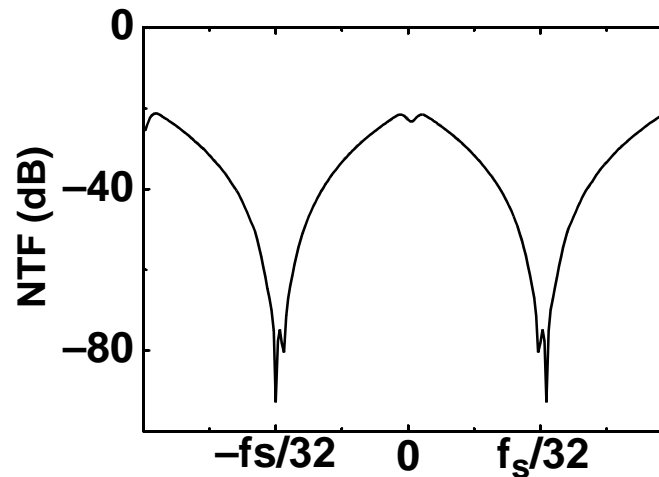


- $NTF = N_1 \times N_2 = N_{LP} \times N_{BP}$

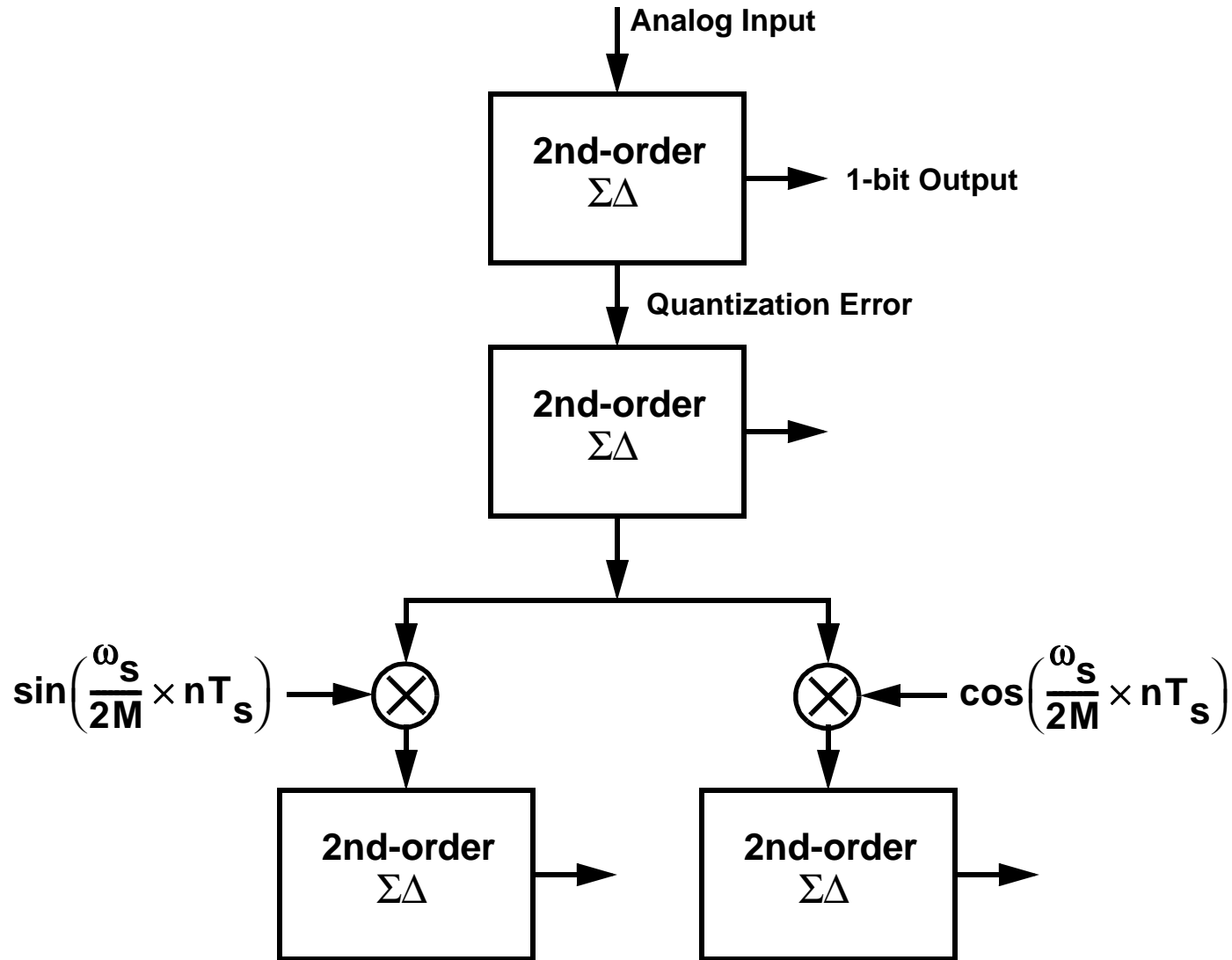
