 Radioengineering
Vol. 3, No. 4, December 1994

Some Problems in Numerical Time Domain Analysis of Real Switched Capacitor Networks

Karel Zaplatilek
Department of Electrical Engineering
Military Academy in Brno
PS 13, 612 00 Brno
Czech Republic

Abstract

The contribution describes some problems which are connected with an application of theoretical methods. The transformation of data fields as a result of an output signal discontinuity and the correction of the time axis length will be discussed.

Keywords:

Numerical time domain analysis, real switched capacitor networks, transformation of data fields, signal approximation.

1. Introduction

The theoretical principles of the real switched capacitor network analysis were published in [1], [2], [3], [4], [5]. A special computer program has been developed for this analysis. The frequency domain analysis is based on the theory of generalized transfer functions [5]. The inversion Laplace transformation is used for the time domain analysis in the special computer program. This idea was published in connection with a computation of time domain response [6]. A lot of interesting problems appear during the development of the computer program. These problems are connected with an application of numerical algebraical methods and that of computer properties. Some of these have considerable influence on the algorithm strategy and practice employment.

We need to define input signals (typical and user signals) before the time domain analysis. The circuit response will result. Many interesting problems rise here. These following aspects will be discussed:

1) Lengthening of the time axis due to the output signal discontinuity. A change of the switching phase is the cause of this phenomenon.
2) An approximation of the input signal course during one switching phase.
3) A change of the maximum computation time which is defined by a user. Finite number of the approximation points calls out this phenomenon inside one phase.

2. Lengthening of the time axis

The user selects the maximum computation time. The output signal values will be computed for this time and for the parameters of the input signal (the output values vector). The analysed circuit has different topology structures in different phases. Therefore, this circuit works with new initial conditions at the beginning of a new phase. This initial condition is recounted from the final state of the previous phase (1).

$$v_1(kT^+) = S_{12} v_2(kT^-)$$
$$v_2(kT + T_1^+) = S_{12} v_1(kT + T_1^-) \ , \qquad (1)$$

where v_1 and v_2 is independent branch variable vector at the beginning of the new phase (+) or at the end of the previous phase (-), S_{12} a S_{21} are transformation matrixes [1].

We can prove by means of an analysis that these output signal changes bear upon a phase changes. The output signal can acquire two function values in one time moment Fig. 1. We must take into account this during the

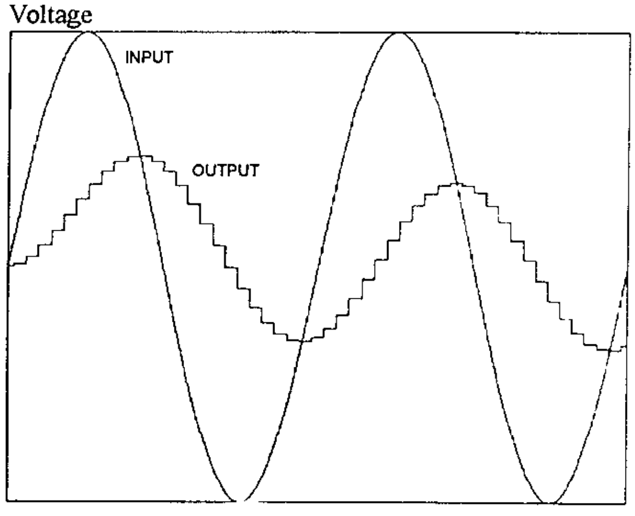

Fig. 1
The output signal discontinuity during phase changes

vectors and matrixes dimension. We can write

$$\tau = \varphi \,, \tag{2}$$

where τ is a number of units which extends the time data field, φ is a number of switching phases during the computation.

This general formula is valid for an arbitrary number of the switching phases.

It is necessary to modify the time data field only. It is useful to change the input and output program data fields, too because the algorithms will be more simple. These three data fields will have the same length Tab. 1.

phase 1st phase 2nd

Input	0	2e-03	4e-03	7e-03	10e-03	10e-03	17e-03	25e-03
Time	0	0,01	0,02	0,03	0,04	0,04	0,05	0,06
Output	0	0	0	0	0	1e-04	2e-04	5e-04

Tab. 1
Modification of the program data fields

3. The approximation of the input signal course during the one switching phase.

The changes of the input signals function values inside the one phase are shown in Tab. 1. We must approximate them for working mathematics models. The approximation functions can be some elementary signals (functions), e. g. a unit step, a unit impulse, a straight line etc., see Fig. 2. These approximations are more suitable than others because the switched capacitor networks analysis is based on the solving of the linear equations system in operator form.

