Higher-Order Modulators

November 2011

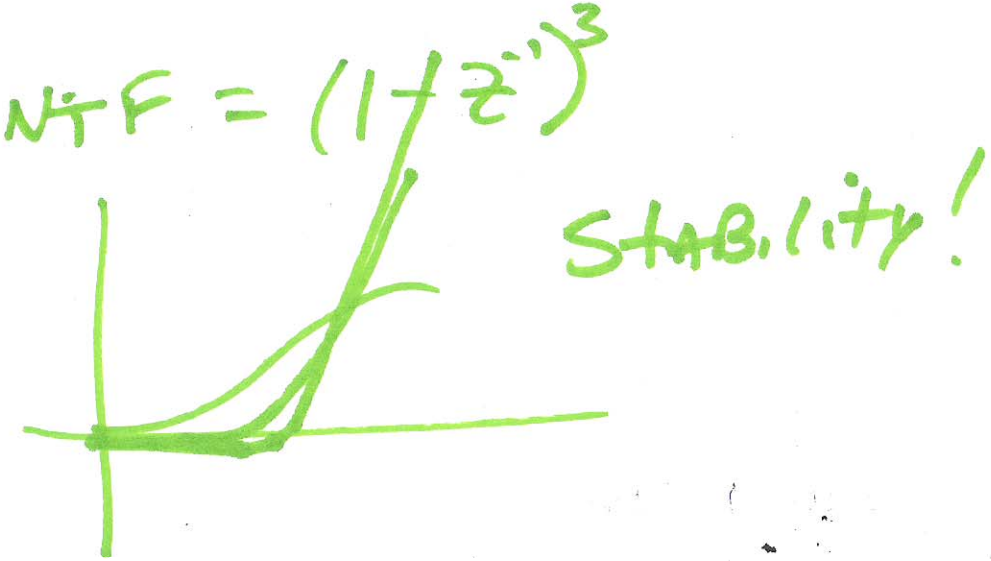
7.3 Noise-shaping topologies

1st & 2nd

Higher-order topologies

3rd DSM

$NTF = (1+z^{-1})^3$



Stability!

Mth-order modulator

filtering

L = 1 + M

order of sinc filter

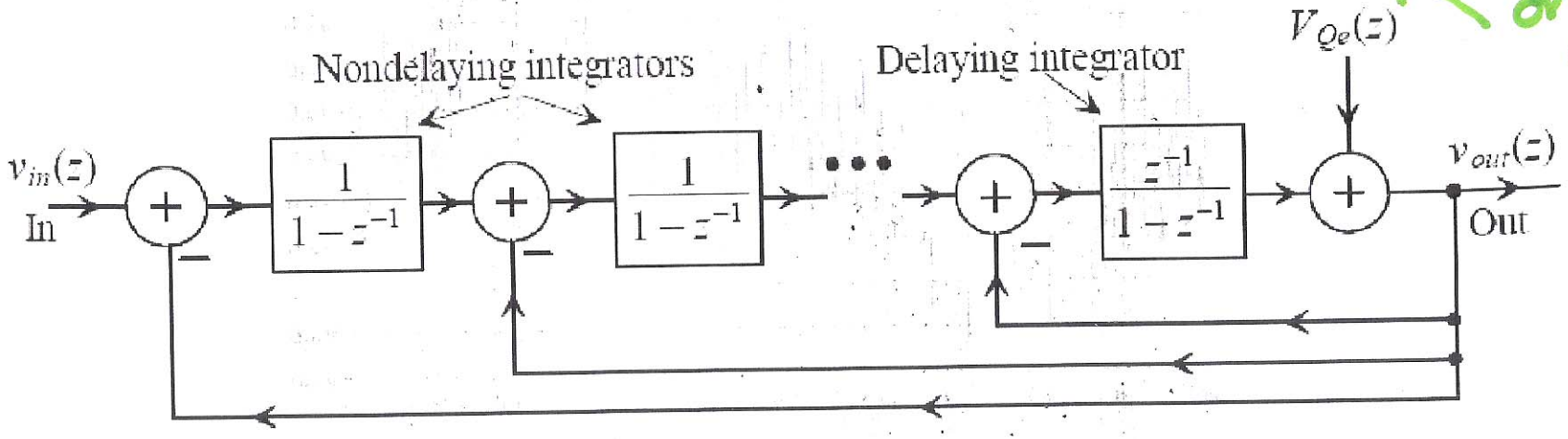
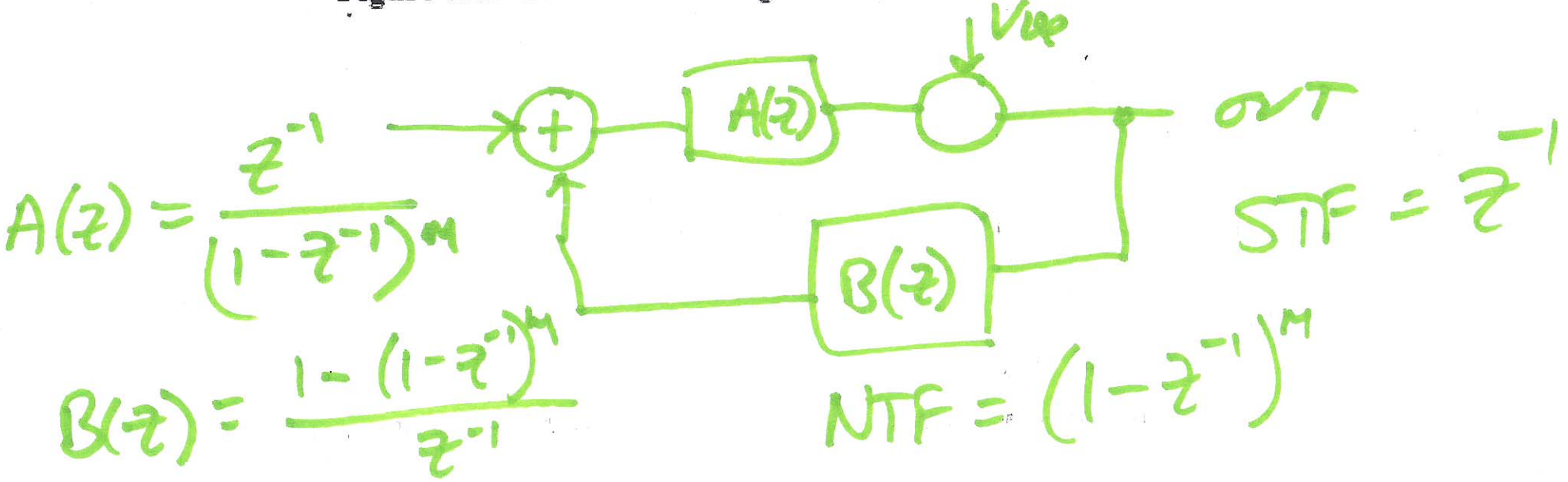


