may assume a constant value, independently of s. This occurs if the following relations hold:

$$\frac{I_{1r}^T A I_{1r}}{I_{1r}^T I_{1r}} = \frac{I_{1j}^T A I_{1j}}{I_{1j}^T I_{1j}} = \frac{I_{1r}^T A I_{1j} + I_{1j}^T A I_{1r}}{I_{1r}^T I_{1j} + I_{1j}^T I_{1r}} = k. \quad (7)$$

If we now indicate by $\lambda_r + j\lambda_j$ the eigenvalues of A, and by $u+jv$ the corresponding eigenvectors, it can be shown that, in order that all the relations (7) may hold, it is necessary, for an eigenvector of A (which we indicate by $\bar{u}+j\bar{v}$), that

$$\bar{u}^T\bar{v} = 0 \quad \text{and} \quad |\bar{u}| = |\bar{v}|. \quad (8)$$

Moreover, if (8) holds, we have

$$k = \bar{\lambda}_r. \quad (9)$$

We can conclude that if, on increasing s, the Rayleigh quotient tends to a constant value k, one of the following conditions holds: 1) k is closer than $\lambda^{(i)}$ to a true eigenvalue; 2) k is equal to the real part of a complex eigenvalue.

To verify whether the convergence is anomalous or not, the form of $x^{(s)}$ must be examined. If $x^{(s)}$, as s increases, oscillates in sign, the convergence is anomalous and, in order to obviate this inconvenience, the procedure must be reinitiated after changing $\lambda^{(0)}$ or $x^{(0)}$.

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Letters

Comments on "Noise in IMPATT Diode Amplifiers and Oscillators"

B. SCHIEK AND K. SCHÜNEMANN

In the above paper,[1] an extensive contribution on the noise of IMPATT oscillators was presented, which is based on the theory of Kurokawa [1]. In our opinion, however, the theoretical results of this work do not apply in all cases to the experiments reported. The authors define a load angle θ (15a) which appears in the equations for the AM and FM noise [(16b) and (17b)] and the correlation coefficient [(18b). Eqs. (16b), (17b), and (18b)] describe the noise of the current through the diode, which is of minor interest and difficult to measure. The AM noise of the load current, which in reality was measured,[1] differs considerably from the noise of the diode current if $\theta \neq 90°$. In this case, an additional FM–AM conversion term appears which, under certain conditions, cancels exactly the load-angle-dependent terms in the expression for the AM noise of the diode current. These conditions are as follows.

1) The transforming network between the diode current and the load current is lossless but otherwise arbitrary; losses in series or parallel to the load or to the active device, however, are allowed.

2) The oscillator is tuned to maximum output power.

Then the AM noise and the correlation coefficient of the load current are independent of θ, while the FM noise remains as in (17b). This can be seen from the following formulas where the symbols of Thaler *et al.*[1] have been used:

$$S_{AA}{}^0(\Omega) = S_{cc}(\Omega)/A_0{}^2 \cdot \left|\frac{\partial Z_D}{\partial A}\right|^2 \cdot \cos^2\eta$$

$$S_{\omega\omega}{}^0(\Omega) = S_{cc}(\Omega)/A_0{}^2 \cdot \left|\frac{\partial Z_L}{\partial \omega}\right|^2 \cdot \sin^2(\theta - \eta)$$

$$\gamma_{A\omega}{}^0 = -\sin\eta.$$

If the conditions 1) and 2) are not exactly satisfied, $S_{AA}{}^0$ and $\gamma_{A\omega}{}^0$ will show only a weak dependence upon θ as derived in [2]. The equations given above have been found to be in close agreement with experimental results obtained for cavity-stabilized Gunn oscillators. In these experiments the distance of the matched cavity from the Gunn diode was varied by a set of disks in order to vary θ without changing the optimum operating conditions. However, the resonance frequency of the cavity has been varied,[1] which introduces a certain mismatch outside the center frequency. Then a discussion of the experimental results becomes more difficult because the tuning condition 2) is violated. The application of (16b) and (18b) is also in this case not justified.

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[1] H. J. Thaler, G. Ulrich, and G. Weidmann, "Noise in IMPATT diode amplifiers and oscillators," *IEEE Trans. Microwave Theory Tech.*, vol. MTT-19, pp. 692–705, Aug. 1971.

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Reply[2] by Hans-Jörg Thaler, Gerhard Ulrich, and Gerhard Weidmann[3]

The comments of Schiek and Schünemann on the results presented in our paper[1] are based on a misinterpretation of the equivalent circuit used in our analysis. This can be shown by analyzing the oscillator circuit in a reference plane at the load terminals. In this representation the operating point of the oscillator in the complex impedance plane is given by the lines of the frequency and RF current dependence of the active device impedance intersecting each other in the point of the real load impedance. The impedance transformation from the reference plane at the active device terminals (used in our original analysis) to the new reference plane does not change the intersection angles of the two loci which enter the formulas for the oscillator noise spectra. Therefore, the load current and the loop current in our equivalent circuit have the same dependence on the oscillator parameters, especially on the load angle θ. The experimental results presented in our paper clearly contradict the state-

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ment in the above comment that the AM noise spectrum and the AM–FM cross spectrum do not (or only weakly) depend on the load angle θ. The noise behavior of Gunn oscillators cannot in general be described by the simplified formulas (16b), (17b), and (18b) of our paper[1] as there are usually present large modulation noise contributions.

The calculations of Schiek and Schünemann seem to be based on rather special tuning conditions which are neither specified exactly in the above comment nor in the references quoted. Their results are quite similar to those given in our paper,[1] if $\theta = 90°$ is assumed. This condition is usually fulfilled in oscillators tuned for maximum power output.

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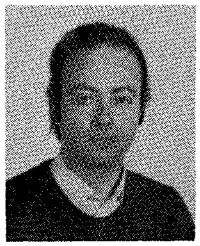

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