Standard Approach to small-signal analysis of nonlinear networks

1. Linearize nonlinear devices

2. Replace all devices with small-signal equivalent

3. Solve linear small-signal network
Review from Last Time:

**Standard Approach to analysis of nonlinear networks**

1. **Nonlinear Network**
2. **dc Equivalent Network**
3. **Q-point**
4. **Values for small-signal parameters**
5. **Small-signal equivalent network**
6. **Small-signal output**
7. **Total output** (good approximation)
Standard Approach to small-signal analysis of nonlinear networks

Nonlinear Network

dc Equivalent Network

Q-point

Values for small-signal parameters

Small-signal equivalent network

Small-signal output

Total output

(good approximation)
Engineering Issues for Using Data Converters

1. Inherent with Data Conversion Process
   - Amplitude Quantization
   - Time Quantization
   (Present even with Ideal Data Converters)

2. Nonideal Components
   - Uneven steps
   - Offsets
   - Gain errors
   - Response Time
   - Noise
   (Present to some degree in all physical Data Converters)

How do these issues ultimately impact performance?
Types of ADCs

- Flash
- Pipelined
- Folded
- Serial
  - Single-slope
  - Dual-slope
- Interpolating
- Iterative (Algorithmic, Cyclic)
- Successive Approximation (SAR)
- Oversampled (Delta-Sigma)
- Charge Redistribution
- Several others
Types of ADCs

Flash ADC
Types of ADCs

Pipelined ADC

Diagram showing the pipeline stages and shift register array.
Types of ADCs

Cyclic ADC

\[ X_{IN} \rightarrow S/H \rightarrow \text{Gain/Shift Stage} \rightarrow \text{Shift Register} \rightarrow X_{OUT} \]

Gain/Shift Stage

\[ X_{IN_k} \rightarrow \text{ADC}_k \rightarrow + \rightarrow A_k \rightarrow \text{S/H}_k \rightarrow X_{OUT_k} \]
Types of ADCs

Single-Slope ADC

Diagram showing the components and signals of a Single-Slope ADC.
Types of ADCs

Dual-Slope ADC

- $X_{IN}$
- $-X_{REF}$
- CLK

Output: $X_{OUT}$
Types of ADCs

**SAR ADC**

- $X_{IN}$
- $X_{REF}$
- $X_{OUT}$

Successive Approximation ADC (SAR)
Types of DACs

- Current steering
- R-String
- Ladder (R-2R)
- Parallel
- Pipelined
- Subranging
- Charge Redistribution
- Algorithmic
- Serial
- Subranging
- Oversampled (Delta-Sigma)
- Several others
Types of DACs

\[ V_{\text{RFF}} \] \quad X_{\text{IN}} \quad V_{\text{OUT}}

\textit{R-string DAC}
Types of DACs

Current-steering DAC
Types of DACs

Ladder DAC (R-2R)
Types of DACs

Charge-Redistribution DAC

\[ C_k = \frac{C}{2^{k-1}} \]
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