

Finite Word Length Effects

■ Overflow of the number range

Large errors in the output signal occur when the available number range is exceeded—*overflow*. Overflow nonlinearities can be the cause of so-called *parasitic oscillations*.

■ Round-off errors

Rounding or truncation of products must be done in recursive loops so that the word length does not increase for each iteration.

The errors that occur under normal operating conditions can be modeled as white noise, but both rounding and truncation are nonlinear operations that may cause parasitic oscillations.

Floating-point addition also causes errors because of the denormalization and normalization of the numbers involved.

■ Aliasing errors

Aliasing and imaging errors occur in A/D and D/A converters and when the sample rate is changed in multirate systems.

These nonlinearities may cause nonharmonic distortion.

■ Coefficient errors

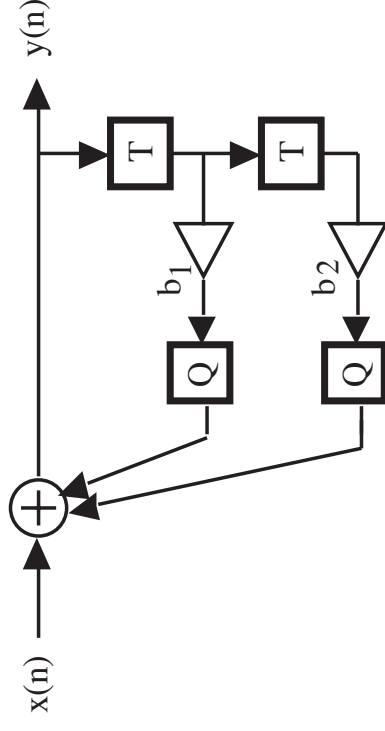
Coefficients can only be represented with finite precision.

This results in a static deviation from the ideal frequency response for a digital filter.

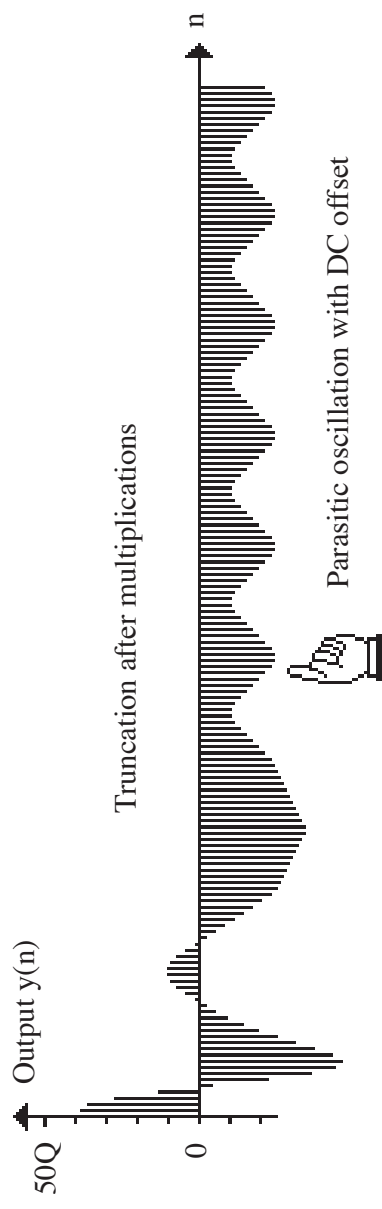
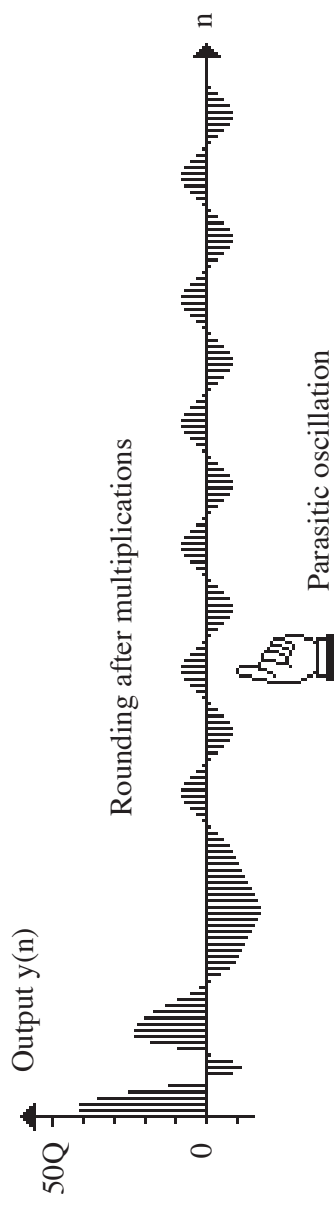
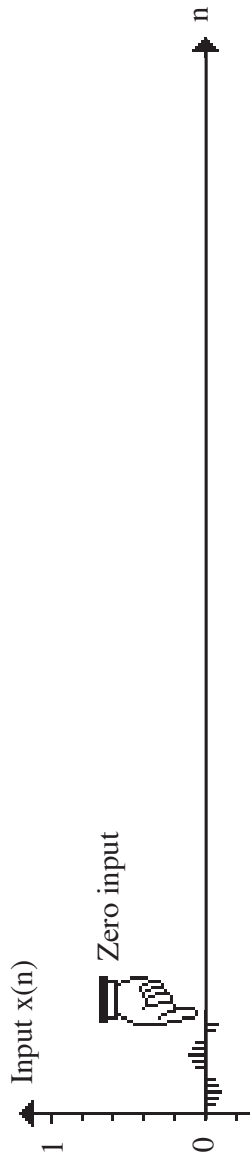
Parasitic Oscillations