Figure 7.41 Generic block diagram of an M^{th}-order NS modulator.



$$A(z) = \frac{z^{-1}}{(1-z^{-1})^M}$$

$$B(z) = \frac{1-(1-z^{-1})^M}{z^{-1}}$$

$$STF = z^{-1}$$

$$NTF = (1-z^{-1})^M$$

2)

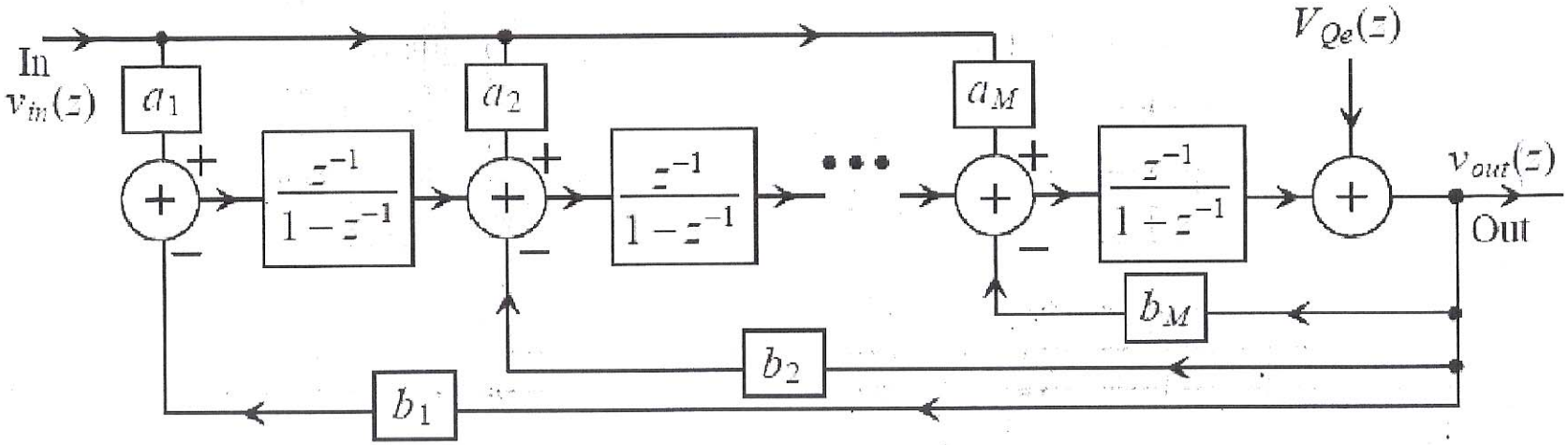


Figure 7.42 Block diagram of a modified M[th]-order NS modulator.

