MODERN ANALOG FILTER DESIGN (ELEC 441/6081)

Mid-term test #2 (March 26, 2008)

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Instructor: Dr. R. Raut Time: 75 minutes

(The students should attempt **ALL** questions. The best THREE scores will be considered for a total point of FIFTEEN)

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Q.1: Consider the three-OA biquadratic filter below. The voltage transfer function *T(s)*= *Vo/V1* is given by:



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(a) Using the above general transfer function, produce the design of a notch filter with, , and *Qp*= 5. Show the design values clearly.

(b) What is the low-frequency value of *T(s)* in your design?

Q.2: For the SCF network shown below, derive the expression for . Assume that the capacitors *B=D=1 pF*. Show your steps clearly.



Q.3: For the second order notch transfer function,  use bilinear *s 🡨> z* transformation, and

(a) Derive the sampled-data transfer function *H(z).* Use a clock frequency of 16 *kHz.* Pre-warp *only* the zero frequency , and the pole frequency of *H(s)*.

(b) Compare the magnitude responses of *H(s)*, and *H(z)* at a signal frequency of 8 *kHz.*

Q.4: The schematic below shows a second order band-pass filter realized using operational transconductance amplifiers (OTA). With *ideal* OTAs , the voltage



transfer function is given by: .

1. Write the expressions for the pole-frequency , and pole-Q (i.e., *Qp*) in terms of the *gm* and *C* values in the schematic.
2. At sufficiently high frequencies, the *gm* shows a frequency dependence as , for *i=1,2,3*. Discuss, with supporting analysis, the ways the nominal , and *Qp* will be affected by this frequency dependence*.*

**TABLE** (Second order *H(z)* vs. standard biquadratic *H(s)*)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Filter Type | Analog Transfer  Function |  | Sampled-data Transfer function\* coefficients  \* |  |
|  |  | hD | a1N | a2N |
| LP |  |  | 2 | 1 |
| HP |  |  | -2 | 1 |
| BP |  |  | 0 | -1 |
| AP |  |  |  | 1/a2D |
| Notch |  |  |  | 1 |

For compactness, the following substitutions have been used in the Table above