Parasitic oscillations are caused by nonlinearities.

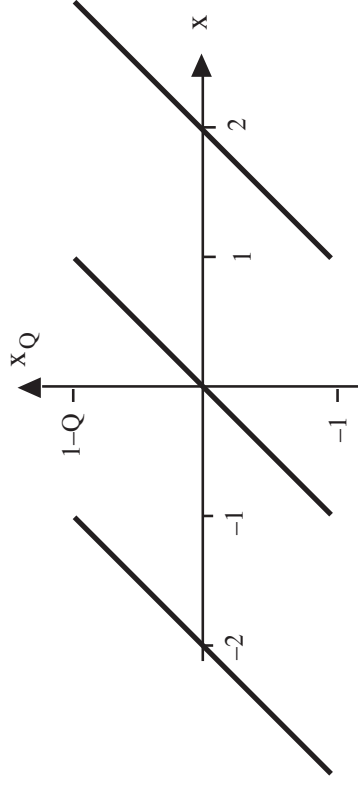
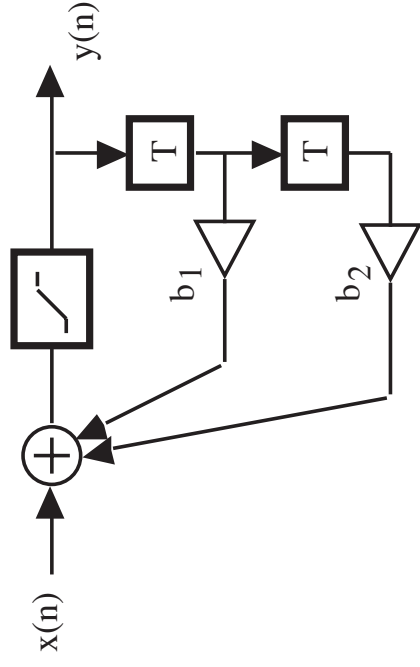
Zero-Input Oscillations



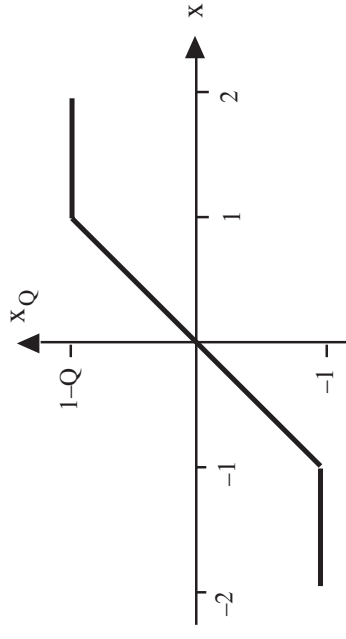
Most studied in the literature because its is the simplest case.



