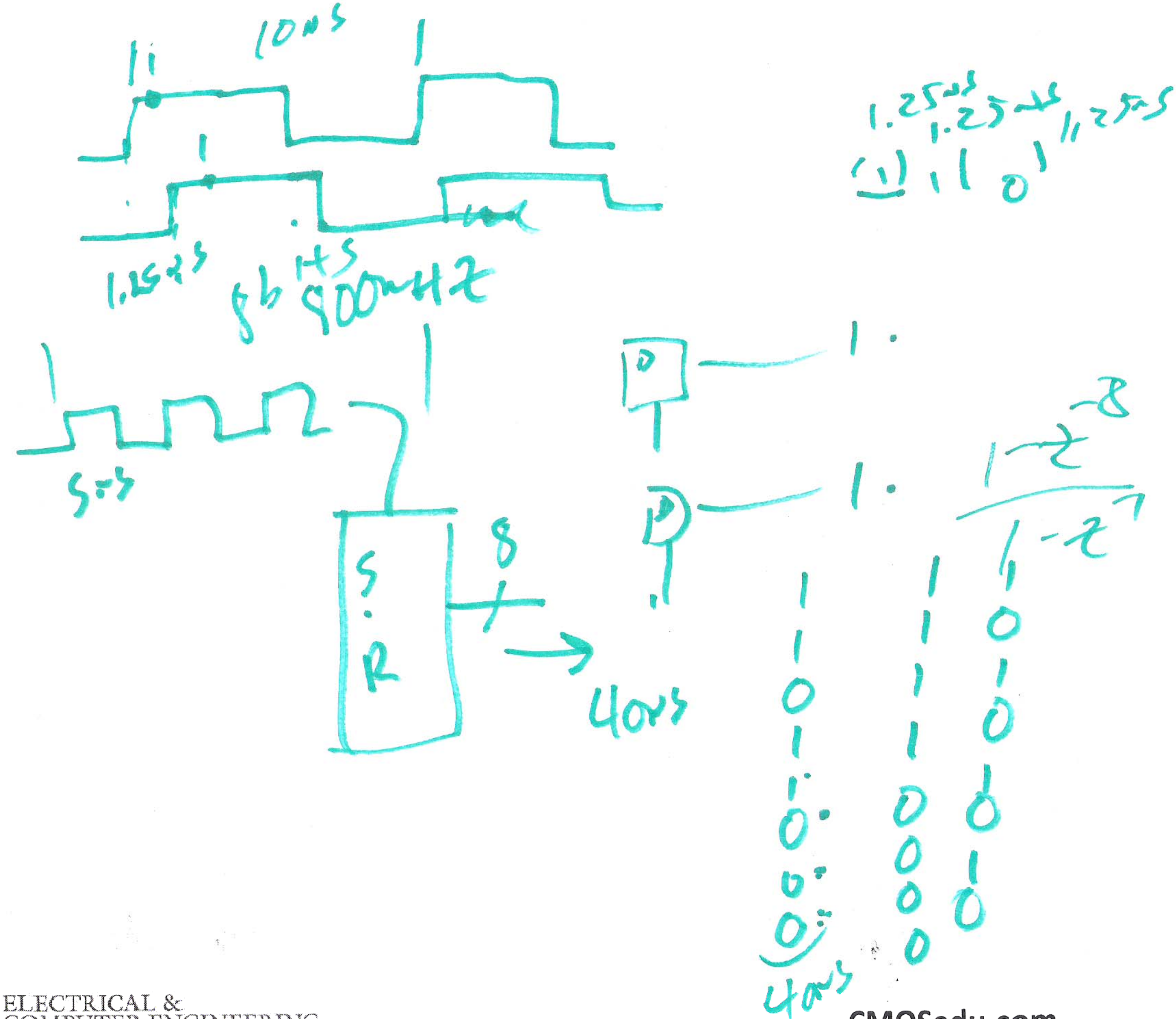


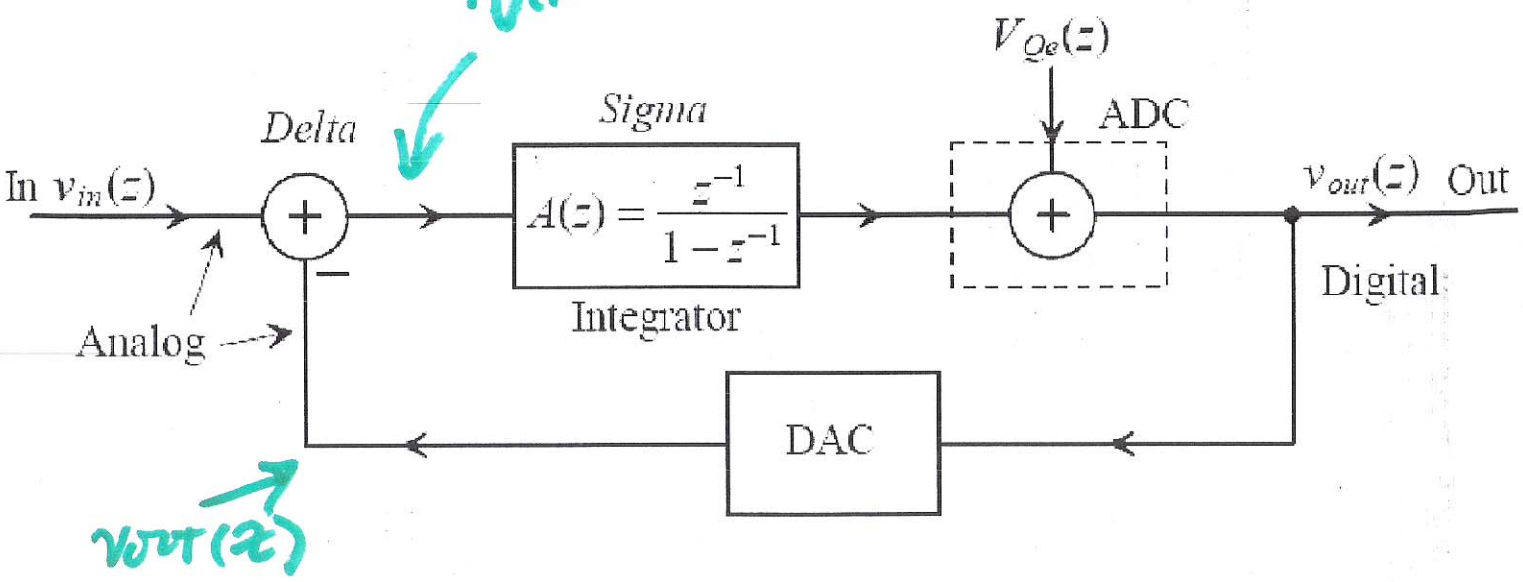


Figure 7.1 Block diagram of a noise-shaping (NS) modulator.

$$V_{out}(z) = V_{Qe}(z) + \frac{z^{-1}}{1-z^{-1}}\left(V_{in}(z) - V_{out}(z)\right)$$

