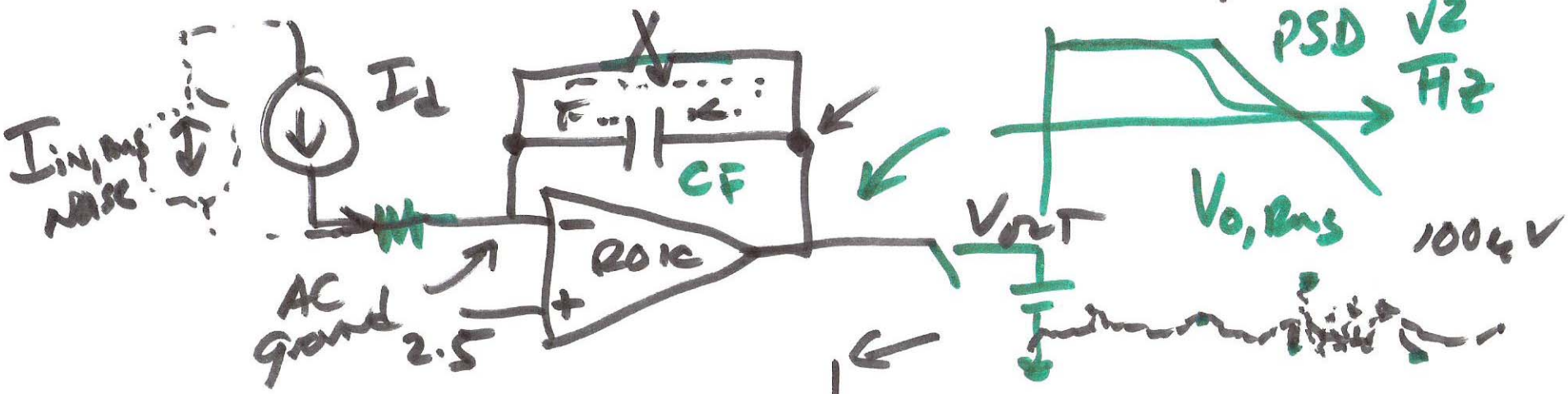
ECE 614 Advance Analog IC Design

BOISE STATE UNIVERSITY

Lecture 15, Oct. 11, 2011



$CV = Q$

$C_F \cdot V_{rms,NOISE} = Q_{NOISE}$

$P = \int PSD \cdot df$

$PSD = \frac{V^2}{Hz}$

V^2_{rms}

$\frac{Q_{noise}}{q}$ = # of electrons

$\frac{\#\text{ of electrons}}{Time}$

q ← $1.6 \times 10^{-19} C$

↑ input referred noise

1)

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$$\frac{\#\ \text{of electrons}}{T_{Integration}} = I_{rms,noise}$$

