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

THE SYSTEM/CIRCUIT INTERFACE IN GUNN DIODE APPLICATIONS

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Summary of Introductory Statement

Farinon's FH-Series systems, intended for either heterodyne or baseband operation with analog transmission capacities of up to 1800 voice channels or the equivalent at frequencies above 5.9 GHz[1,2], use Gunn diodes in all three active radio-frequency functions, i.e. in the receiver local oscillator (LO), in the frequency-modulated transmitter oscillator (OSC-MOD), and in the transmitter power amplifier operating in the injection-locked mode (ILA). The LO is also being used, since 1970, in Farinon's SS-Series baseband systems[3].

The LO produces an output power of 3 mW or higher, using a 50 mW diode which is loosely coupled to a cavity resonator. The loaded Q of the oscillator circuit is approximately 3000. The OSC-MOD uses varactor tuning for linear frequency modulation and automatic frequency control, producing an output power of .25 W or higher, using a .5 W Gunn diode. The loaded Q of the OSC-MOD is of the order of 100. The ILA produces 1.5 or 2 W of output power by paralleling three or four .5 W diodes, respectively[4]. The power gain is typically between 16 and 18 dB, and the loaded Q approximately 20.

These electrical characteristics indicate that the predominant noise contribution should be expected from the OSC-MOD. On one hand, the combined effect of the relative Q values and output powers of the LO and of the OSC-MOD gives the former a substantial noise advantage. On the other hand, the ILA's power output and gain point toward negligible noise contribution even when Gunn diodes with relatively high noise figures are used. All available noise test data confirm these relationships.

The most complete overall noise evaluation of these active radio-frequency components using Gunn diodes has been carried out on a 4-hop FH1-7 heterodyne system (7.125-7.725 GHz band). The intrinsic noise was measured in 3.1 kHz slots centered at the standard baseband test frequencies. CCIR preemphasis and deemphasis networks were used. Data are presented here only for the lower end of the baseband spectrum where system performance requirements are most difficult to satisfy due to the predominance of 1/f noise. The average values of intrinsic equipment noise per FH1-7 repeater were found to be as follows

- 960 voice channel capacity, 200 kHz RMS deviation:

  3 pWp (6 dBrnC0) at 70 kHz
  (The corresponding unweighted noise without emphasis is -86.5 dBm0 relative to 200 kHz RMS deviation)

- 1800 voice channels, 140 kHz RMS deviation:

  4 pWp (7 dBrnC0) at 534 kHz
  (Corresponds to -88.5 dBm0 relative to 200 kHz, unweighted, without emphasis)

These figures represent the average totals of the noise contributions of the LO, the OSC-MOD and the ILA. An exact breakdown of the individual contributions has not been made but the OSC-MOD has been identified as the predominant noise source.

The above figures satisfy the most stringent systems requirements with substantial margin. However, higher noise has been measured in other OSC-MOD tests carried out in the 6, 7 and 11 GHz frequency bands. The observed range of wafer-to-wafer noise variation is close to 10 dB, whereas diode-to-diode noise variations within the same batch are of the order of 1 dB.

Diodes with higher than average noise may not satisfy the requirements of some systems. Wafer selection is, therefore, indispensable at this stage in order to secure diodes with sufficiently low noise for OSC-MOD applications. This is not necessary and is not being practiced with the Gunn diodes for LO and ILA applications where lower noise contributions are being consistently observed.

The reported experience resulted from extensive use of 50 to 100 mW Gunn diodes from several suppliers, and of .5 W diodes from Microwave Associates. This experience firmly supports the established role of Gunn diodes in fundamental-frequency generation and amplification for microwave radio systems applications. However, a better understanding of the factors affecting FM-noise would be most beneficial in tightening up production control over this important electrical characteristic of Gunn diodes.

Acknowledgements

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Eugene Hwan and Walter Dandridge made substantial contributions to the development of the OSC-MOD and of the ILA, respectively.

References:

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