3)

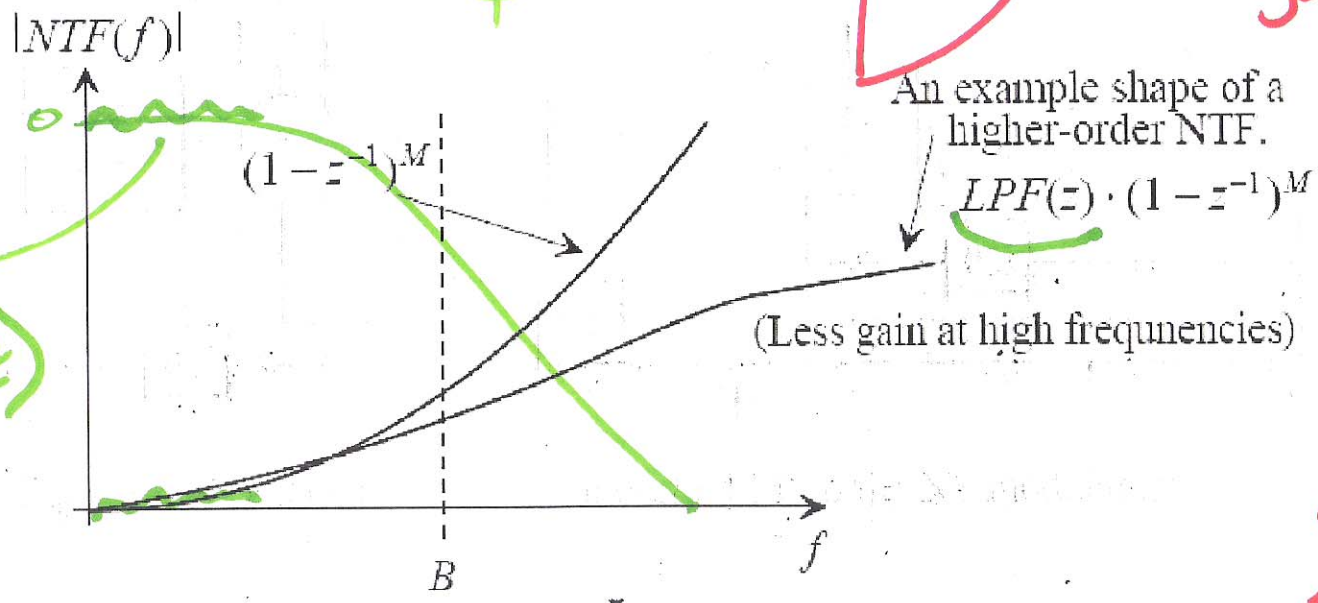


Figure 7.43 Showing the change in the NTF in a higher-order modulator.