↑ input referred noise current

$T = 50K$ ← 50Kelvin

$= -222$

fix

Hand calculations

$$\sqrt{\frac{kT}{C}} = V_{rms,noise}$$ ←

$$Q_{noise} = \frac{1}{2} V_{rms,noise}$$

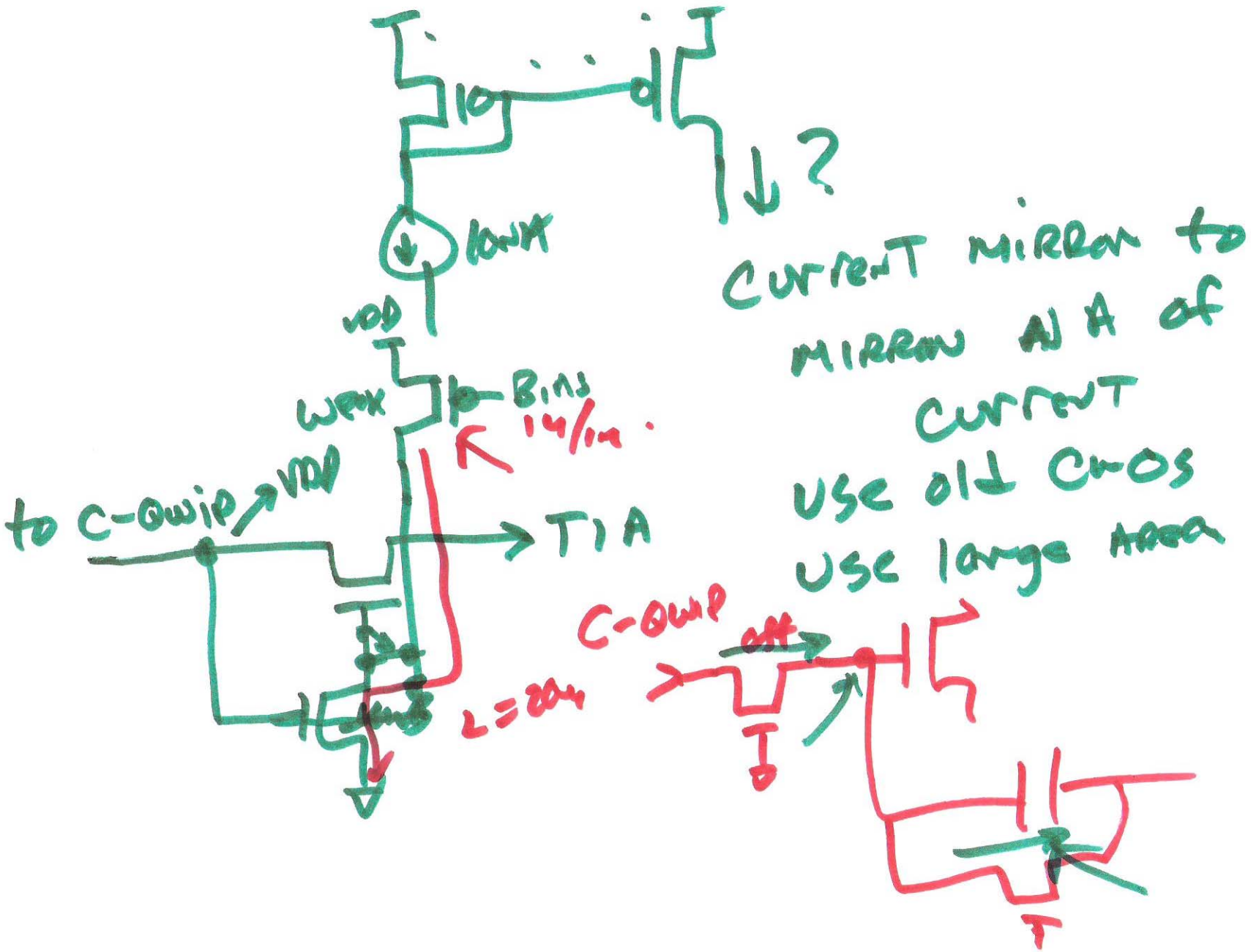
$100\mu V$, $400fF$

$$\sqrt{\frac{1.38 \times 10^{-23} \cdot 50}{400fF}} \overset{?}{\approx} 924\mu V$$

$\frac{1}{2}$

2)

Mismatch < 10nA



Current mirror to mirror a fraction of current

Use old CMOS

Use large area

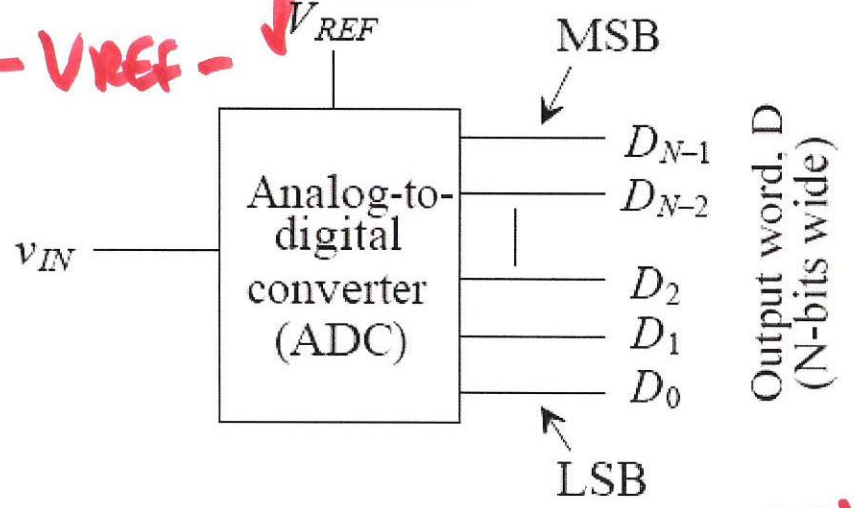


Figure 28.18 Block diagram of the digital-to-analog converter.

