NEW DESIGN METHOD FOR THE DISTRIBUTED AMPLIFIER

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ABSTRACT

The inherent relations between the microwave distributed amplifier and the FIR (Finite Impulse Response) digital filter are determined by the digital signal processing theory. In accordance with the relations, the distributed amplifier can be designed in time domain and the window function technique can be introduced into the design method. In addition, the design example is offered to demonstrate that the design method is simple and effective.

INTRODUCTION

The distributed amplifier was first proposed to produce an amplifier without the gain — bandwidth constraint [1]. Recently, with the rapid development of MMIC, much attention is paid to the performance of the microwave distributed amplifier using MESFETs. How—ever, up to now, there is no explicit procedure for the amplifier synthesis.

In this paper, these inherent relations between the distributed amplifier and the FIR filter are deteremined. With these relations, the distributed amplifier can be regarded as an FIR filter and some design methods for the FIR digital filter can be exploited for the distributed amplifier synthesis. As a simple and useful design method for the FIR filter, window function one [5]is introduced to the distributed amplifier synthesis so as to improve the efficiency of the distributed amplifier. The design procedure is proposed and an example is given.

THE RELATIONS BETWEEN THE DISTRIBUTED AMPLIFIER AND FIR DIGITAL FILTER

The FIR filter is a kind of simple and absolute stable digital filter with the property of linear phase shift. It is composed of the time delays and the multipliers whose coefficients are the contents of the time—domain impulse response function h(k) of the FIR filter. The travelling path of the unit input signal in the FIR filter is shown in Fig. 1.

During the advanced of DSP, a lot of methods have been proposed for the FIR digital filter design. Among them, window function method is a simple one. The core of the method is utilizing window function W(k) as expressed in eq. 1 to truncate the time— domain impulse response function $h_d(k)$ of the ideal low—pass filter as defined in eq. 2 to obtain h(k).

$$W(k) = 1 \qquad 0 \leqslant k \leqslant N-1$$

$$W(k) = 0 \qquad otherwise \tag{1}$$

where N is the length of window function

$$h_d(k) = \frac{sin(\omega_p * k)}{\pi * k} \tag{2}$$

where ω_p is the normalized cutoff angle frequency of the ideal lowpass filter.

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$$h(k) = h_d(n) * W(k) \quad (3)$$

The scheme of the distributed amplifier is shown if Fig. 2. The travelling path of the unit input signal from the input port (port 1) to the isolate port (port 4) in the distributed amplifier is shown in Fig. 3.

Comparing Fig. 1 with Fig. 3, it is found that

(1) The phase shift in the distributed amplifier caused by each transmission line section corresponds to the time delay in the FIR filter.

(2) The amplification coefficient of each stage amplifier A_k in the distributed amplifier corresponds to the coefficient of each stage multiplier a_k in the FIR filter.

THE DESIGN PROCEDURE AND EXAMPLE

In this way, the design methods for the FIR digital filter can be used for the distributed amplifier synthesis. The distributed amplifier can be designed as follows:

(1) Chose the window function w(k) according to the specified standards of the reverse gain of the distributed amplifier.

(2) Let $g_{mk} = \alpha * \omega(k)$ (4)

(3) According to the forward gain G_f of the distributed amplifier, the parameter α can be obtained from the following equation.

$$\alpha = \sqrt{4G_f/[(\sum_{k=1}^{N}\omega^2(k))Z_{\pi d}Z_{\pi g}]} \quad (5)$$

For example, Using the Hamming window function, a 5 — stage distributed amplifier with gain =15dB, $Z_{\pi d} = 50\Omega$ and $Z_{\pi g} = 50\Omega$ is designed. The g_{mk} can be calculated and the results are listed in Table 1. The normalized reverse gain characterestic against θ of the distributed amplifier is shown in Fig. 4.

CONCLUSION

For there are correspondence relations between the distributed amplifier and the FIR digital filter, many design methods for the FIR filter can be exploited for the distributed amplifier synthesis to improve its specification. Here, for its simplity, the window function method is utilized for the distributed amplifier synthsis. In addtion, the current widely used distributed amplifier can be synthezed by directly using the rectangular window function.

REFERENCES

[1] W. S. Pervial, British Patent 460 — 562, July 1936

[2] E. L. Ginzton, W. R. Hewlett, J. H. Jasberg, and J. D. Noe, "Distributed amplification,", Proc. IRE, vol. 36, PP. 956—959, Aug. 1948

[3] K. B. Niclas, W. T. Wilser, T. R. Kritzer, and P. R. Pereira, "On theroy and performance of solid state microwave distributed amplifiers", IEEE Trans. vol. MTT—31, PP. 447—456, June 1983

[4] Colin S. Aitchison, "The intrinsic noise figure of the MESFET distributed amplifier", IEEE Trans. vol. MTT—33, PP. 460—465, June 1985

[5] A. V. Oppenheim and R. W. Shafer, Digital Signal Processing, Prentice —Hill: New Jersey, 1975

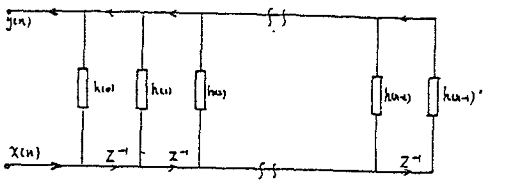

Fig.1 The travelling path of the unit input signal in FIR filter

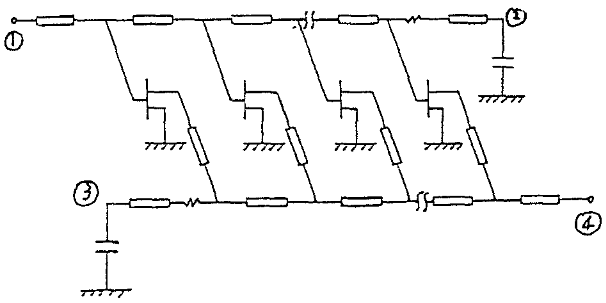

Fig.2 The scheme of the distributed amplifier

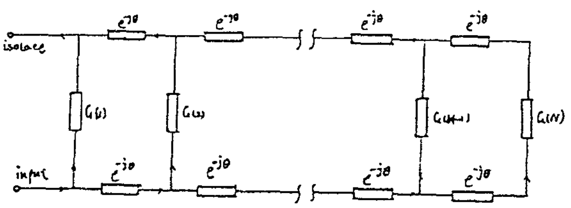

Fig.3 The travelling path of the unit input signal from port 1 to port 4 in the distributed amplifie

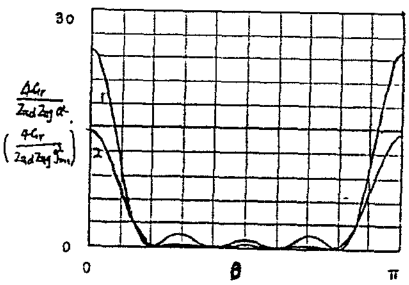

Fig.4 The normalized reverse gain characteristic against θ

Table 1 g_{mk} FOR THE 5-STAGE DISTRIBUTED AMPLIFIER

k	1	2	3	4	5
g_{mk} (ms)	78	104	130	104	78