ANALYSIS OF CIRCUITS WITH SWITCHED CAPACITORS BY MEANS OF SIGNAL-FLOW GRAPHS

T. Dostal and J. Mikula

Izvestiya VUZ. Radioelektronika,
Vol. 35, No. 11, pp. 25-31, 1992

UDC 621.372.001

A method of constructing signal-flow graphs of circuits having an arbitrary configuration with switched capacitors is examined. The signal-flow graph is constructed by means of a transformation graph of subgraphs of individual switched capacitors. The transformation graphs take into account also the effect of nonstandard active components of the circuit and switches.

Signal-flow graphs are a convenient tool for analyzing not only classical analog circuits [1] but also circuits with switched capacitances (SCs) [2, 3, 4], both for two-phase and for multiphase switches. The various types of signal-flow graphs and methods of their construction and analysis usually used at present are cumbersome and are often limited to a certain type of circuits being analyzed.

In the present article a method is proposed for constructing a signal-flow graph for an SC circuit having an arbitrary configuration by means of a transformation graph [1], which transforms the subgraphs of individual capacitors. The transformation graphs quite simply make it possible to take into account the effect of irregular (nonstandard) active components of the circuit and switches. The given form of transformation graph is considerably simpler and more effective than that proposed earlier in [4].

The proposed method is rather general and can be used when analyzing SC circuits with two- and multiphase switching. It also enables avoiding the construction and transformation of equivalent circuits of the circuit in various phases of the switches, etc. [3].

The signal-flow graph describing the SC circuit is obtained (without any additional constraints) by means of the transformation graph (T graph) introduced in [1].

The T graph is auxiliary and describes the relations between the variables of individual subcircuits (blocks), denoted by primes (U′, I′), and the quantities (U, I) describing the circuit as a whole.

Let the capacitor C_3 in the SC circuit (Fig. 1, *a*) be connected between nodes 1 and 2. The voltage across it

$$U_3' = U_1 - U_2 = a_{13} U_1 + a_{23} U_2 = (+1) U_3 + (-1) U_2, \quad (1)$$

then the charge

$$Q_1 = Q_3' = b_{31} Q_3' = (+1) Q_3', \quad (2a)$$

$$Q_2 = -Q_3' = b_{32} Q_3' = (-1) Q_3'. \quad (2b)$$

The transformation graph in Fig. 1b (dashed lines) corresponds to the given equation.

If the capacitor (for example, C_4) is connected (Fig. 1, *a*) to the node voltage U_1, i.e., between node 1 and "ground" (0), then we obtain

$$U_4' = U_1 = a U_1 = (+1) U_1, \quad (3)$$

$$Q_1 = b Q_4' = (+1) Q_4, \quad (4)$$

REFERENCES

1. T. Dostal and J. Mikula, "Analysis of circuits by means of signal-flow and transformation graphs," Izv. VUZ. Radioelektronika, no. 9, pp. 28-32, 1992.
2. T. Dostal and J. Mikula, "Reseni obvodu se spinanymi kapacitory v grafech MC," Slaboproudy obsor 46, no. 12, pp. 560-565.
3. A. Dabrowski and G. S. Moschytz, "Direct analysis of multiphase SC networks using signal-flow graphs," Proc. IEEE Tran. on CAS, vol. 37, no. 5, pp. 594-607, May 1990.
4. T. Dostal and J. Mikula, "Analysis and synthesis of SC networks using flow graphs," Proc. ECCTD 85, Prague, pp. 705-708, Sep. 1985.

2 June 1992

Higher Technical School, Brno,
Czechoslovakia