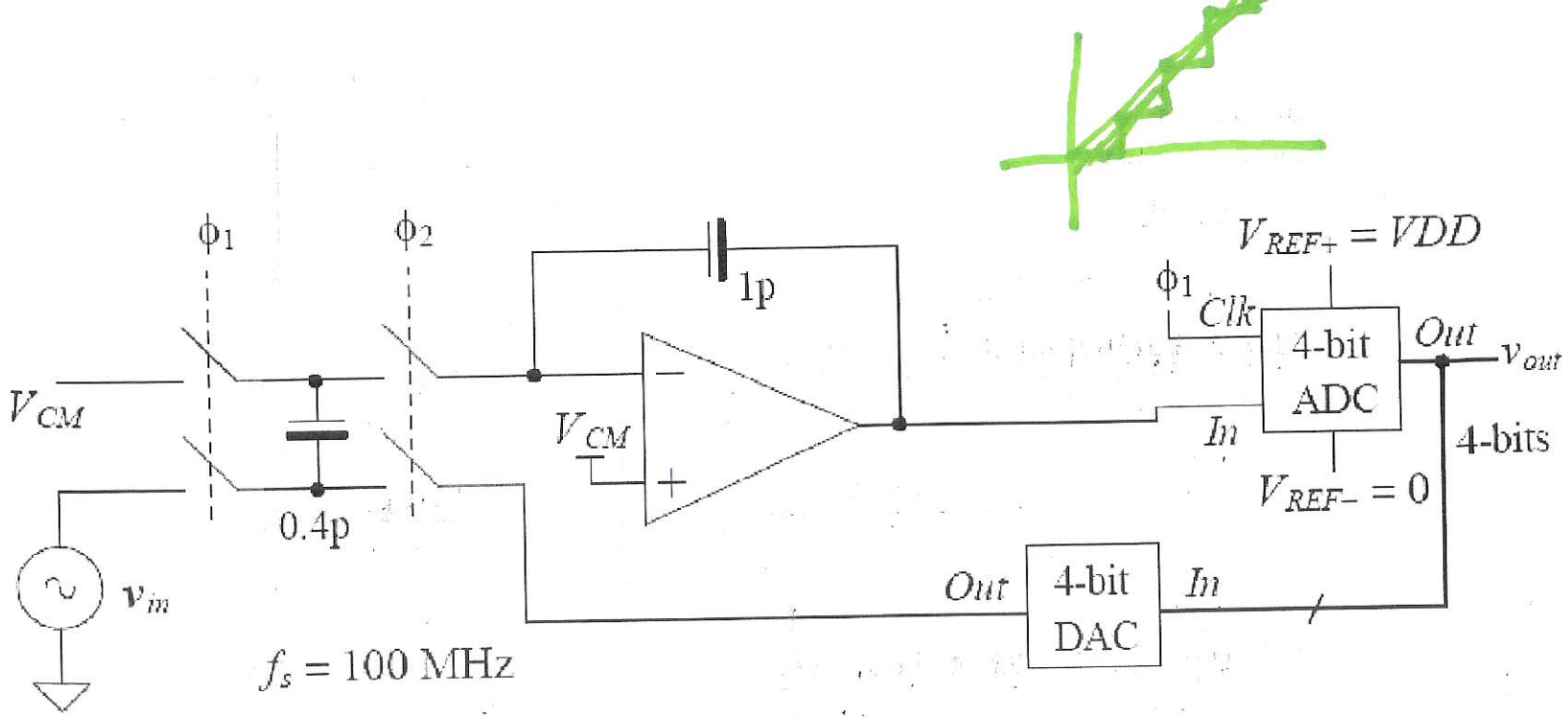
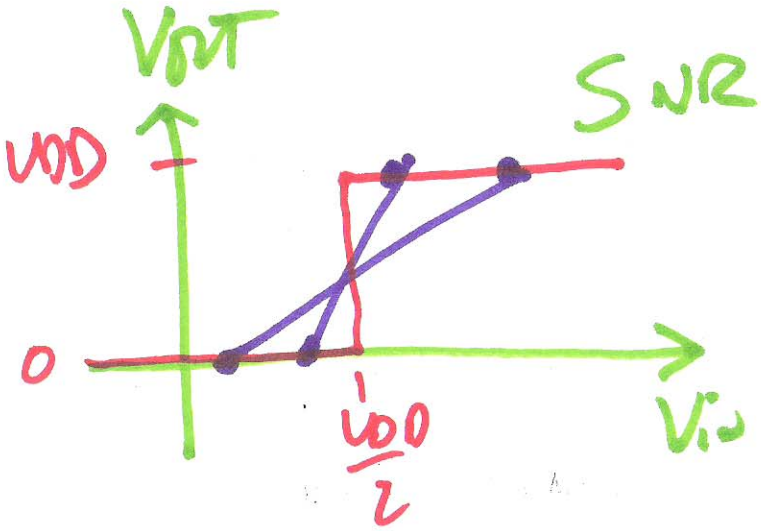


Figure 7.44 Circuit implementation of a first-order multi-bit NS modulator.



