ECE 627 MAKE-UP PROJECT

By Sameer Somvanshi

ID: 931732943

1. The input of the modulator shown may be 75 % of full scale. The quantizer Q has N levels.
   a. What is the largest possible input to Q ?
   b. What is the minimum number of levels N if Q is not to overload?

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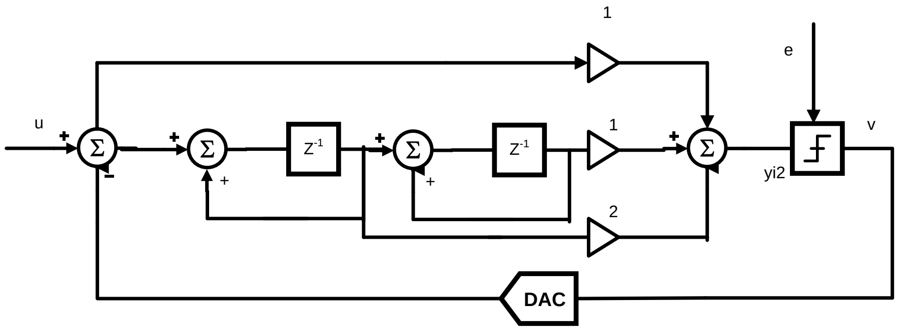

Solution:

v = e + u + $(2I+I^2)$(u-v)

$(1+2I+I^2)$v = $(1+ I^2)$v = $(1+ I^2)$u + e

$(1+I)^2 = [1 + \frac{1}{z-1}]^2 = \frac{1}{(1-z^{-1})^2}$

v = u + $(1-z^{-1})^2$ e = u + e – $2z^{-1}$e + z^{-2} e

v(n) = u(n) + e(n) - 2 e(n-1) + e(n-2)

$|y(n)|_{max} = |u(n)|_{max} + 3|e(n)|_{max}$

Assume FS = V_{ref} = ((N-1)/2) V_{LSB}

(N-1) is the number of steps

$|u|_{max}$ = (3/4) V_{ref} = 3(N-1)/2 V_{LSB}

$|e|_{max}$ = V_{LSB} /2

Linear input range : $|y(n)| <= (N/2)\ V_{LSB}$

$(N/2)\ V_{LSB} >= 3/8(N-1)\ V_{LSB} + (3/2)\ V_{LSB}$

Thus,

$N>=9$

2. Consider a cascaded 2-0 delta-sigma ADC given in following figure. Derive the STF and NTF of the ADC using its linearized model