VREF+
VREF
VREF-

DYNAMIC RANGE

$$1LSB = \frac{V_{REF}}{2^N} = \frac{V_{R+} - V_{R-}}{2^N}$$

$$1LSB = \frac{V_{REF+} - V_{REF-}}{2^N}$$

$$V_{REF+} - V_{REF-} = \frac{V_{REF+} - V_{REF-}}{2^N}$$

$$MAX\ OUT = \frac{V_{REF+} - V_{REF-}}{2^N}$$

$$1LSB = \frac{V_{REF}}{2^N}$$

$$MAX\ OUT = V_{REF}\left(\frac{1 - 2^N}{2^N}\right)$$

$$MAX\ OUT = V_{REF+} \cdot \frac{(2^N - 1)}{2^N} - \frac{V_{REF-}}{2^N}$$

$$DR = \frac{V_{REF}(1 - 2^N)}{\frac{V_{REF}}{2^N}} = \frac{2^N - 1}{1}$$

4)

DAC

$$1LSB = \frac{VREF}{2^N}$$

Digital	Analog
0 0 0 0 0	0
0 0 0 0 1	$2^0 - 1$
1 1 1 1 1	VREF - 1LSB
1 1 1 1 1	$2^N - 1$

$$DR = \frac{MAX}{MIN}$$

$$= \frac{(2^N - 1)\,LSBs}{1LSB}$$

$$DR = 2^N - 1$$

$$20 \log(2^N - 1)$$

$$\simeq 6.02N \text{ dB}$$

5)

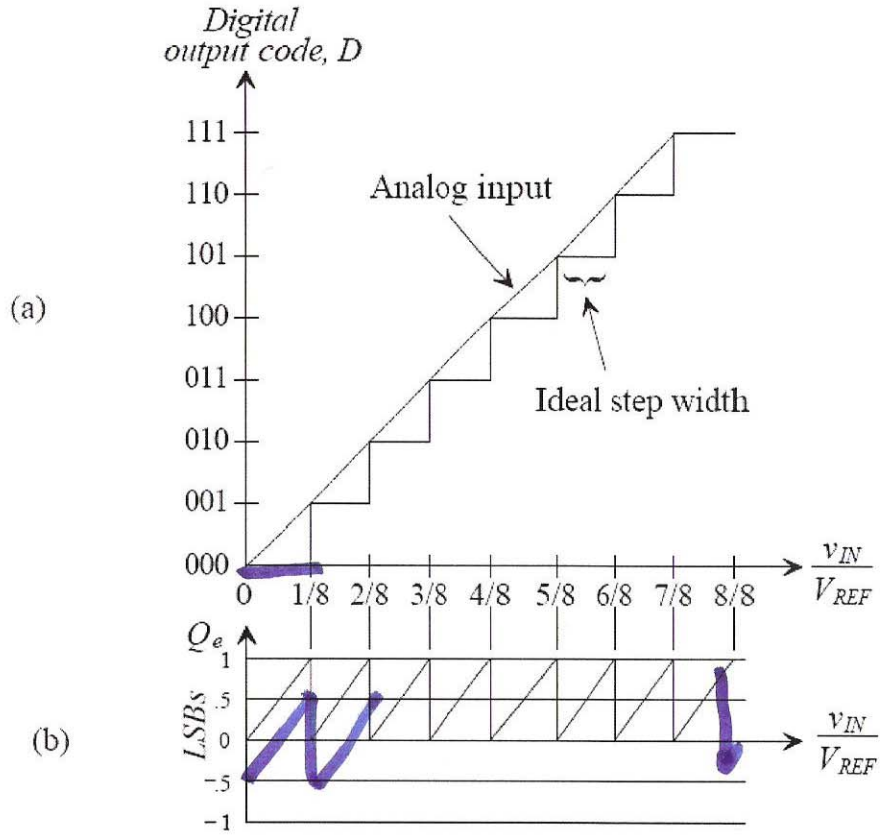


Figure 28.19 (a) Transfer curve for an ideal ADC and (b) its corresponding quantization error.