$$V_{out}(1-z^{-1}) = V_{Qe}(z)(1-z^{-1}) + z^{-1}V_{in}(z)$$

$$V_{out}(z) = V_{in}(z)z^{-1} + V_{Qe}(z)(1-z^{-1}) - z^{-1}V_{out}(z)$$

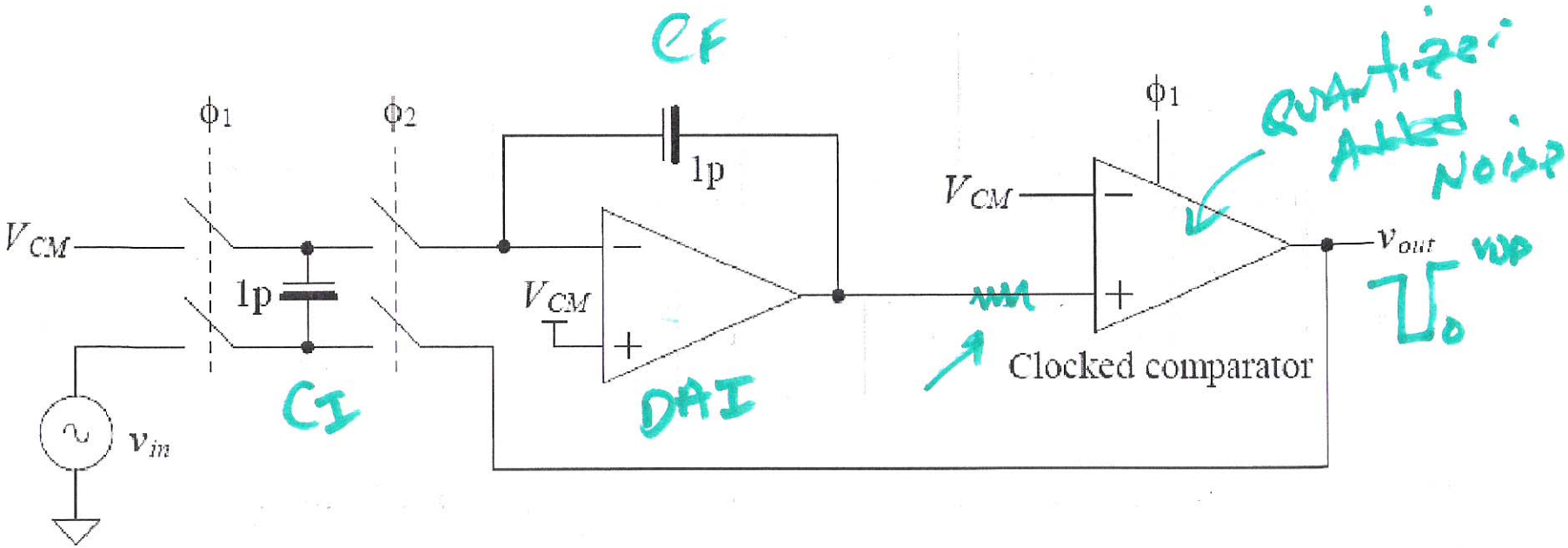


Figure 7.2 Circuit implementation of a first-order NS modulator.