Bandpass Modulator



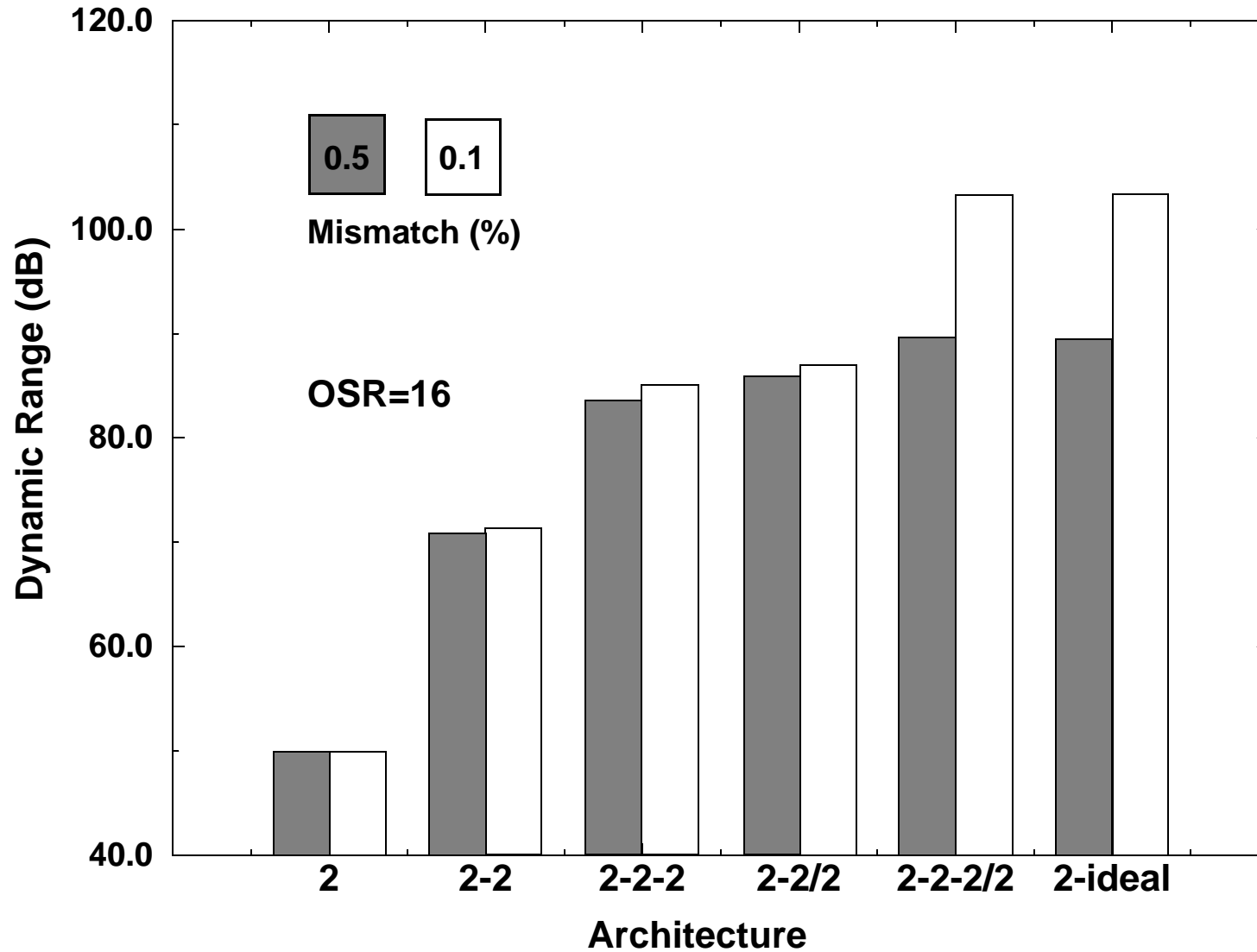
2/2 bandpass modulator



2-2-2/2 Modulator (Lowpass)

