Letters

Explicit Microwave Rotary Phase Shifter Calibration Algorithm

P. I. SOMLO

A microwave rotary phase shifter calibration method described previously[1] requires the device under test (DUT) to be connected in tandem with a 2-state phase stepper (flap) of initially unknown phase shift F to form an arm of a phase bridge circuit. The measurement is carried out by setting the DUT sequentially to a series of cardinal points, α_{oi}, $i=1,\cdots,M$, equally spaced around the dial. At each, the phase bridge is balanced, and after introducing the flap, the new setting α_{fi} of the DUT needed to return the phase bridge to balance is found.

The advantages of the method are that no standard phase shifter is required; that since the method is not a buildup method, errors are not cumulative; and that the phase bridge need not have any long-term stability. The algorithms previously described for data reduction are both iterative.

A new algorithm is presented here that provides an explicit solution for the M unknowns.

We represent the DUT's error by a Fourier series as a function of dial setting, and solve for the $M-1$ Fourier coefficients,[2] plus the (initially unknown) phase shift of the flap, F.

The relationship between the true phase shift, α_{true}, and the dial setting, α, of the DUT is defined as

$$\alpha_{\text{true}} = \alpha + \text{corr} = \alpha + \sum_{m=1}^{M/2-1}\left[A_m\cos(m\alpha)+B_m\sin(m\alpha)\right] + A_{M/2}\cos\left(\frac{M}{2}\alpha\right). \quad (1)$$

Because the difference between the corresponding pairs of readings is the phase shift of the flap, we may write

$$(\alpha_{fi}+\text{corr}_{fi})-(\alpha_{oi}+\text{corr}_{oi}) = F, \qquad i=1,\cdots,M.$$

This with (1) leads to a set of simultaneous equations:

$$\sum_{m=1}^{M/2-1} A_m\left[\cos(m\alpha_{fi})-\cos(m\alpha_{oi})\right] + B_m\left[\sin(m\alpha_{fi})-\sin(m\alpha_{oi})\right] + A_{M/2}\left[\cos\left(\frac{M}{2}\alpha_{fi}\right)-\cos\left(\frac{M}{2}\alpha_{oi}\right)\right] - F = \alpha_{oi}-\alpha_{fi}, \quad i=1,\cdots,M \quad (2)$$

which may be readily solved by matrix inversion.

It is worthwhile noting that the error may also be obtained by deconvolving the observed data, $\alpha_{oi}-\alpha_{fi}$, with an odd impulse pair of baseline F, but the method given here is simpler.

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[1] P. I. Somlo *et al.*, "The absolute calibration of periodic microwave phase shifters without a standard phase shifter," *IEEE Trans Microwave Theory Tech.*, vol. MTT-20, pp 532–537, Aug. 1972.

[2] There is no constant term in the Fourier series because this would represent a fixed offset phase shift. With the phase shifter used in the differential mode this offset cancels out. Also (for M even), the highest harmonic in the error spectrum has only two points per period, and therefore is represented by only a cos term

Corrections to "High-Frequency MESFET Noise Modeling Including Distributed Effects"

WOLFGANG HEINRICH

In the above paper[1] Figs. 5, 6, and 8 were partially illegible owing to poor reproduction. These figures are reprinted here.

The paper also contains an inconsistency in notation concerning the source resistance. The resistance R_s used in equations (5), (6), and (A1) is identical to the element R_{gs} shown in Fig. 7.

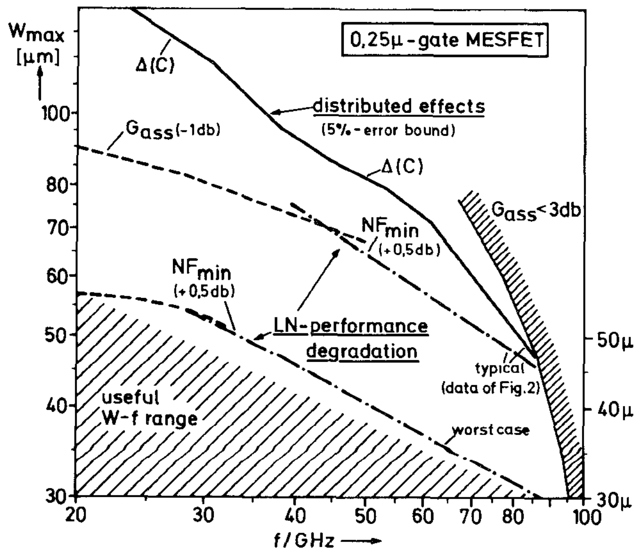

Fig. 5.

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[1] W Heinrich, *IEEE Trans. Microwave Theory Tech.*, vol. 37, pp. 836–842, May 1989.

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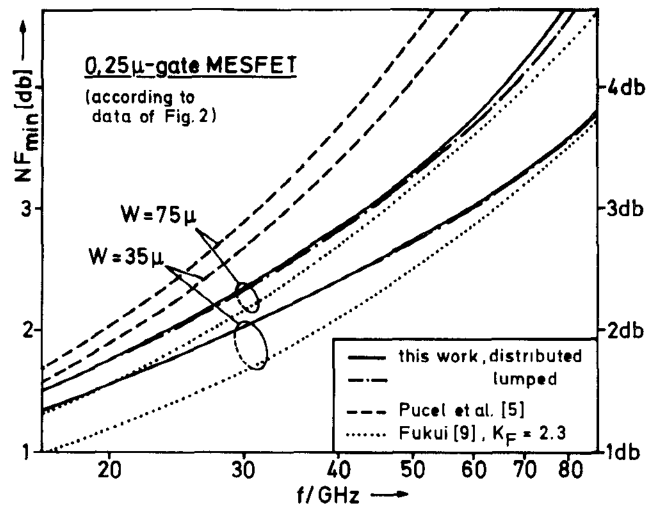
0.25µ-gate MESFET
(according to
data of Fig. 2)
NFmin [db]
W=75µ
W=35µ
this work, distributed
lumped
Pucel et al. [5]
Fukui [9], KF = 2.3
4db
3db
2db
1db
f/GHz

Fig. 6

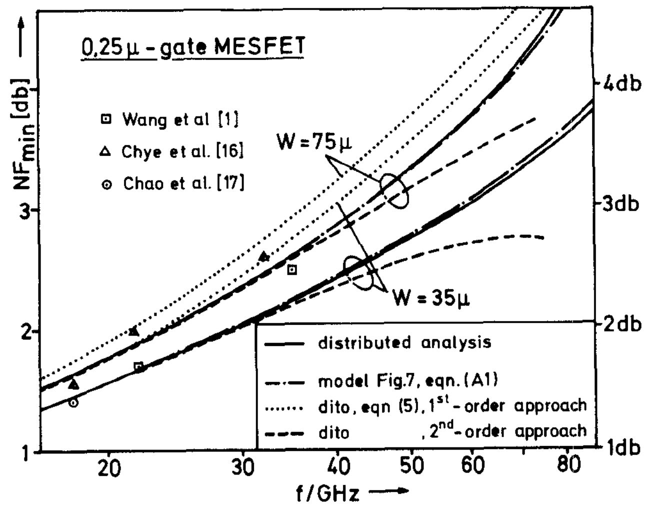
0,25µ - gate MESFET
NFmin [db]
Wang et al [1]
Chye et al. [16]
Chao et al. [17]
W=75µ
W = 35µ
distributed analysis
model Fig.7, eqn. (A1)
dito, eqn (5), 1st - order approach
dito , 2nd - order approach
4db
3db
2db
1db
f/GHz

Fig. 8.