3-bit ADC

6)

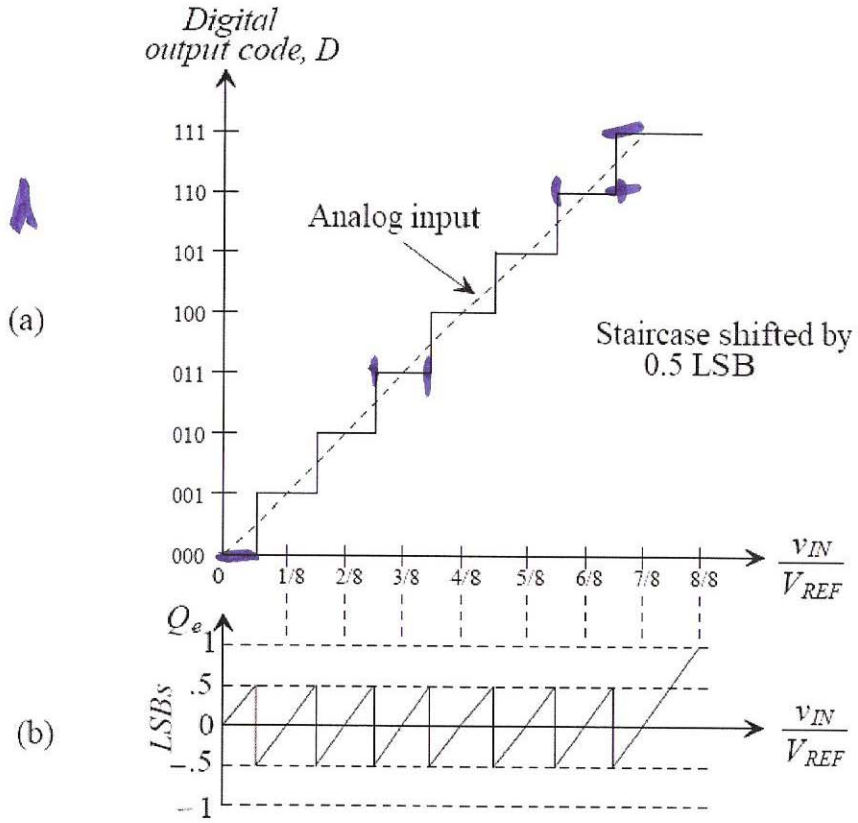
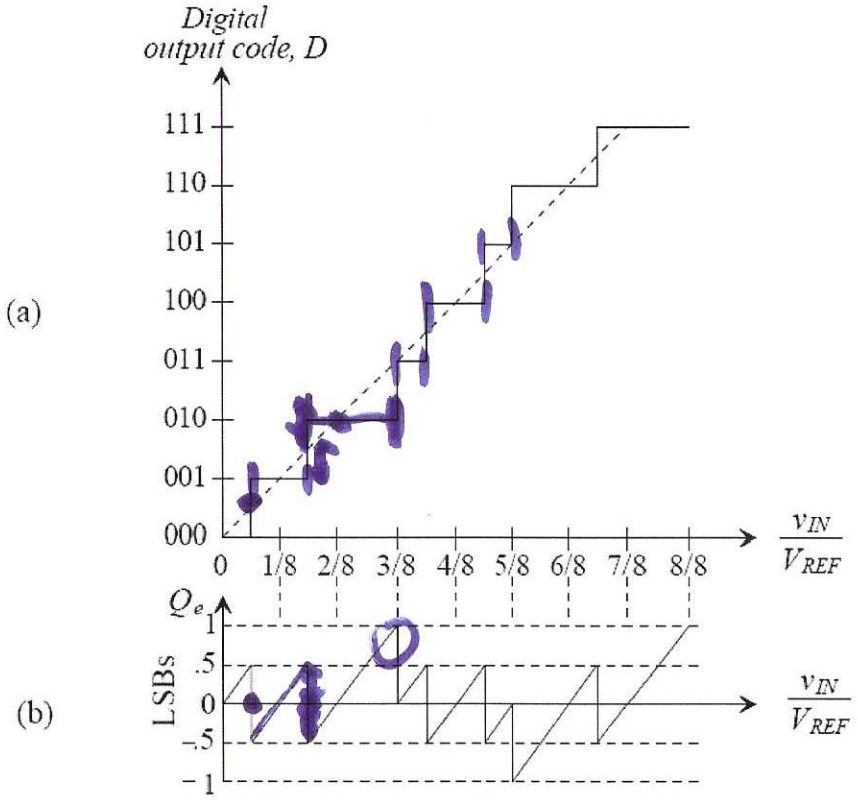