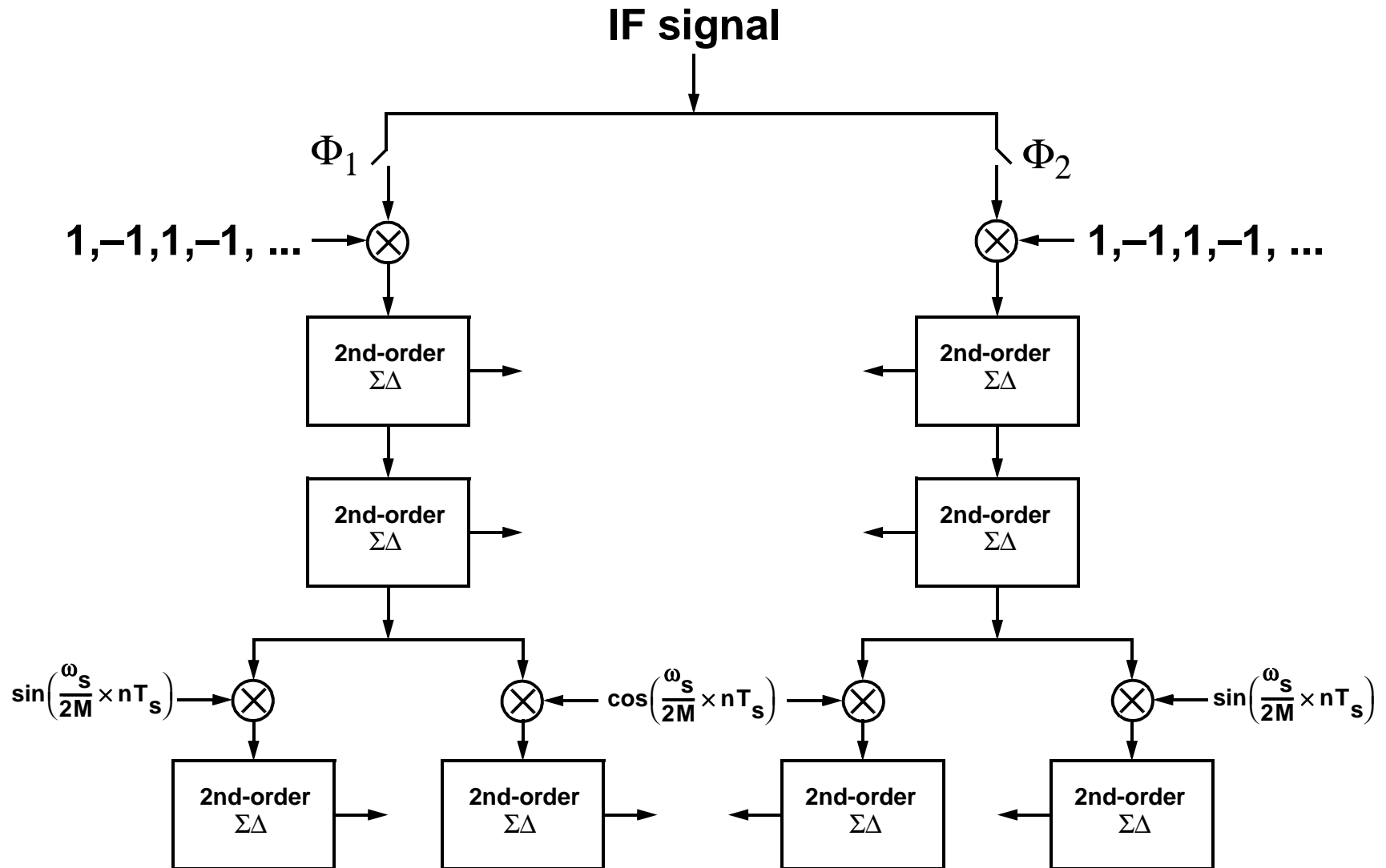


Architectural Comparison

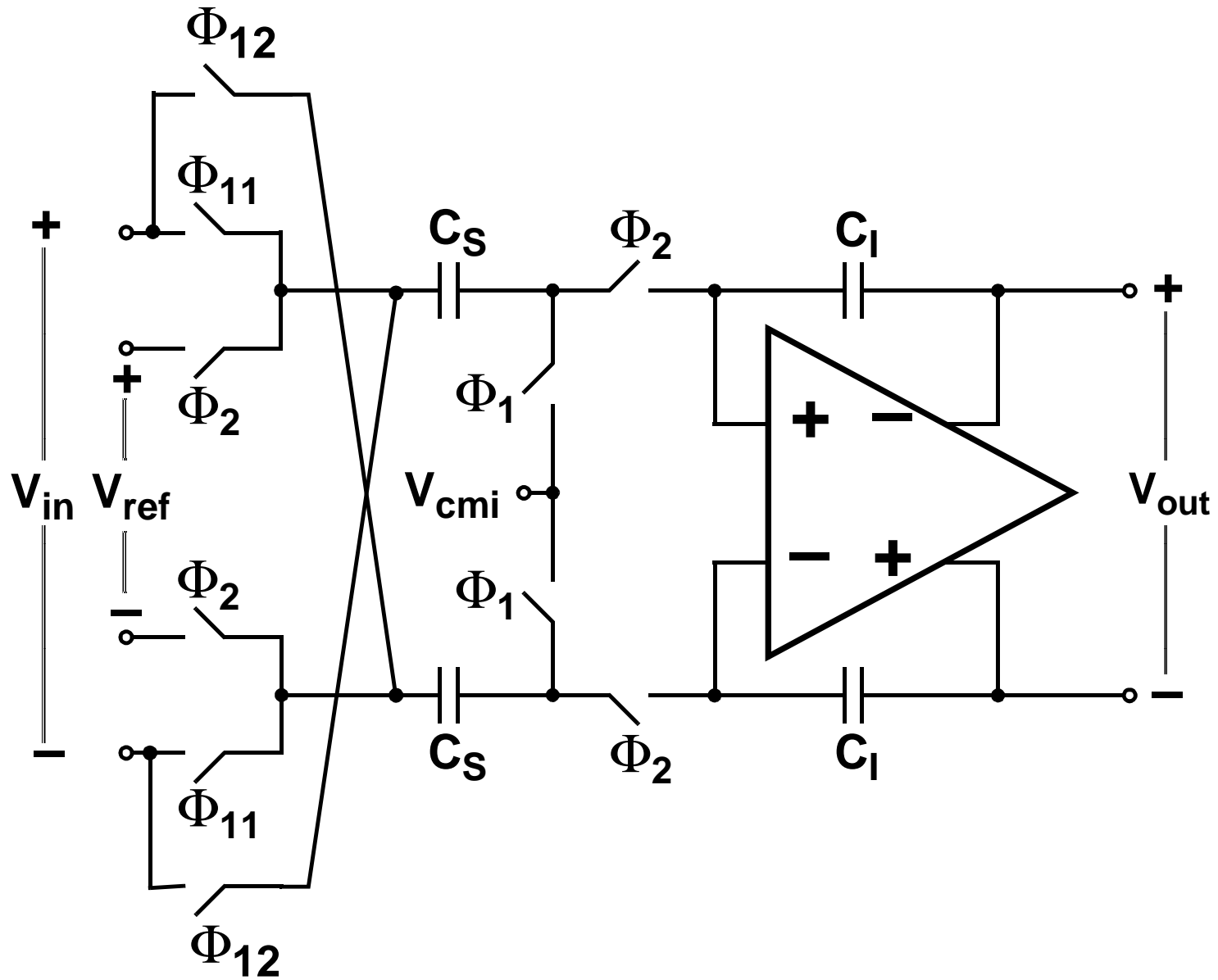


- **2-2-2/2 is the only