Above $\omega_R$ no external negative resistance is exhibited by a tunnel diode by definition—in this case all $j\omega$ plots terminate somewhere in the RH $H$ plane. It is therefore justified to draw an arbitrary loop *from* just above $\omega_R$ *to* just below $-\omega_R$ in the RH $H$ plane (along a constant resistance or conductance line just to the right of the imaginary-axis, say) regardless of which limiting case of Table I applies.

Analogous limiting cases will now be found for the $\rho'$ plane, for $R' = Z_C(p)|_{p\to\infty}$.

$$\text{If } Z_L(p)|_{p\to\infty} \to \frac{1}{pC},$$

$$\rho'(p)|_{p\to\infty} \to -1. \tag{10}$$

$$\text{If } Z_L(p)|_{p\to\infty} \to R,$$

$$\rho'(p)|_{p\to\infty} \to \frac{R + R'}{R - R'}. \tag{11}$$

$$\text{If } Z_L(p)|_{p\to\infty} \to pL,$$

$$\rho'(p)|_{p\to\infty} \to +1. \tag{12}$$

The infinite CCW semicircle in the LH $p$ plane of Fig. 2(a) will, therefore, coalesce into a single point on the real $\rho$ or $\rho'$ axis, according to Table II.

The question of where an arbitrary loop can be drawn without ambiguity presents some difficulty. It is important to distinguish between whether the Smith chart is being used with the stability criterion in terms of immittance or in terms of voltage reflection coefficient. Figure 3 illustrates the difficulty with the aid of Tables I and II, with $Z_L$ representing the tunnel-diode equivalent circuit either in the form of Fig. 3(a) or (b), and with $Z_C(p)$ equal to a constant. Note that the $H$-plane criterion is associated with a closing loop through the region of the origin. The closing loops for the $\rho'$-plane criterion, however, pass through $\rho = \pm 1$ according to whether $L$ or $C$, respectively, predominates as $p \to \infty$.

To summarize:

1) The numerator of $\rho(p)$ may have zeros in the RH $p$ plane other than "active" ones which would have to be determined.
2) The arbitrary closing loop in the $\rho'$ plane cannot be so easily dismissed (see Fig. 4) as in the $H$-plane.
3) No further information on *stability* is forthcoming by considering $\rho'$ rather than $H$.

It is advisable, therefore, that when using the Smith chart for predicting simultaneously the stability and gain of reflection amplifiers, for example, the stability criterion itself should be formulated in terms of $H$ to avoid ambiguity. The Smith chart plot is visualised as a distorted $H$-plane plot for this purpose.

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REFERENCES

[1] J. W. Bandler, "Stability and gain prediction of microwave tunnel-diode reflection amplifiers," *IEEE Trans. Microwave Theory and Techniques*, vol. MTT-13, pp. 814–819, November 1965.
[2] W. F. Chow, *Principles of Tunnel Diode Circuits*. New York: Wiley, 1964, p. 116.
[3] P. H. Smith, "A new negative-resistance Smith chart," *Microwave J.*, vol. 8, pp. 83–92, June 1965.
[4] J. W. Bandler, "Frequency responses in the reflection coefficient plane plotted by digital computer," *IEEE Trans. Microwave Theory and Techniques (Correspondence)*, vol. MTT-14, pp. 399–400, August 1966.
[5] H. W. Bode, *Network Analysis and Feedback Amplifier Design*. Princeton, N. J.: Van Nostrand, 1945.
[6] B. T. Henoch and Y. Kvaerna, "Stability criteria for tunnel-diode amplifiers," *IRE Trans. Microwave Theory and Techniques (Correspondence)*, vol. MTT-10, pp. 397–398, September 1962.

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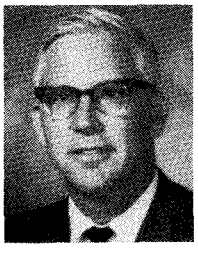
# Contributors



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Mr. Engen was awarded the Department of Commerce Silver Medal for Meritorious Service. He is a member of Commission I of the International Scientific Radio Union (URSI).

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From 1956 to 1963, he was employed at Radio Corporation of America as a Design and Development Engineer. He worked on microwave components, IF and video devices, and radar subsystems. He was Project Engineer on a five-frequency telemetry receiver and on an *L*-band parametric amplifier field change kit for operational radars. In May, 1963, he joined Sperry Microwave Electronics Co., as a Design Engineer in the Advanced Microwave Techniques Section. He subsequently worked on tunnel-diode amplifiers, parametric amplifiers, and frequency multipliers. From February, 1965, to March, 1966, he was assigned to the Research Section as Project Engineer on a ferroelectric material study program. His work involved ferroelectric material research and the application of ferroelectric materials to microwave components. In April, 1966, he joined Texas Instruments Incorporated as a Member of the Technical Staff of the Semiconductor Research and Development Laboratories. He is presently involved in microwave integrated circuits and is concerned with the frequency multipliers of the MERA microwave module.

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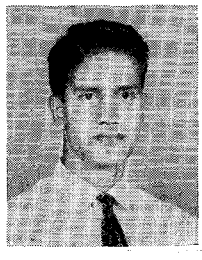

**N. Seshagiri** (M'66) was born in Satyamangalam, Madras State, India, on May 10, 1940. He received the B.E. degree in electrical engineering from the University College of of Engineering, Bangalore, Mystore State, India, in 1961. He held a Senior Research Fellowship from the Indian Institute of Science, Bangalore, while working toward the Ph.D. degree in field theory and was a Research Student in the Department of Electrical Communication Engineering.

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