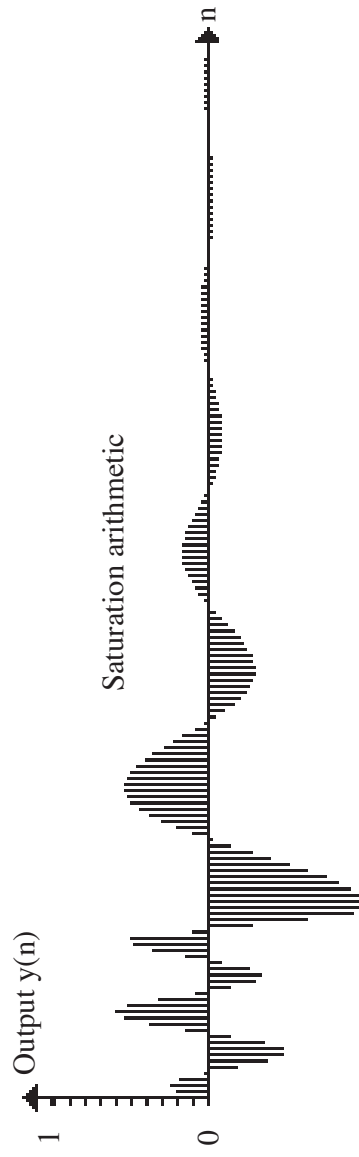
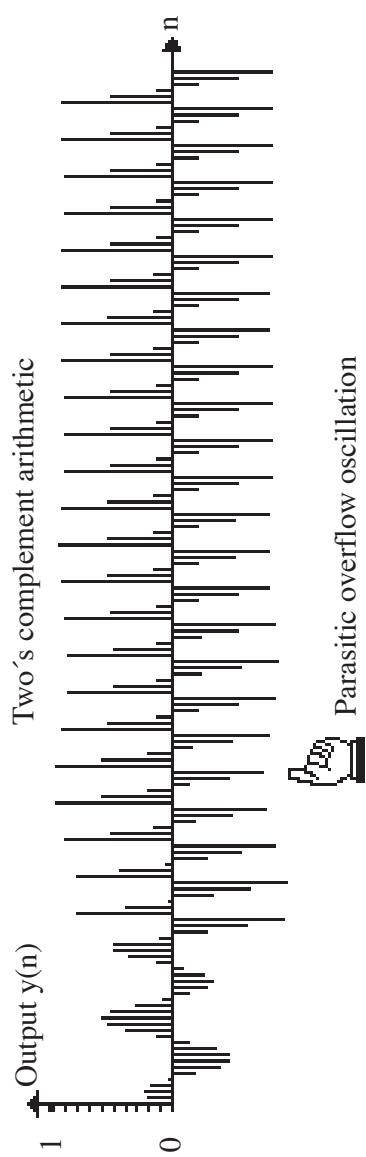
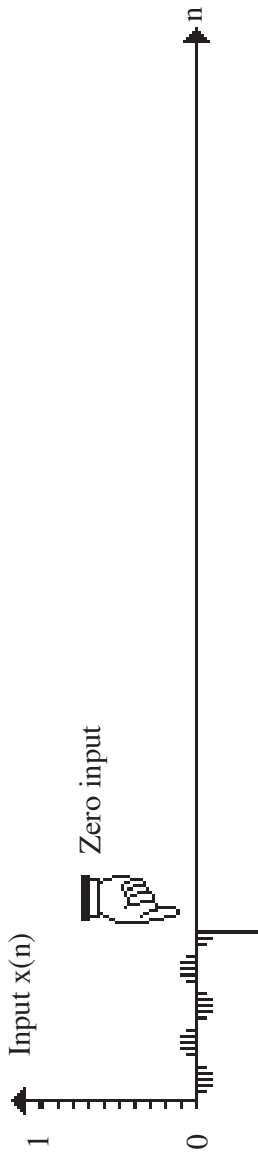
Overflow Oscillations