$$SNR = 6.02(N + N_{INC})$$

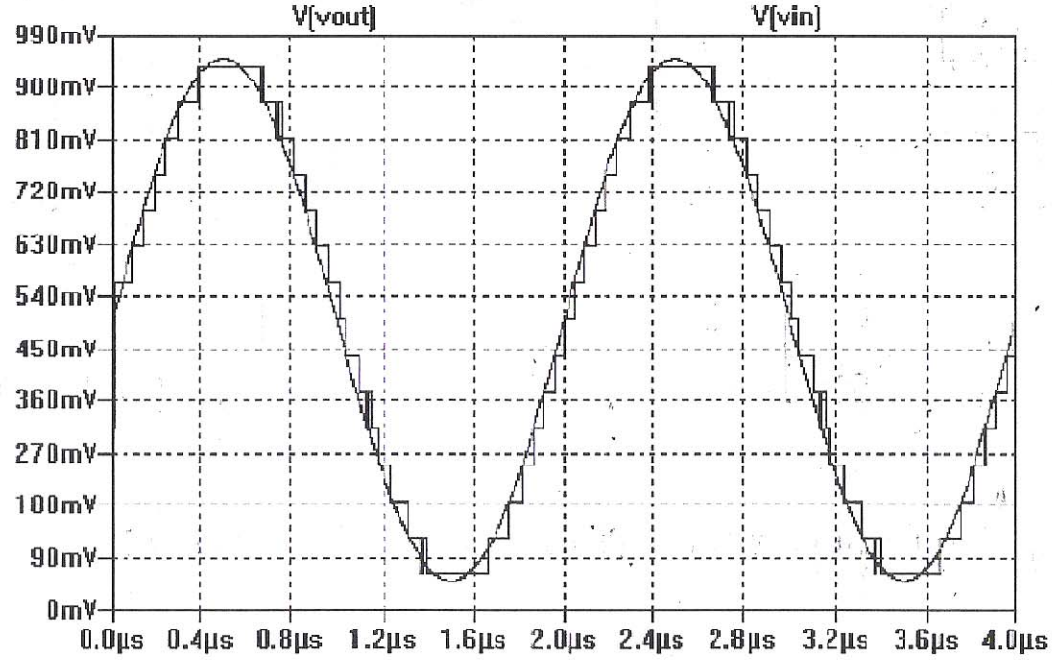
# of bits in the quantizer

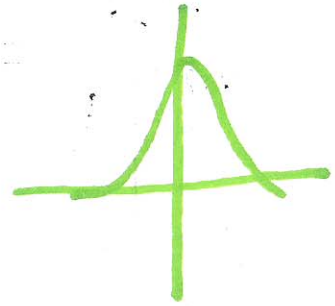
increase due to oversampling

5)

LSB = 10μA

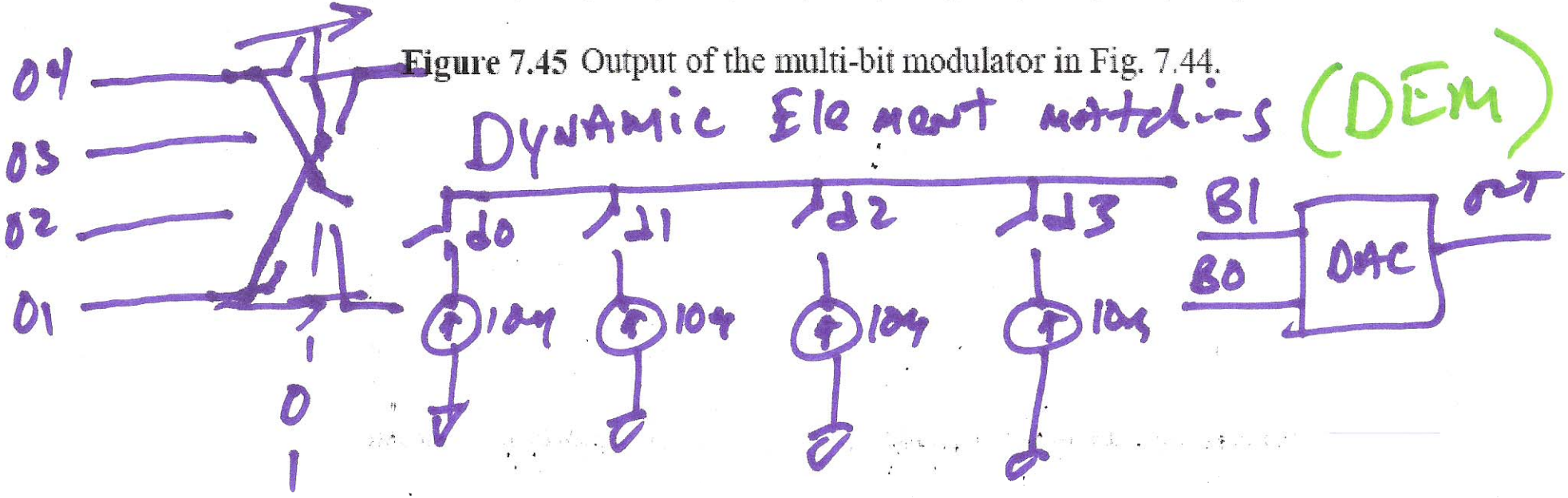
B1	B0	OUT
0	0	10μ
0	1	20μ
1	0	30μ
1	1	40μ





VARIANCE = $\frac{\sigma^2}{K}$

Figure 7.45 Output of the multi-bit modulator in Fig. 7.44.



6)