Figure 28.20 (a) Transfer curve for an ideal 3-bit ADC with (b) quantization error centered about zero.



DNL

Figure 28.21 (a) Transfer curve for a nonideal 3-bit ADC used in Ex. 28.4 with (b) quantization error illustrating differential nonlinearity.

8)

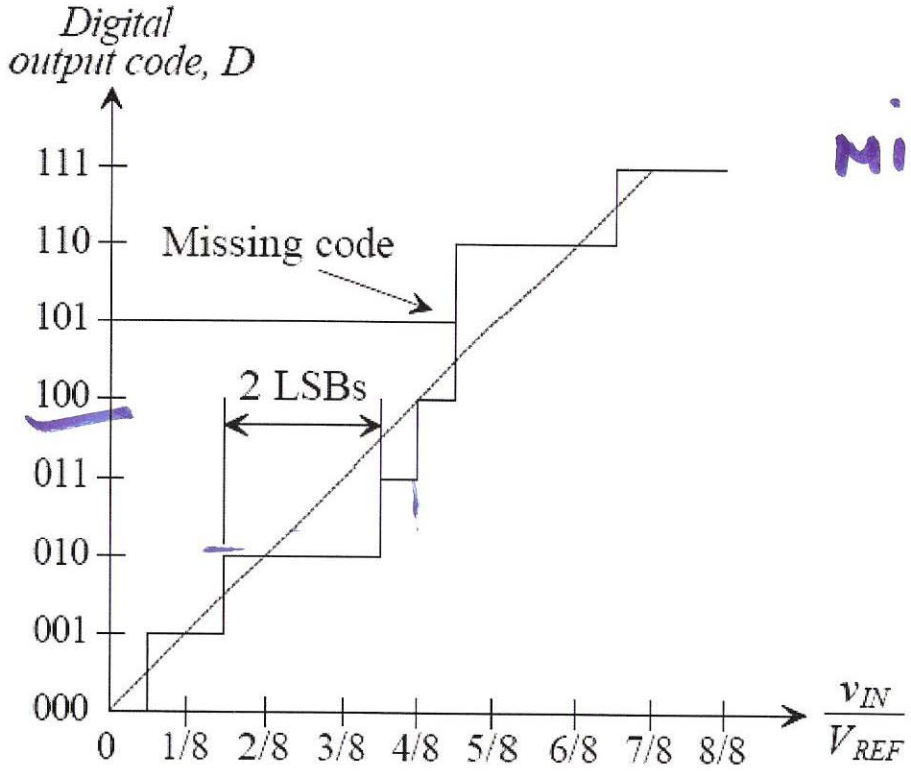
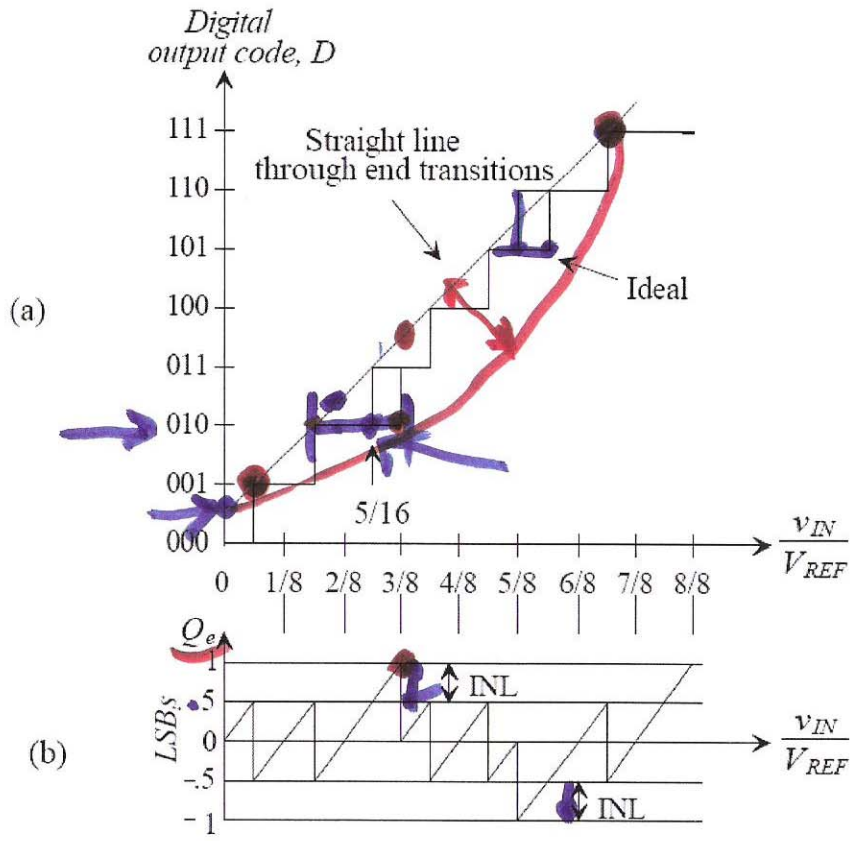