architecture limited by mismatch**

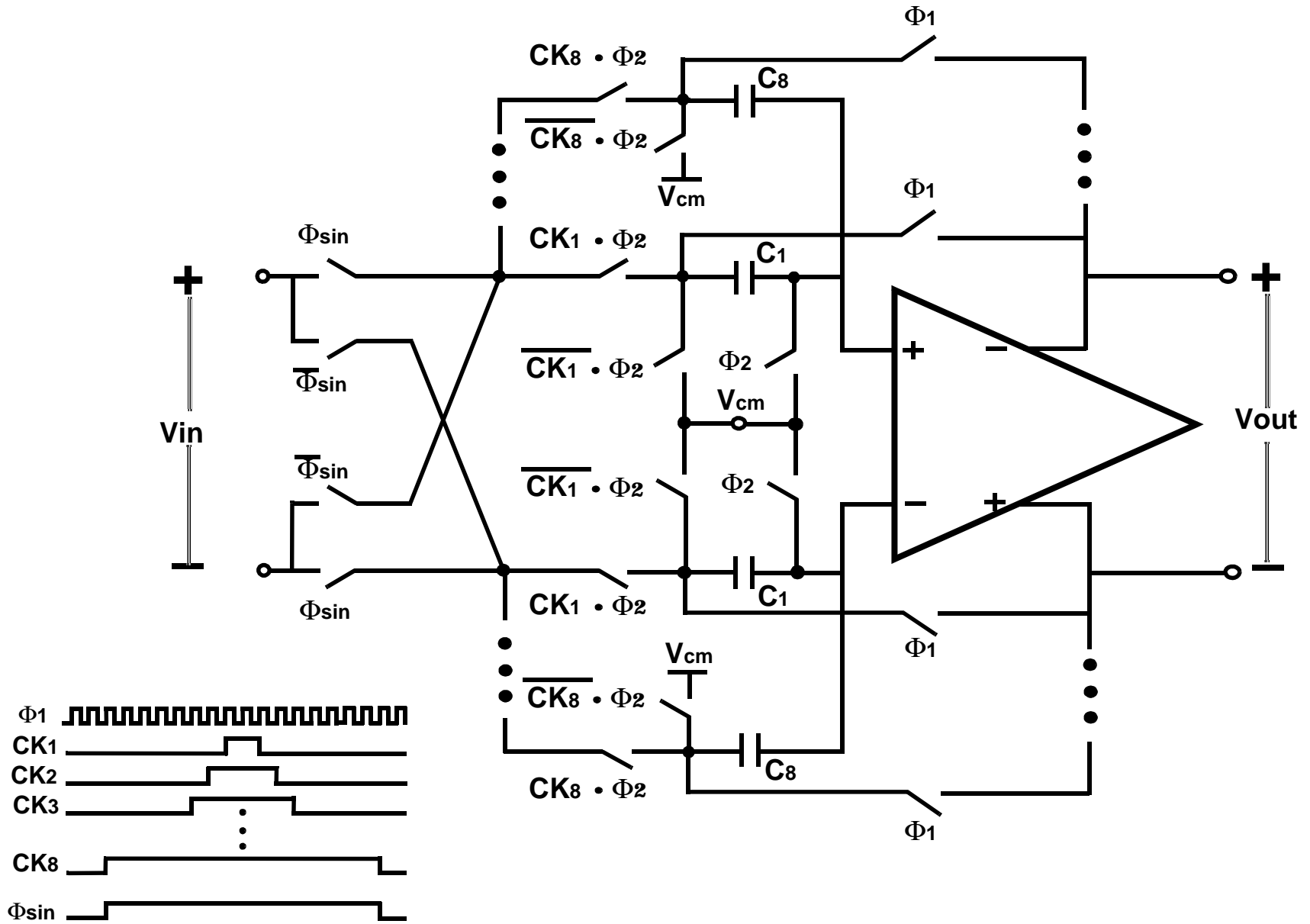
$f_s/4$ Bandpass Architecture



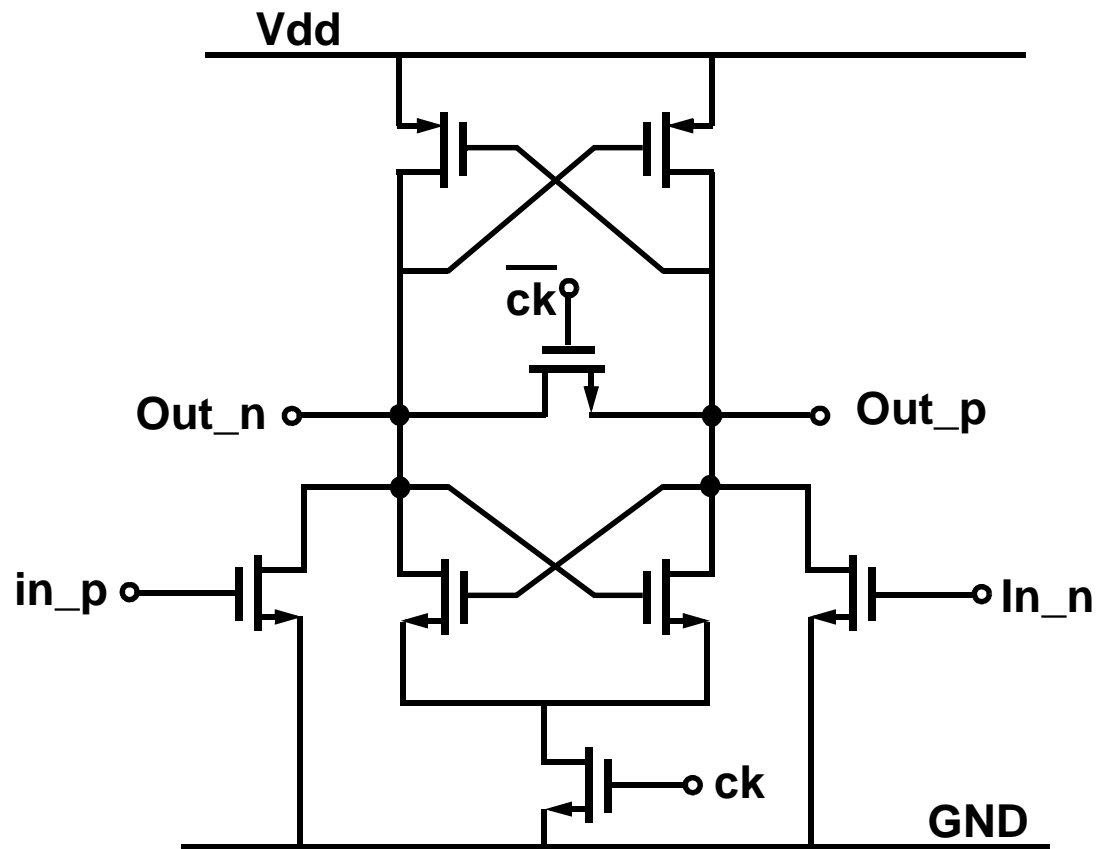