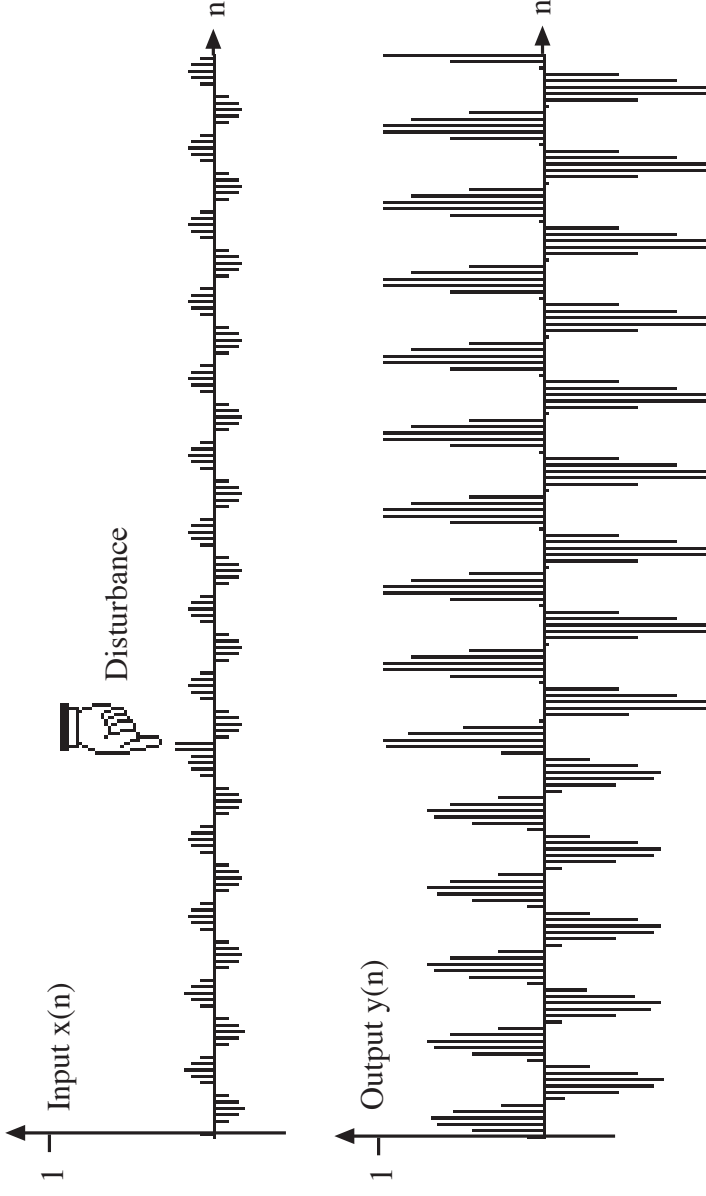
Two's-complement overflow
characteristic



Saturation arithmetic

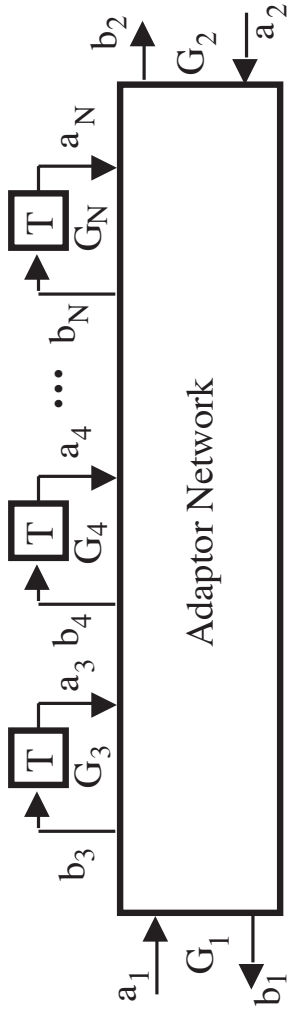


Periodic Input Oscillations



See also sections 5.2.4 Nonobservable Parasitic Oscillations and
 5.2.5 Parasitic Oscillations In Algorithms Using Floating-Point Arithmetic

Quantization in WDFs



$$p(n) = \Delta \sum_{k=1}^N G_k [a_k(n)^2 - b_k(n)^2]$$

Quantization rule for WDFs

$$\begin{cases} |b(n)_Q| < |b(n)_{exact}| \\ b(n)_Q b(n)_{exact} \geq 0 \end{cases}$$