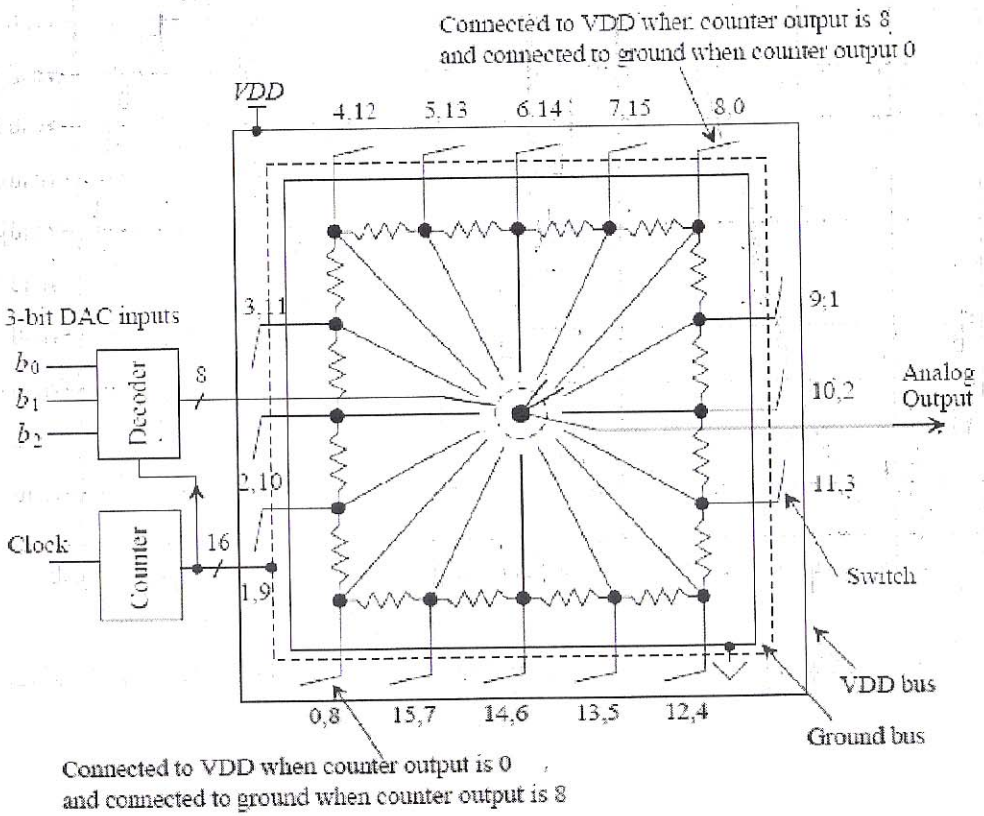


Figure 7.46 Implementation of a DAC for use in a multibit NS modulator.