First Integrator



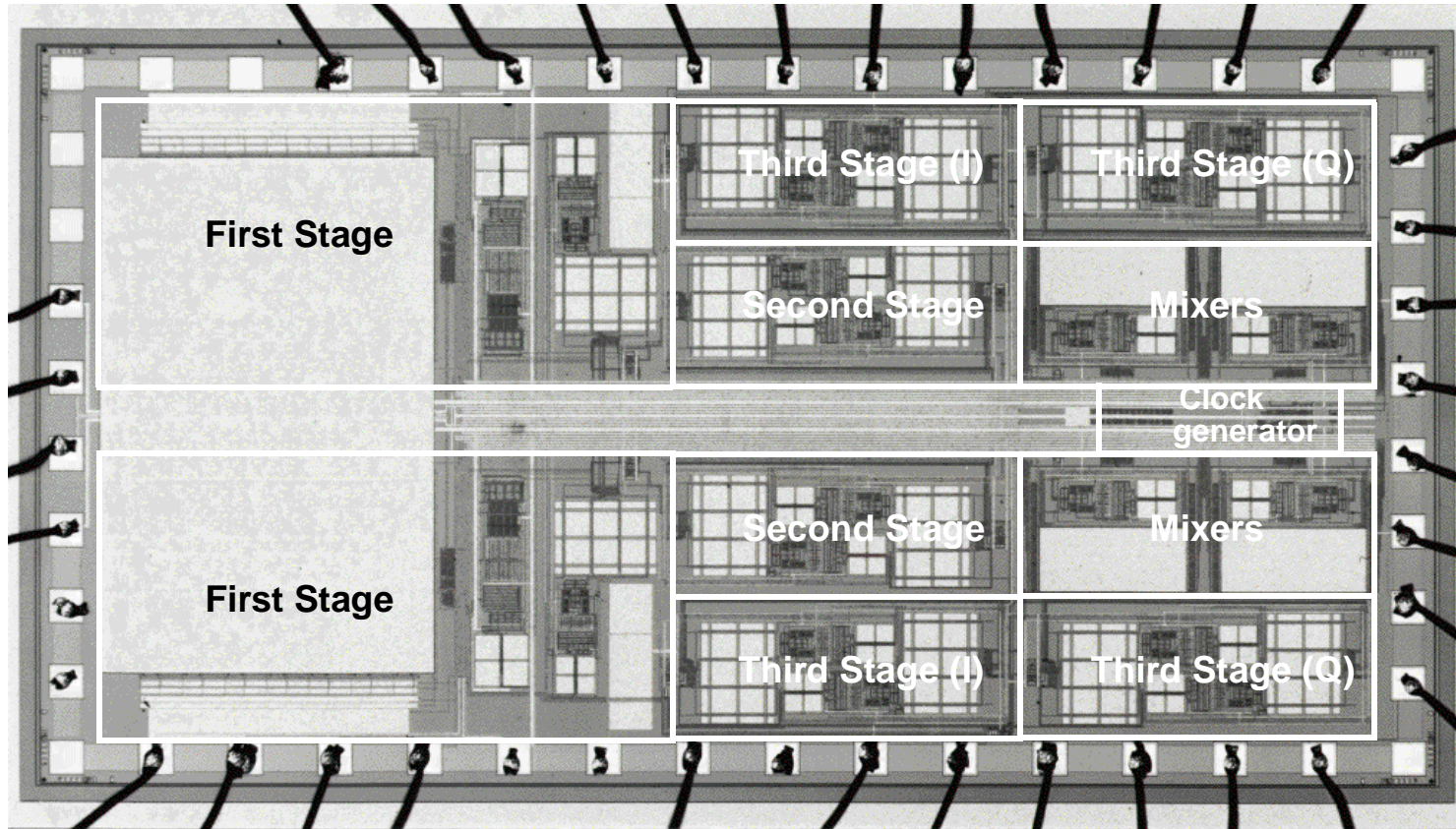
Mixer



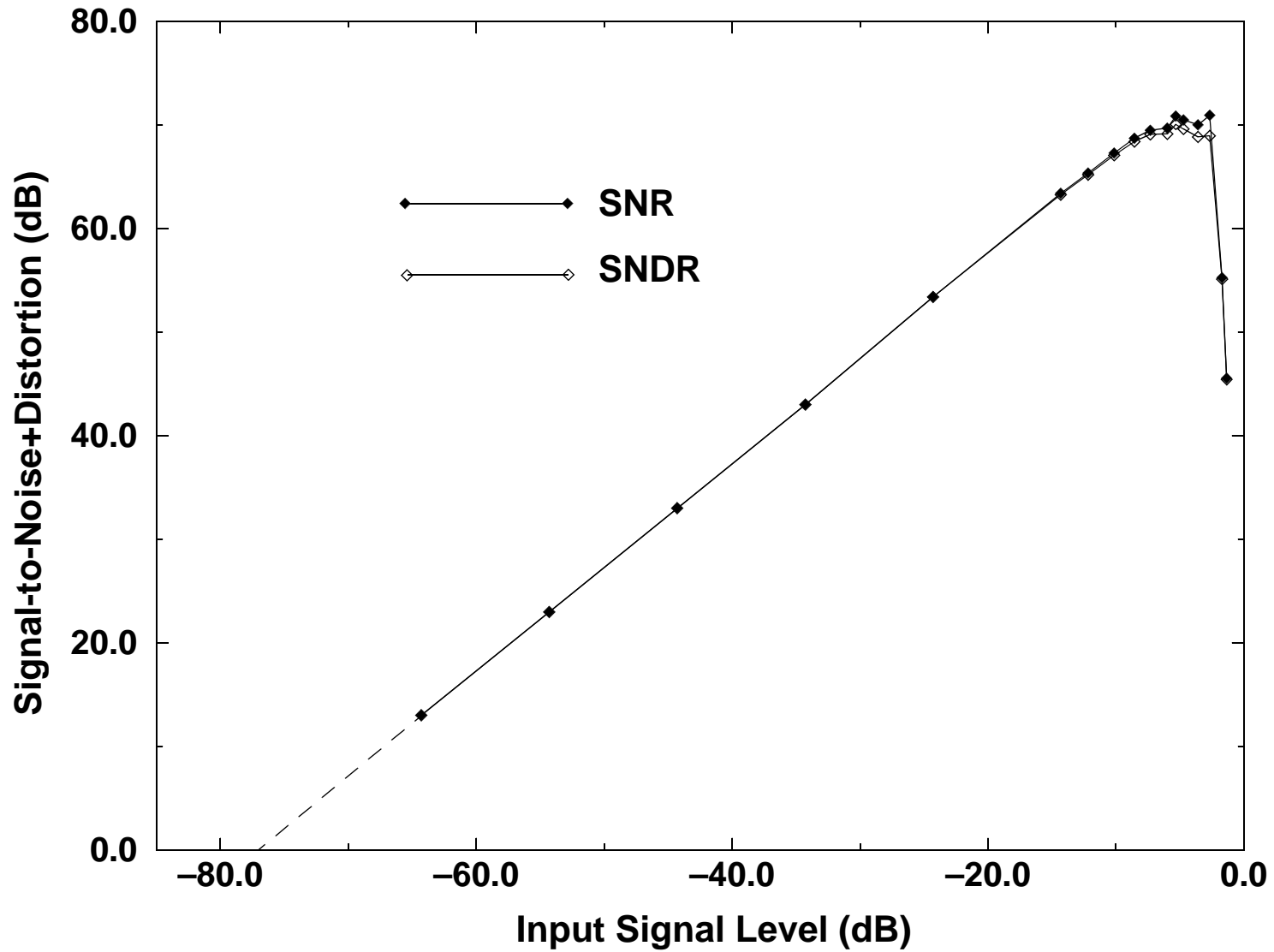
Comparator