$$G = \frac{C_I}{C_F} \cdot \frac{z^{-1}}{1 - z^{-1}}$$

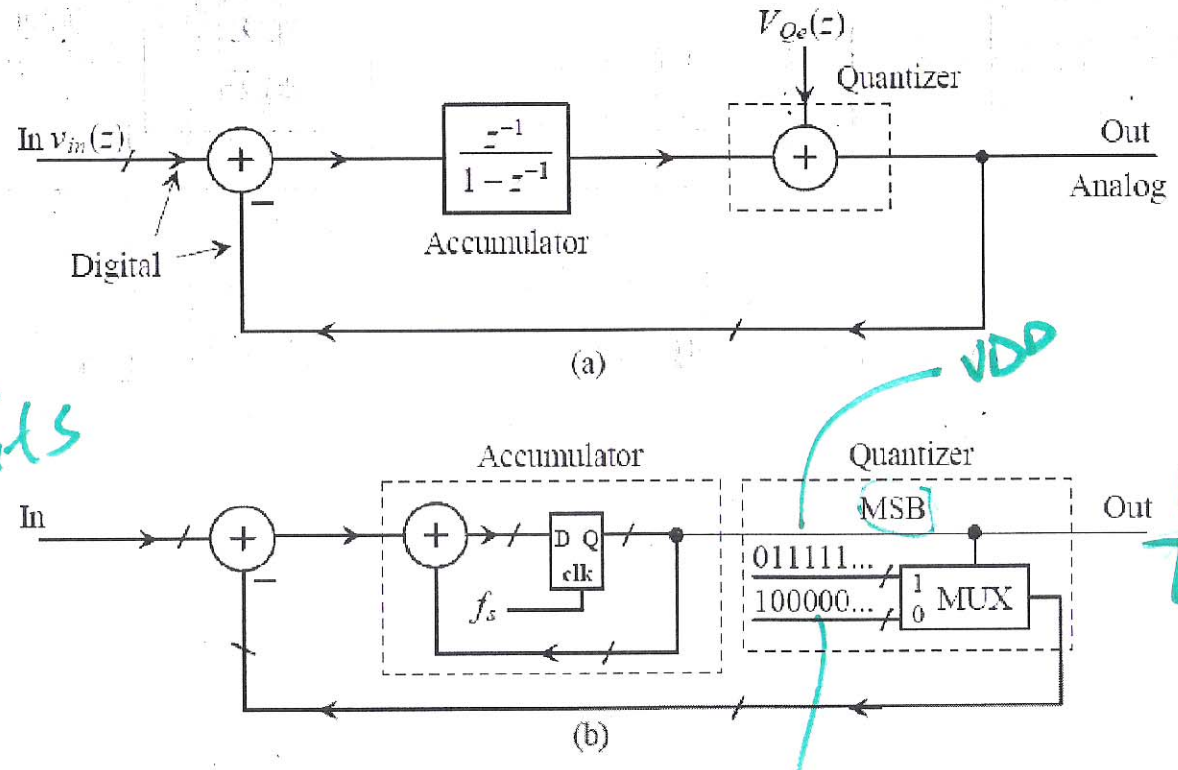


Figure 7.5 Block diagram of (a) a NS demodulator and, (b) a more detailed implementation for use in a DAC.

$$OSR = \frac{f_s}{2 \cdot f_b} = 50$$

$$V_{out}(z) = V_{in}(z^{-1}) + V_{qe}(1 - z^{-1})$$

$$V_{out}(nT_s) = V_{in}((n-1)T_s) + V_{qe}(nT_s) - V_{qe}((n-1)T_s)$$

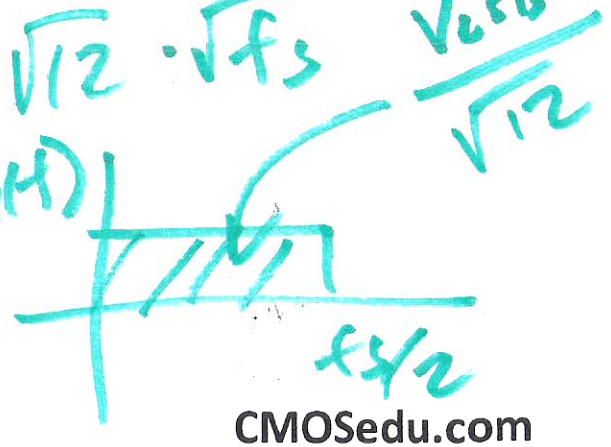
modulation noise

$$= NTF \cdot V_{qe}(f) = (1 - z^{-1}) V_{qe}$$

$$= \left(1 - e^{-j2\pi f \cdot T_s}\right) V_{qe}(f)$$

$$V_{qe}(f) = \frac{V_{LSB}}{\sqrt{12} \cdot \sqrt{f_s}}$$

$$|NTF(f)|^2 \cdot |V_{qe}(f)|^2 = \frac{V_{LSB}^2}{12 f_s} \cdot 4 \sin^2 \pi \frac{f}{f_s}$$



Rms modulations

$$V_{QQ,Rms}^2 = 2 \cdot \frac{V_{LSB}^2}{12 f_s} \cdot 4 \int_0^B Sin^2 \pi \frac{f}{f_s} \cdot df \qquad \frac{f}{f_s} \ll 1 \; Sin x = x$$

$$OSR = K = \frac{f_s}{2 \cdot B}, \quad B = \frac{f_s}{2K}$$

K ← oversampling ratio

$$V_{QQ,Rms} \simeq \frac{V_{LSB}}{\sqrt{12}} \cdot \frac{\pi}{\sqrt{3}} \cdot \frac{1}{K^{3/2}}$$

$f_s = 100\ MHz$

$B = 6.25\ MHz$

$K = \frac{100m}{2 \cdot 6.25} = 8$

Oversampling ratio

first order $m = 1$

$\left(\frac{1 - z^{-8}}{1 - z^{-1}}\right)^2$

$L = 2$

$L = M + 1$

5.3

7

4

1

Analog in

f.o. Modulw.

$\frac{1 - z^{-8}}{1 - z^{-1}}$

$\frac{1 - z^{-8}}{1 - z^{-1}}$

$27 - 5.17 = 22$

$f_s = 100MHz$

$N_{inc} = \frac{30 \log 2^3 - 5.17}{6.02}$

$\frac{27}{6} = 4.3$