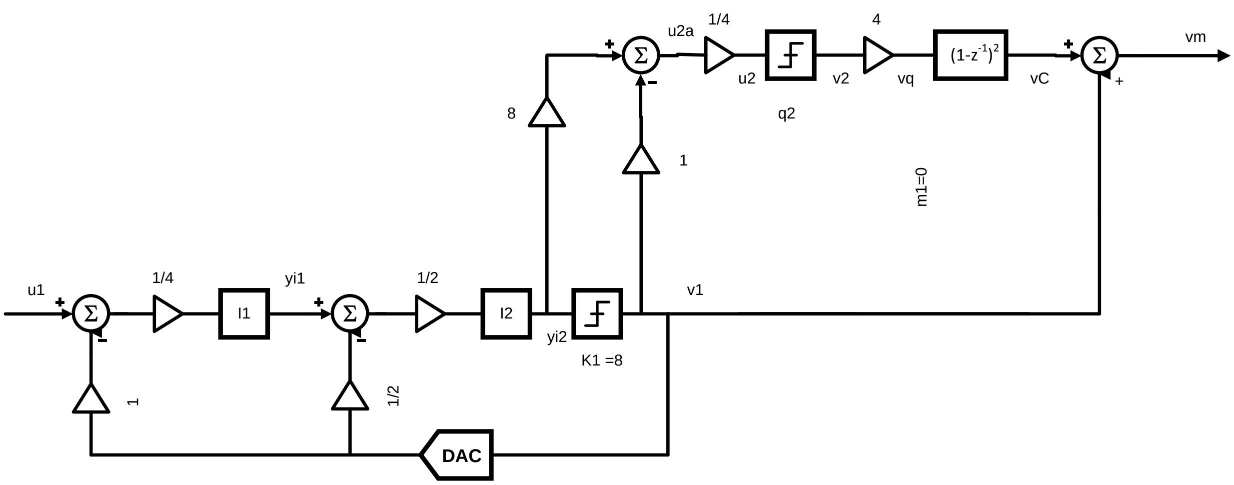

Figure 1. Cascaded 2-0 delta-sigma ADC

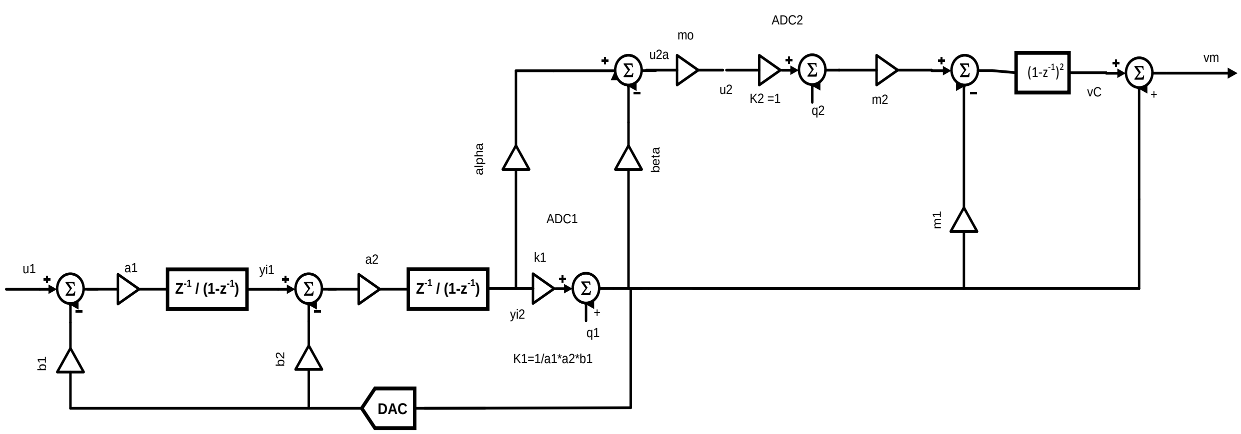

Figure 2. Linearized model of the cascaded 2-0 delta-sigma ADC

Solution:

v1 = k1 *a2 * $\frac{z^{-1}}{1-z^{-1}}$ (-b2*v1 + a1* $\frac{z^{-1}}{1-z^{-1}}$(-b1*v1 + u1))+ q1

v(z) = $\frac{a1*a2*k1*z-2*u1+(1-z^{-1})^2 q1}{1+(a2*b2*k1-2)z^{-1}+\ (1-a2*b2*k1+a1*a2*b1*k1)z^{-2}}$

a1 = ¼, a2 = ½ , b1 = 1, b2 = ½, k1 = 1/(a1*a2*b1) = 8

v1(z) = z^{-2} u1 + (1-z^{-1})^2 * q1

Second stage:

U2a = α*Ti2 – β(K1*Ti1+ q1)

U2a = (α- βK_1)*Ti2 – β*q1

α = 8, β = 1, k1 =8, So U2a = -q1

v2 = m0*k2 *u2a + q2

vc= m0*m2*k2*(1-z^{-1})^2*(-q1) + m2*(1-z^{-1})^2*q2

vc = -(1-z^{-1})^2*q1 + m2*(1-z^{-1})^2*q2

v1 = + (1-z^{-1})^2 * q1 + z^{-2} *u1

Thus,

vm = z^{-2} *u1 + m2*(1-z^{-1})^2 *q2

STF = z^{-2}

NTF = m2*(1-z^{-1})^2

Thus the quantization error of first stage is eliminated.

However, delta sigma modulator is very sensitive to imperfections. So q1 is never eliminated.