Figure 28.22 Transfer curve for a nonideal 3-bit ADC with a missing code.



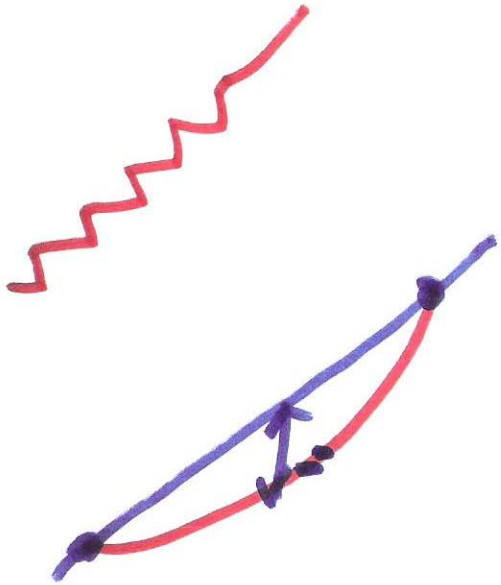


Figure 28.23 (a) Transfer curve of a nonideal 3-bit ADC and (b) its quantization error illustrating INL.

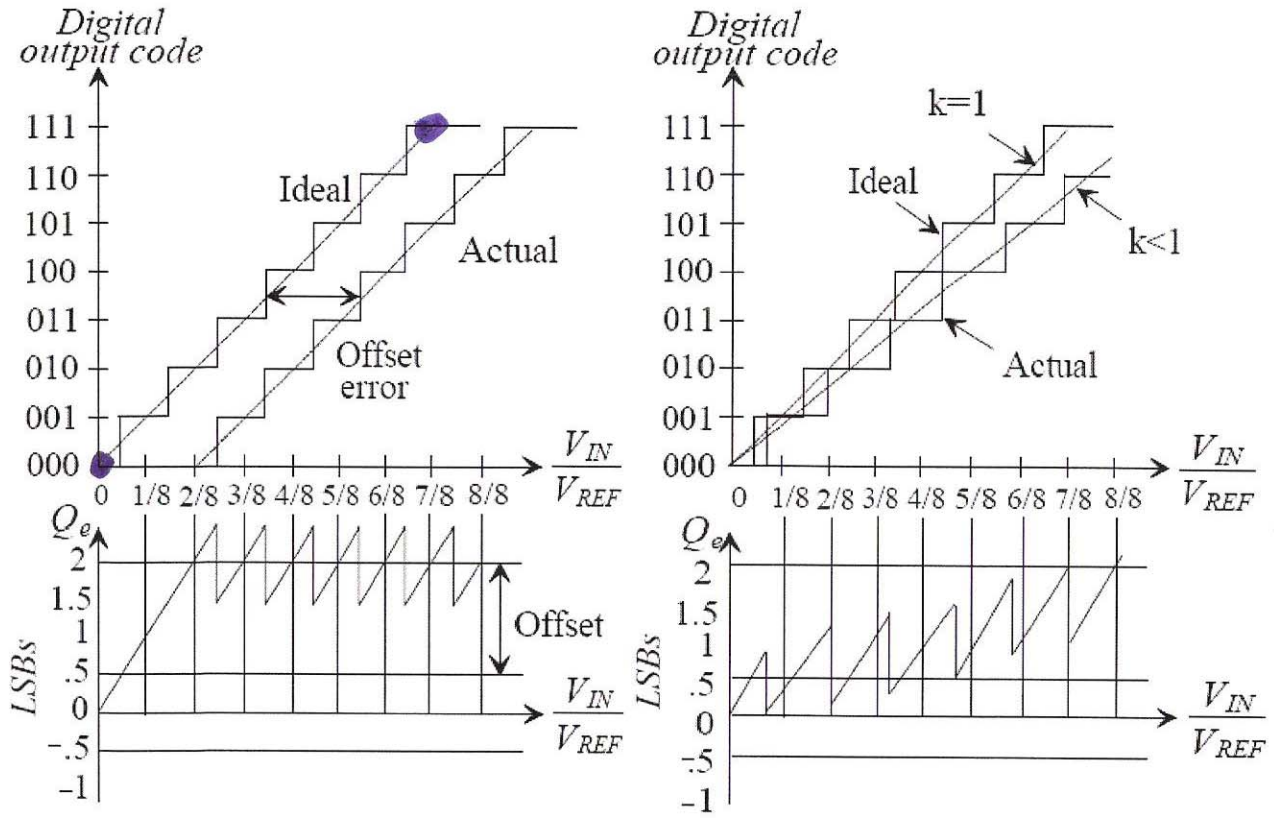


Figure 28.24 Transfer curve illustrating (a) offset error and (b) gain error.

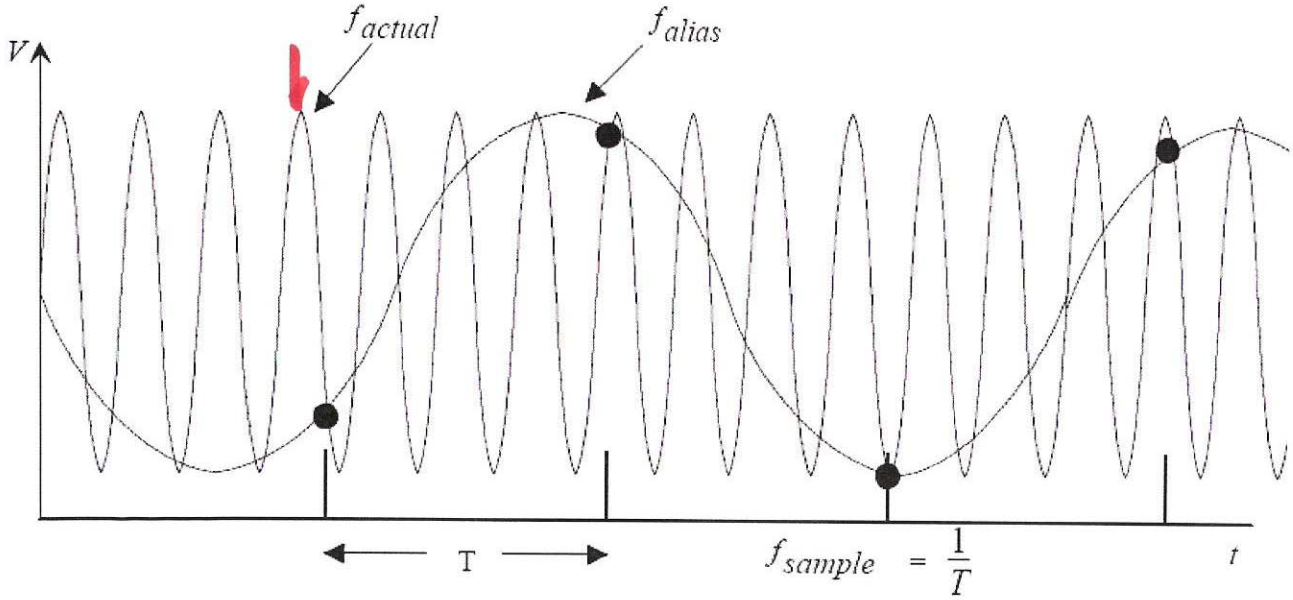


Figure 28.25 Illustration of aliasing caused by undersampling.

