Panel: Noise in Microwave Transmission Applications of Gunn and IMPATT Diodes

THE SYSTEM/CIRCUIT INTERFACE IN IMPATT DIODE APPLICATIONS

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Summary of Introductory Statement

Output power amplifiers using Impatt diodes are now being used in FM radio relay transmitters.[1] In order to obtain high overall efficiency, the diodes are operated close to maximum rf output power. Since the noise figure increases monotonically with output power, an optimum tradeoff between power and noise must be sought.[2]

The figure shows transmitter output power versus thermal noise for a typical short-haul FM radio system. The dashed lines are contours of constant baseband thermal noise performance in dBrnc0.[3] The solid curves show typical power-noise characteristics for a silicon Impatt diode oscillator injection-locked by a 10dBm input signal. For each diode current there is an optimum operating point for best system performance, obtained by proper circuit loading. One also notes that system performance improves with diode dc current; however, an upper limit is set by considerations of diode reliability. Although these diode curves were measured for an injection-locked oscillator, the stable amplifier curves are found to be similar, and both modes of operation are commonly referred to as amplifiers.

The overall system performance may be further degraded several dB by intermodulation noise due to nonlinearities in all parts of the repeater. Impatt injection-locked oscillators have typically been found to contribute negligible intermodulation distortion.

The amplifier designer relates the performance data of the figure to amplifier noise figure using the equation:

$$F(\text{dB}) = 171 + P_{\text{Lock}}\ (\text{dBm}) - C/N|_{\text{DSB-FM}}\ (\text{dB})$$

where P_{Lock} is the input signal (assumed noiseless) and $C/N|_{\text{DSB-FM}}$ is the double-sideband carrier-to-noise ratio. This FM noise figure is equal numerically to the free-running oscillator noise measure used previously by K. Kurokawa, J. G. Josenhans, A. M. Cowley, and others. On the other hand, R. L. Kuvas has defined noise measure so as to obtain values which are 3dB lower.

One notes from the above equation the importance of the (noiseless) input signal level. For a fixed amplifier noise figure, the system performance improves directly with the input signal level.

When greater output power is required than that available from a single diode, amplifier stages may be cascaded, and the overall noise figure is calculated using the well known cascade noise formula. Overall performance is optimized with the first stage diode operating at low noise and low power, the output stage diode operating near maximum output power, and intermediate stage diodes operating between these extremes.[4]

Thus, we see how careful design enables Impatt amplifiers to meet the exacting requirements of FM radio systems.

References

1. J. E. Morris and J. W. Gewartowski, "A One-Watt 6-GHz Impatt Amplifier for Short-Haul Radio Applications," Bell System Technical Journal, 54, April 1975.
2. I. Tatsuguchi, N. R. Dietrich, and C. B. Swan, "Power-Noise Characteristics of Phase-Locked Impatt Oscillators," IEEE Journal of Solid-State Circuits, SC-7, pp 2-10, February 1972.
3. Bell Laboratories Staff, Transmission Systems for Communications, Western Electric Company, Inc., Winston-Salem, N.C., 4th ed., pp 31-34, 482, 1970.
4. I. Tatsuguchi and J. W. Gewartowski, "A 10-W 6-GHz GaAs Impatt Amplifier for Microwave Radio Systems," 1975 IEEE Int. Solid-State Circuits Conference Digest of Technical Papers, 18, pp 134-135, February 13, 1975.

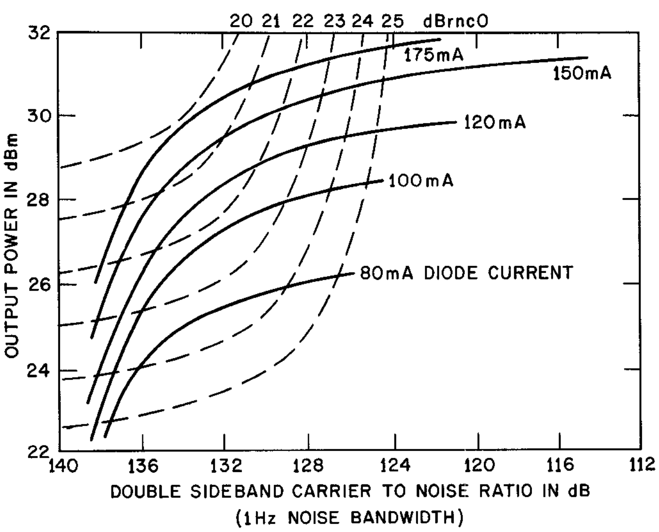

Fig. 1 Graphical method of determining amplifier operating conditions for best system performance. The dashed lines are contours of constant system thermal noise performance per hop. The solid lines plot amplifier power output and noise for a 10dBm input signal.