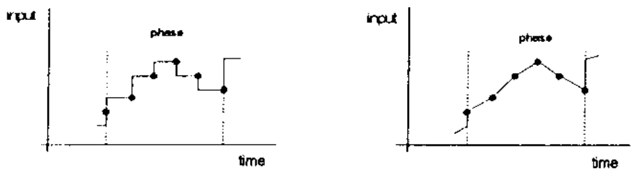

Fig. 2
Input signal approximation inside one phase

The changes of the input signal are small inside the one phase if the sampling frequency is sufficiently high. The computer program user will have the possibility to choice of the approximation functions. The approximate errors depend on the number of input signal points inside the one phase, too. In general, this number of the points is arbitrary but it has the influence on the other phenomenons.

4. Change of the maximum computation time

The user can define the maximum computation time t_{max}, too. However, this time will be modified during the circuit analysis. If t_{max} and graphic screen points number are known the number of the input signal points will be computed inside the one phase. The result of this computation is not the integer. That is why the points number will be rounded (integer). The maximum computation time is necessary to recount by means of the new points inside the one phase. The maximum time difference is not substantial as far as the points difference is small. The user can be informed about this fact.

The second reason exists for modifiing of the maximum computation time. The user need not to agree with the computation number of points. He can define other one. Afterwards, the new maximum time t+max must be computed again.

It is evident that the maximum computation time and the number of input signal points (inside one phase) are influenced reciprocally.

The user can define the sampling signal period T_{sam}, the size of the ratio $f_{sam}/f_{in}/(T_{in}/T_{sam})$ and t_{max}. The input signal frequency (or period) is computed automatically. It can be proved

$$P = 2\frac{T_{in}}{T_{sam}} \,, \tag{3}$$

where P is the phase number per input signal period (for two-phase switching).

We can write

$$n_T = \frac{t_{max}}{T_{in}} \,, \tag{4}$$

where n_T is number of the output signal period.

The number of points inside the one phase is given

$$n_p = \frac{N}{n_T P} \,, \tag{5}$$

where N is the number of the screen points.

The maximum and minimum points number are limited.

5. Conclusion

The development of the computer program is not finished up to this time. New interesting phenomenons are discovered now. These problems are connected with a numerical form of the theoretical methods. Some of them have a substantial influence on the program algorithms.

We can generalize the described phenomenons on the multi-phase switched networks.

6. References

[1] BIOLEK,D.: Počítačová analýza reálných spínaných obvodů. Dílčí výzkumná zpráva grantového úkolu Syntetické prvky vyššího řádu, Brno, 1993.

[2] BIOLEK,D.: Numerical Multi-Step Laplace Inversion. Radioengineering, No.1, 1992, pp.25-28.

[3] BIOLEK,D.: Time Domain Analysis of Linear Systems Using Laplace Inversion. Radioengineering, No.1, 1994, pp.17-20.

[4] BIOLEK,D.: Computer Aided Analysis of Switched Circuits by means of Generalized Transfer Functions. XXIV GA URSI, Kyoto 1993, Abstracts p.132 Japan.

[5] BIOLEK,D.-ZAPLATÍLEK,K.: Frequency domain analysis of switched networks by generalized transfer functions. ECCTD 93 Davos, pp.957-962. Switzerland.

[6] SINGHAL,K.-VLACH,J.: Computation of Time Domain Response by Numerical Inversion of the Laplace Transform. J. Franklin inst., vol.299, Feb.1975, pp.109-126.

[7] ZAPLATÍLEK,K.: Numerical Laplace Inversion by using Chebyshev Approximation. ECCTD '93, student PhD poster session, Davos, Switzerland.

About author, ...

Karel Zaplatílek was born in Svitavy, Czechoslovakia, in 1964. He received the M.E. degree in electrical engineering from the VUT Brno, in 1989. At present he is a PhD student. He is the senior lecturer at the department of Electrical Engineering of the VA Brno. His research interests include continuous-time and switched-capacitor networks, computer-aided analysis and numerical methods in circuit theory.

RADIOENGINEERING REVIEWERS

December 1994, Volume 3, Number 4