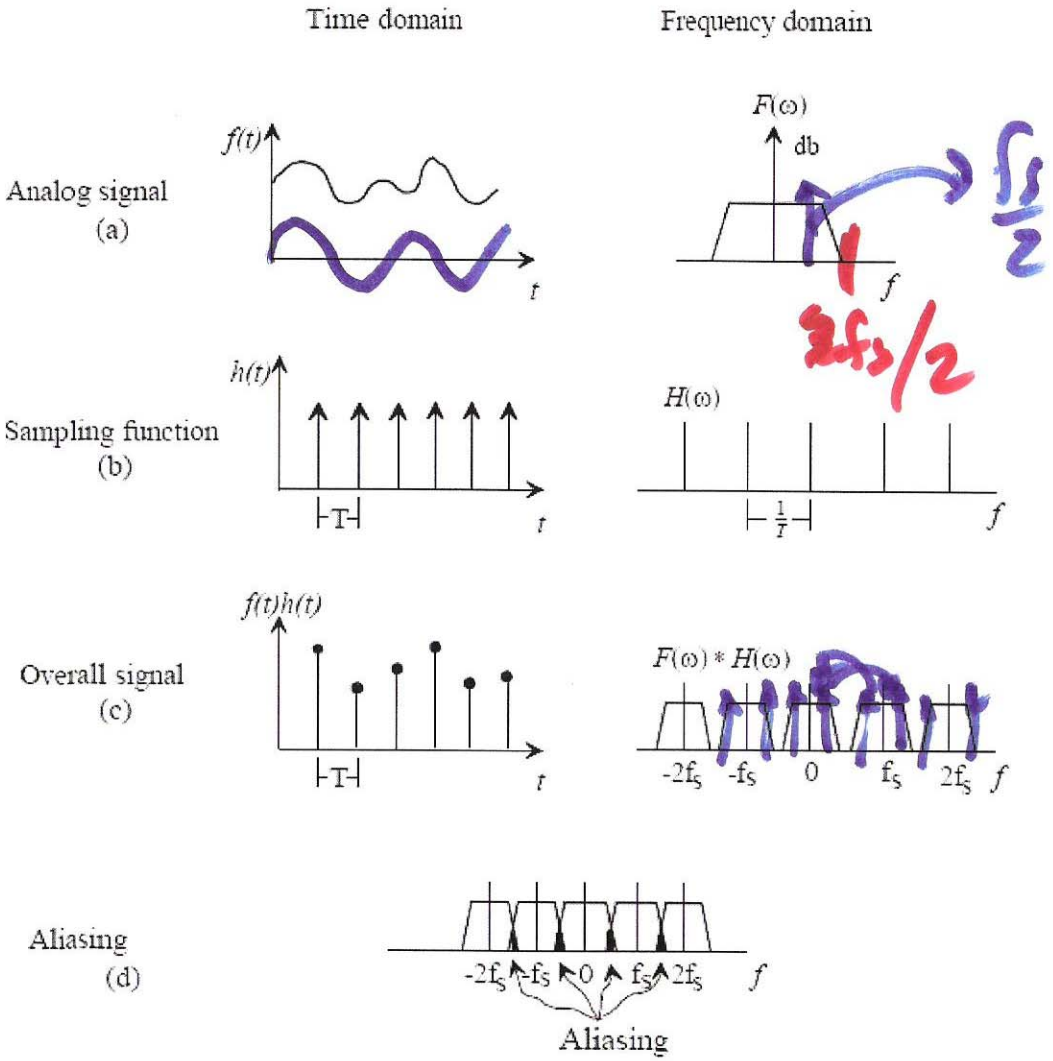


Figure 28.26 Illustration of aliasing in the time and frequency domain. (a) The analog signal; (b) the sampling function; (c) the overall signal; and (d) aliasing in the frequency domain.

INL - ADC

13)