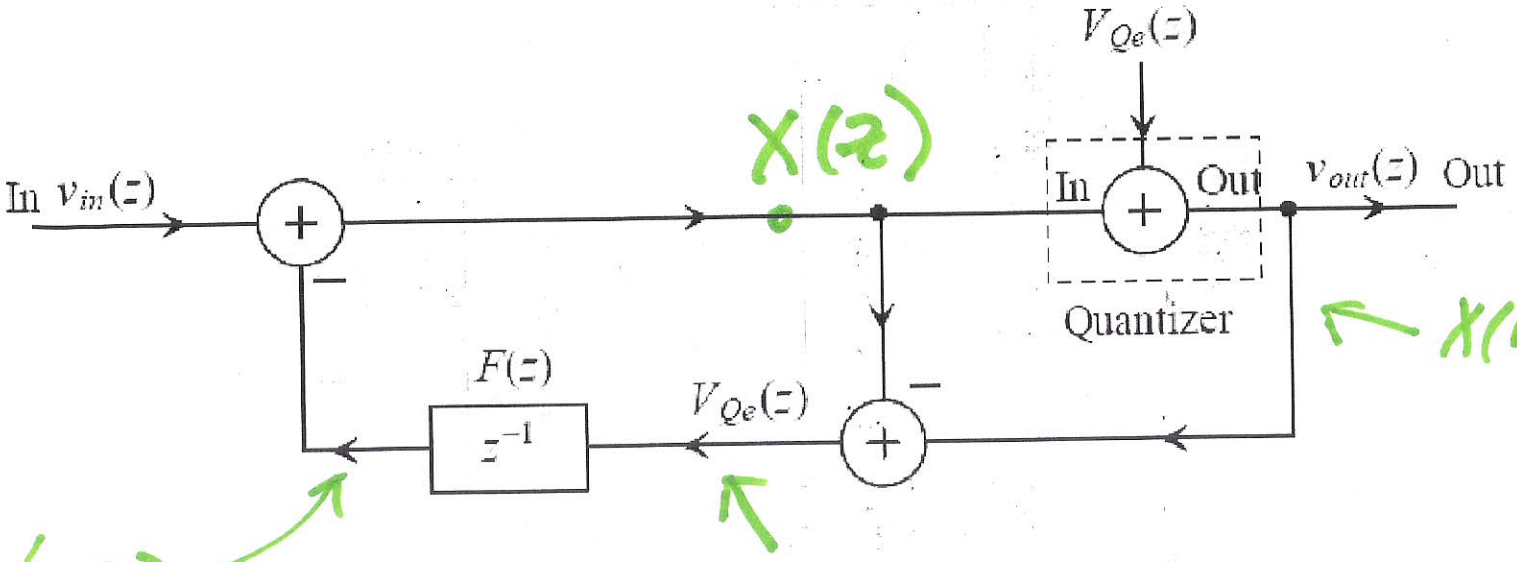


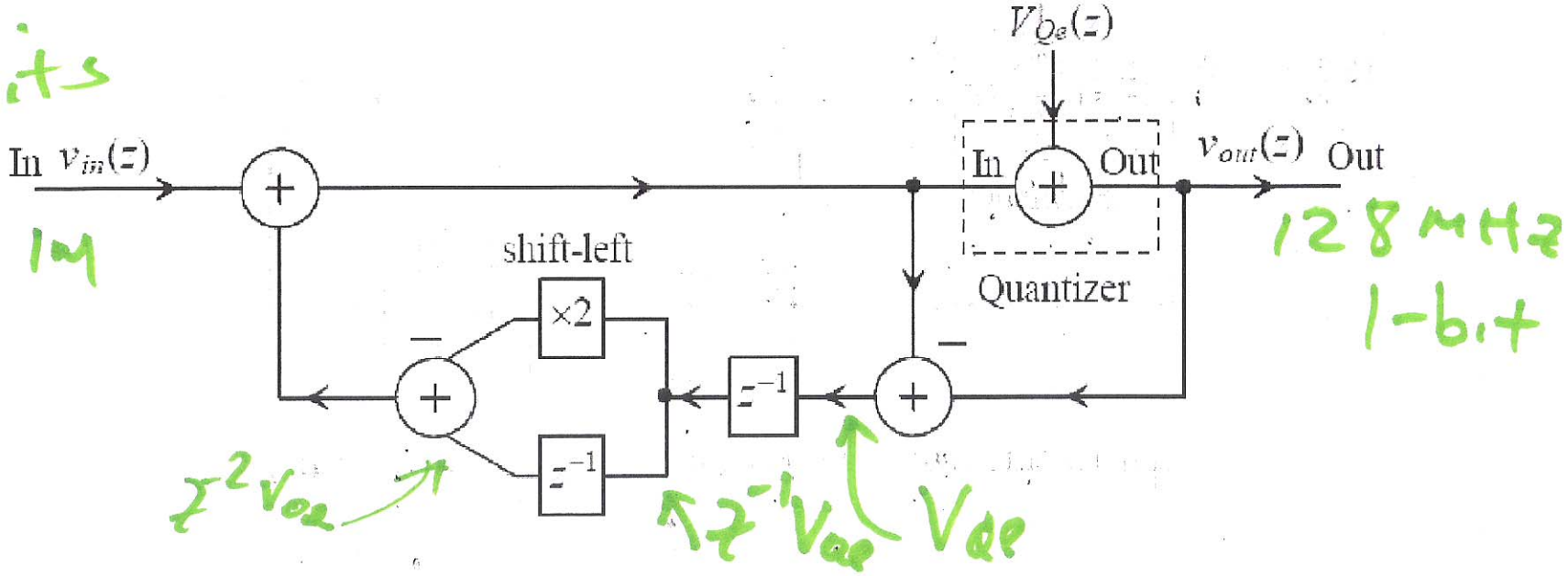
Figure 7.47 Block diagram of an error feedback modulator.

$$X(z) = V_{IN}(z) - V_{QE}(z) \cdot z^{-1}$$

$$V_{OUT}(z) = V_{Qe}(z) + V_{IN}(z) - V_{QE}(z) z^{-1}$$

$$V_{OUT}(z) = V_{IN}(z) + V_{Qe}(z)(1 - z^{-1})$$

10-bits



1M

128 MHz

1-bit

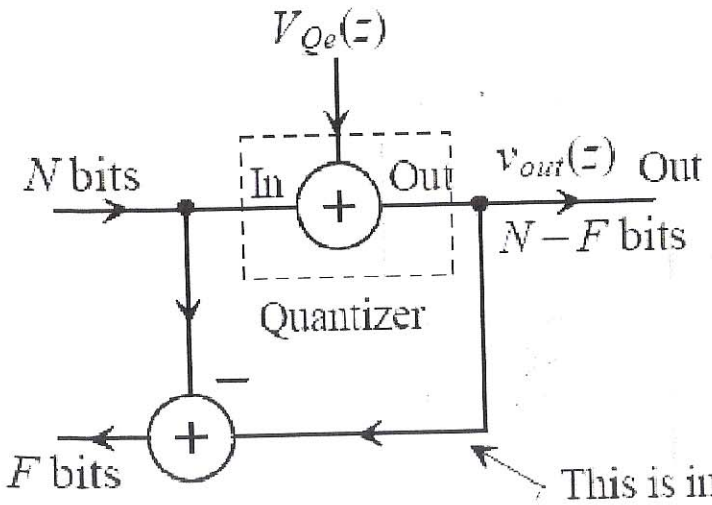
Figure 7.48 Block diagram of a second-order error feedback modulator.

