SYNTHESIS OF NONMINIMUM PHASE RC TRANSFER FUNCTIONS

USING THE CURRENT CONVEYOR

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Abstract

Two canonic structures for realizing a nonminimum phase RC transfer function using the second generation current conveyor are given. One has the advantage of having a unity gain factor.

1. INTRODUCTION

The realization of all-pass transfer functions using the second generation current conveyor was recently discussed(1-2). The purpose of this paper is to give two minimal realizations for synthesizing any nonminimum phase transfer function having zeros anywhere in the right half plane and poles on the negative real axis.

2. GENERAL CONFIGURATION

The general circuit is shown in Fig. 1 which uses CC II (3) as the active element. By direct analysis, the open circuit voltage transfer function is given by:

$$G(s) \equiv \frac{V_o}{V_i} = \left(1+\frac{b}{2}\right)T(s) - \frac{b}{2} \qquad (1)$$

where

$$T(s) = \frac{V_2}{V_i} \qquad (2)$$

The above expression for the transfer function is similar to that of the dual input configuration which uses the operational amplifier as the active element(4), thus using Dutta Roy synthesis technique (5), it is seen that the given configuration is capable of realizing any nonminimum phase transfer function having poles restricted to the negative real axis. The realization obtained however using the above method is nonminimal. In this paper two minimal realizations are given for realizing a nonminimum phase transfer function of the form:

$$G(s) = H\,\frac{s^2 - \left(\frac{\omega_o}{Q_o}\right)s + \omega_o^2}{s^2 + \left(\frac{\omega_o}{Q_p}\right)s + \omega_o^2} \qquad (3)$$

where $0 < Q_p < 0.5$

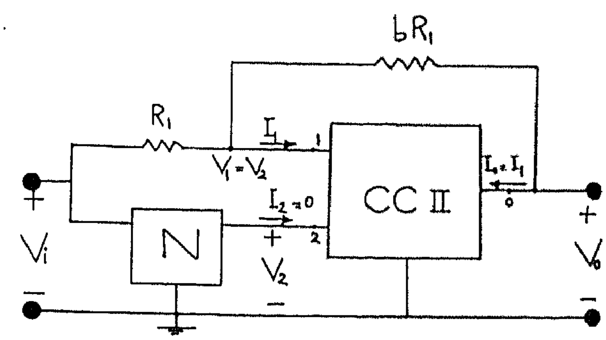

Fig.1 A general configuration for realizing a nonminimum phase transfer function.

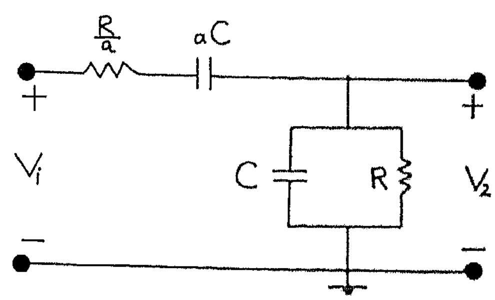

Fig.2 Realization 1 of the network N.

2.1 REALIZATION 1

Fig 2 represents the passive RC network N. By direct analysis:

$$T(s) = \frac{\left(\frac{a}{CR}\right)s}{s^2 + \left(\frac{2+a}{CR}\right)s + \left(\frac{1}{CR}\right)^2} \qquad (4)$$

From (4) in (1), hence

$$G(s) = -\frac{b}{2}\cdot\frac{s^2 - \left(\frac{2a-2b}{bCR}\right)s + \left(\frac{1}{CR}\right)^2}{s^2 + \left(\frac{a+2}{CR}\right)s + \left(\frac{1}{CR}\right)^2} \qquad (5)$$

Comparing (5) and (3), it is seen that the network realizes a nonminimum phase transfer function having:

$$|H| = \frac{b}{2}, \quad \omega_0 = \frac{1}{CR}$$

$$Q_p = \frac{1}{a+2} \quad \text{and} \quad Q_0 = \frac{b}{2(a-b)}$$

ω_0 is adjusted by varying C or R, a controls Q_p and b controls Q_0. For a specified ω_0, Q_p and Q_0 the design formulas are:

$$CR = \frac{1}{\omega_0} \qquad (6)$$

$$a = \frac{1}{Q_p} - 2 \qquad (7)$$

$$b = 2\cdot\frac{\frac{1}{Q_p} - 2}{\frac{1}{Q_0} + 2} \qquad (8)$$

For an all-pass transfer function, the above equation becomes:

$$b = 2\cdot\frac{\frac{1}{Q_p} - 2}{\frac{1}{Q_p} + 2} = \frac{2a}{a+4}.$$

and for a notch filter,

$$b = \frac{1}{Q_p} - 2 = a.$$

A disadvantage of the above realization is that the gain factor H depends on Q_0 and Q_p. Another minimal realization which has a unity gain factor is given next.