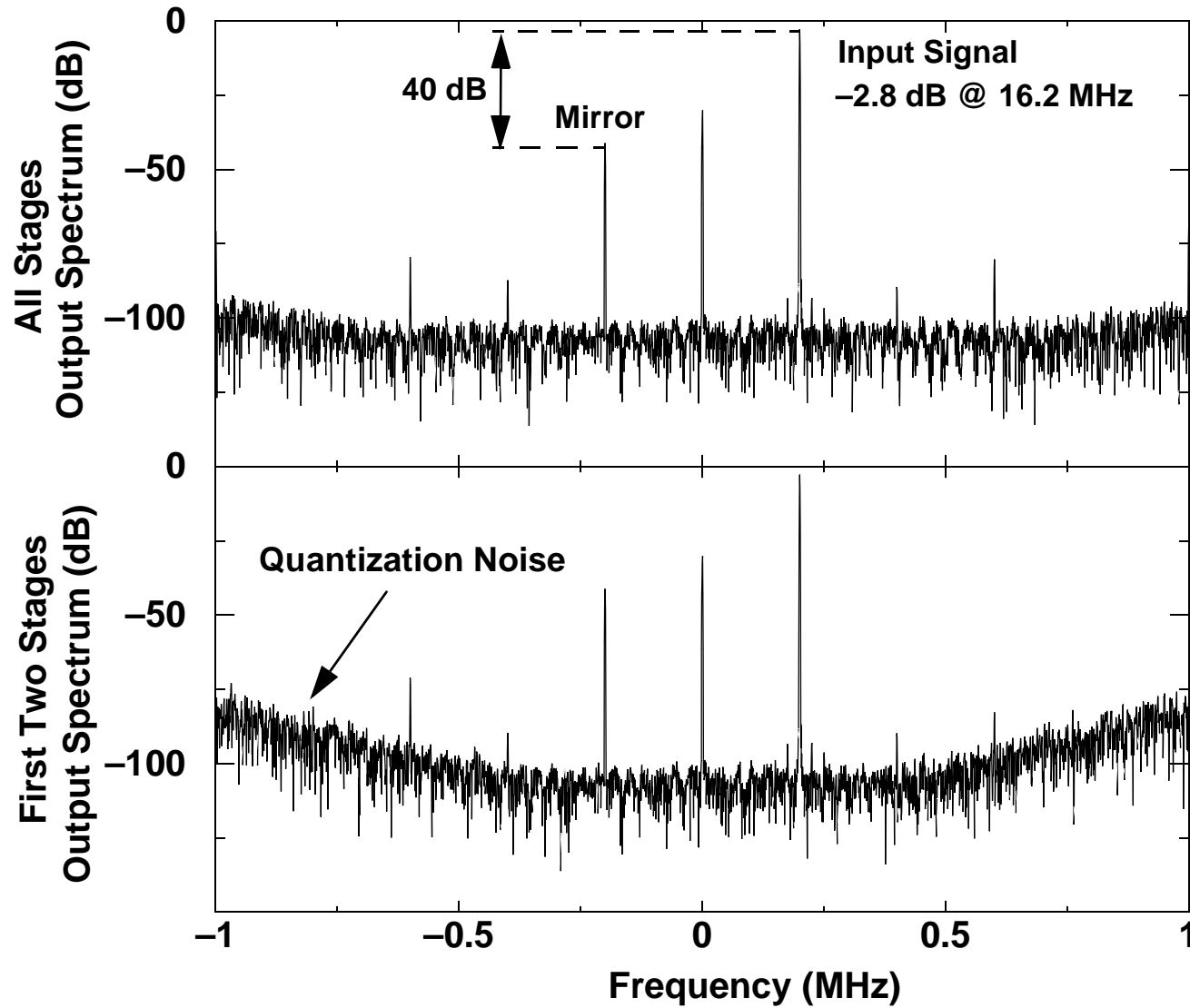
Chip Micrograph



Measured SNR and SNDR



Measured Output Spectrum



Performance Summary

Sampling speed:	64 MS/s
Passband:	2 MHz centered at 16 MHz
Oversampling ratio:	16
Dynamic range:	75 dB
Max SNDR:	70 dB
Power supply:	2.5 V
Power dissipation:	110 mW
Technology:	0.25-μm, 5-metal layer
Active Area:	2.8 mm²

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