$$z^{-2}V_{Qe}(z) - 2z^{-1}V_{Qe} + V_{IN}(z) + V_{Qe}(z) = V_{OUT}$$

$$V_{OUT} = V_{IN}(z) + V_{Qe}(z)\left(1 - 2z^{-1} + z^{-2}\right)$$

$$= V_{IN}(z) \; V_{Qe}(z)\left(1 - z^{-1}\right)^2$$

9)



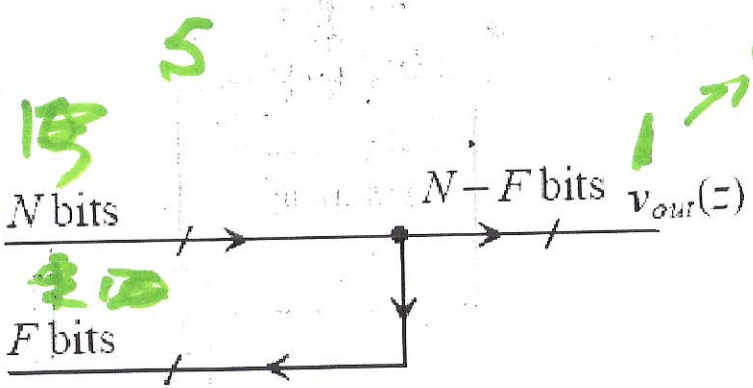


Figure 7.49 Showing how the quantizer and difference block are implemented.

0111 → 7
⋮
0010 → 2
0001 → 1
0000 → 0
1111 → -1
1110 → -2
⋮
1000 → -8

01010 → +10 - 8
00010 → +2
1110 → -3
→ 4

10)

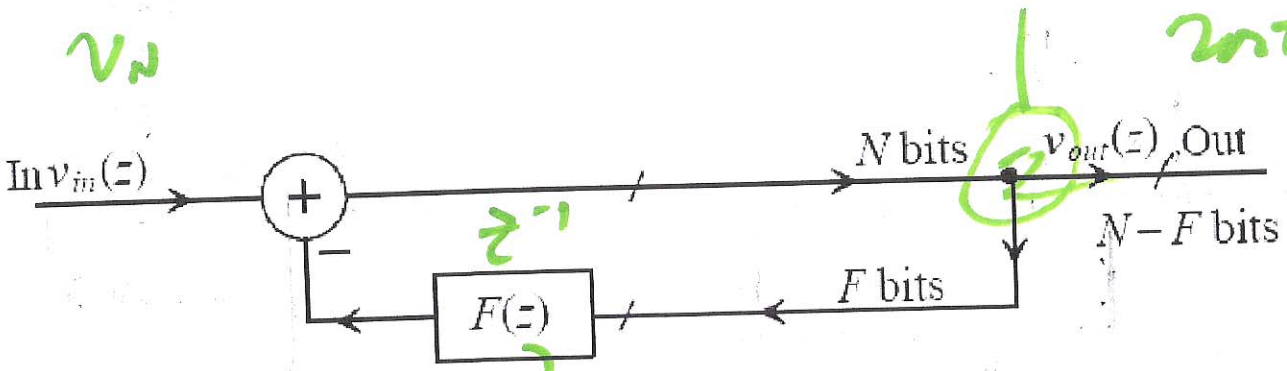


Figure 7.50 Block diagram of an error feedback modulator.

v_N

v_{NT}

$F(z) = z^{-1}$ for first-order

$v_N - z^{-1} v_{NT} = v_{NT}$

$v_{in} = v_{NT}(1 + z^{-1})$

$\frac{v_{NT}}{v_{in}} = \frac{1}{1+z^{-1}}$

11)

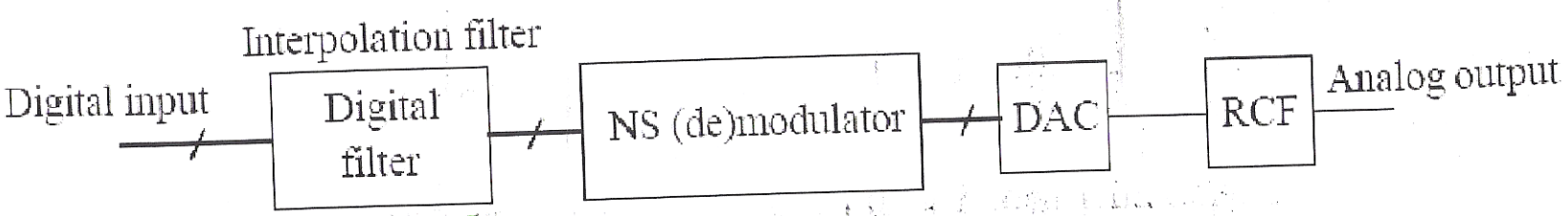


Figure 7.51 DAC using a NS modulator and digital filter.