2.2 REALIZATION 2

The transfer function of the network N shown in Fig 3 is given by:

$$T(s) = \frac{s^2 + \left(\frac{2}{CR}\right)s + \left(\frac{1}{CR}\right)^2}{s^2 + \left(\frac{2+a}{CR}\right)s + \left(\frac{1}{CR}\right)^2} \qquad (9)$$

From (9) in (1), hence,

$$G(s) = \frac{s^2 - \left(\frac{ab-4}{2CR}\right)s + \left(\frac{1}{CR}\right)^2}{s^2 + \left(\frac{a+2}{CR}\right)s + \left(\frac{1}{CR}\right)^2} \qquad (10)$$

which realizes a nonminimum phase transfer function having:

$$H = 1, \quad \omega_0 = \frac{1}{CR}$$

$$Q_p = \frac{1}{a+2} \quad \text{and} \quad Q_0 = \frac{2}{ab-4}$$

The sequence of adjusting is as follows: C or R for ω_0, a for Q_p and b for Q_0. The design formulas are:

$$CR = \frac{1}{\omega_0} \qquad (11)$$

$$a = \frac{1}{Q_p} - 2 \qquad (12)$$

$$b = 2\,\frac{\frac{1}{Q_0} + 2}{\frac{1}{Q_p} - 2} \qquad (13)$$

For an all-pass transfer function:

$$b = 2\cdot\frac{\frac{1}{Q_p} + 2}{\frac{1}{Q_p} - 2} = 2 + \frac{8}{a}$$

and for a notch filter:

$$b = \frac{4}{\frac{1}{Q_p} - 2} = \frac{4}{a}.$$

For a specified Q_p the value of a obtained using realization 1 or 2 is the same, and its variation versus Q_p is shown in Fig 4.

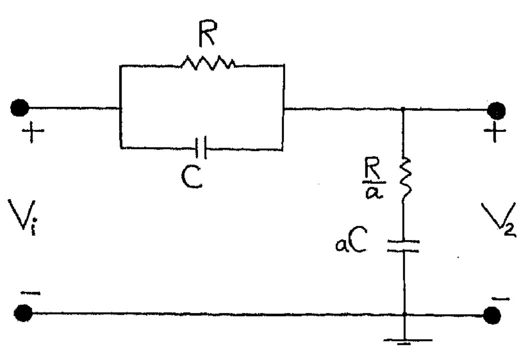

Fig 3. Realization 2 of the network N.

On the other hand for a specified Q_o and Q_p, b/2 obtained using realization 1 is the reciprocal of b/2 obtained using realization 2. Fig 5 represents the variation of 2/b of realization 1 or b/2 for realization 2 versus Q_p with Q_o as a variable parameter.

3. CONCLUSIONS

Two minimal realizations were given for synthesizing any nonminimum phase transfer function having zeros anywhere in the right half plane and poles on the negative real axis. The active element used is CCII.

4. REFRENCES

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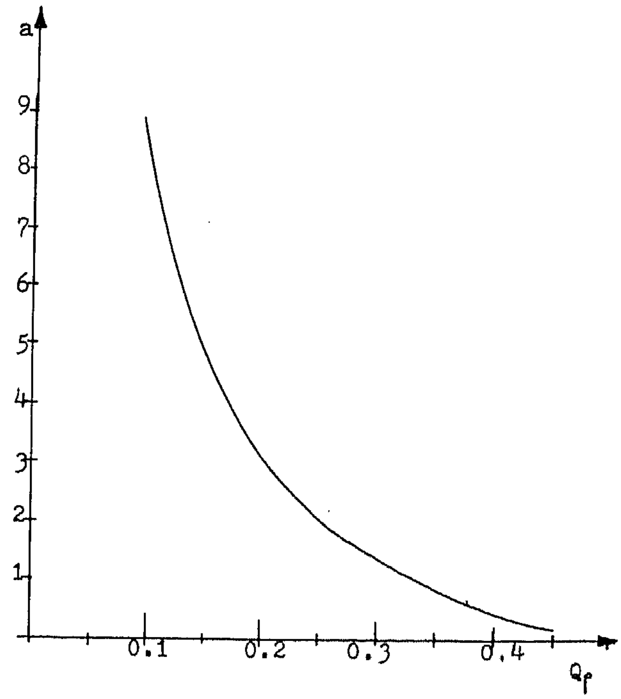

Fig 4 Variation of a versus Q_p for realizations 1 and 2.

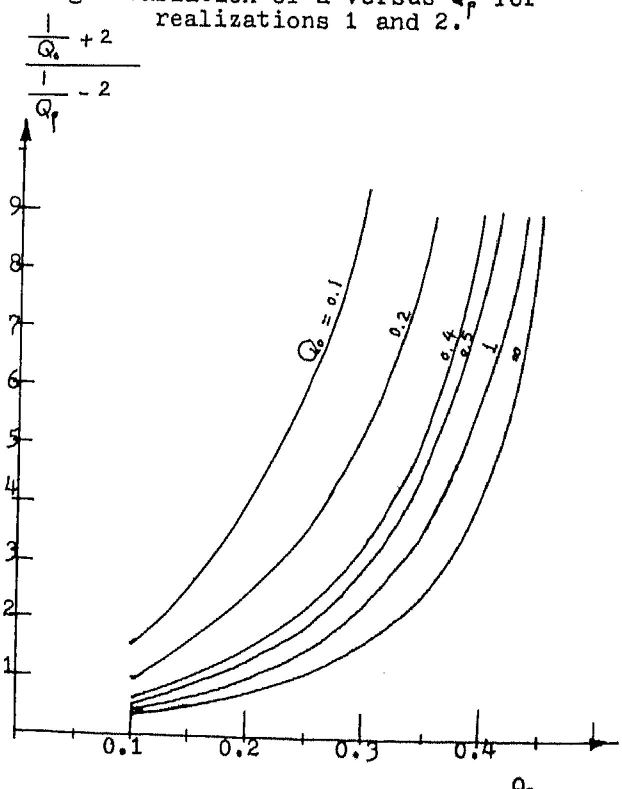

Fig 5 Variation of 2/b for realization 1 or b/2 for realization 2 versus Q_p with Q_o as a parameter.

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