"LASER DIODE CHARACTERIZATIONS FOR MULTI-CHANNEL APPLICATIONS"

Dr. C.S. Kim
Electronics Laboratory
General Electric Company
Syracuse, New York 13221
315-456-2254

ABSTRACT

Commercially available laser diodes for multi-channel applications are characterized; results on intermodulation distortions and S/N levels, obtained using a new procedure in the RF frequency range and at various operating points above threshold levels, are included.

SUMMARY

Background

Non-linearity and noise in a laser diode limit its performance in multi-channel analog and digital applications. These factors become more pronounced in analog operation [1] [2] where low intermodulation distortions and high S/N levels are required.

Laser S/N is not only a function of bias current, I_B, but also of the AM modulation index m_a, and intermodulation distortions are inversely related to m_a. Thus, an optimum characteristic can be found for specific applications in terms of intermodulations and S/N levels.

The optical system of Figure 1 was used to characterize the laser.

Noise

Figure 2 shows the noise contributions, from the components shown in Figure 1, as a function of average incident light power, L_I, at the input of a photodetector. Three current noises, $\overline{i_{sh}^2}$ (quantum noise of detector), i_{la}^2 (laser noise) and $\overline{i_{eq}^2}$ (equivalent noise from detector load and pre-amp) are plotted for BW = 6 MHz. $\overline{i_{sh}^2}$ and $\overline{i_{la}^2}$ are proportional to L_I and L_I^2, respectively, and $\overline{i_{eq}^2}$ and $\overline{i_{eq}^2}/G_I^2$ are independent of L_I where G_I is the avalanche current gain [*] (photo-detector).

In an optical system the ordinary noise factor, F, does apply; S/N is used to characterize noise. Here, the peak-to-peak laser light output power, $L_{p\text{-}p}$, with $m_a = 0.5$ ($L_{p\text{-}p} \doteq L_I$) is used conveniently to represent the S/N of the detector and various laser noises.

*Excessive noise produced in a detector can be corrected.

Consider a region where the laser noise becomes predominant; for example $L_I = 10^{-2}$ mw, i_{la}^2 (S/N = 10^4) and $\overline{i_{eq}^2}/G_I^2$ ($G_I^2 > 10^2$) in Figure 2. In this region, the laser noise measurement can be made using Figure 1; it is simpler than other techniques [3] used. A tunable receiver and power meter was used and quantitative noise measurements were made by doubling to noise power at the power meter with an RF signal (generator) calibrated to the RF input current of a laser diode (about 1 Ω).

Noise measurements for a NEC laser diode are shown in Figure 3. Here the relative noise was measured vs I_B for various frequencies. Values of S/N = 55 dB at I_B = 150 mA with $m_a = 0.5$ at 190 MHz were used as a reference (BW = 6 MHz).

Intermodulation Distortions

The tunable filter and spectrum analyzer (Figure 1) was used to measure intermodulation distortion, including harmonic components and $2f_1 - f_2$ of third-order distortion components. Other third-order distortion components can be derived from $2f_1 - f_2$. [4]

Measured $2f_1 - f_2$ distortions and relative output power of the NEC laser diode were plotted vs. RF input current for various values of I_B (see Figure 4). For a given $m_a \simeq 0.5$ ($I_{p\text{-}p} = 22.4$ mA), the minimum distortion was 48 dB below the fundamental level at I_B = 180 mA.

OPTIMUM OPERATIONS

The operational characteristics of a laser vs I_B and m_a at various frequencies can be optimized. For example, optimum performance of a NEC laser diode for 8 channel CATV (C, D, E, 9, 10, 11, 12, 13) operation was obtained at I_B = 170 mA, with $m_a = 0.5$. This corresponds to an S/N of 40 dB and a $2f_1 - f_2$

CH1355-7/78/0000-0127$00.75

distortion 48 dB below the fundamental level.

Other laser diodes were also characterized with similar results. For example, a laser diode provided an S/N of 40 dB and a $2f_1 - f_2$ distortion of -50 dB at I_B = 330 mA and m_a = 0.5.

REFERENCES

1) D. Chan and T.M. Yuen, "System Analysis and Design of a Fiber Optic VSB-FDM System for Video Trunking", IEEE Trans. Comm. July 1977.

2) E. H. Hara and T. Ozeki, "Optical Video Transmission by FDM Analog Modulation", IEEE Trans. Cable TV, Jan. 1977.

3) T. Paoli, "Noise Characteristic of Stripe Geometry Double-Heterostructure Junction Lasers ---", IEEE Jour. of Quantum Elec. June 1975.

4) K. A. Simons, "The Decibel Relationships Between Amplifier Distortion Products", Proc. IEEE, July 1970.

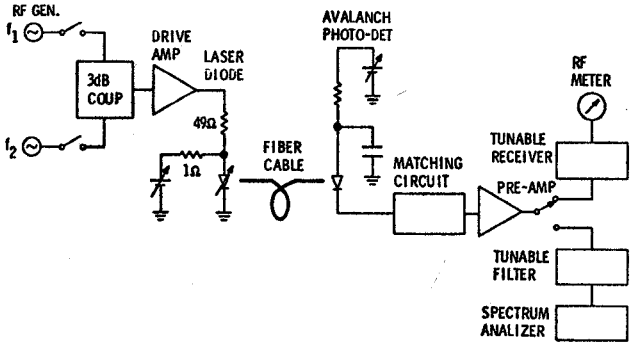

Figure 1. Optical System for Device Characterization

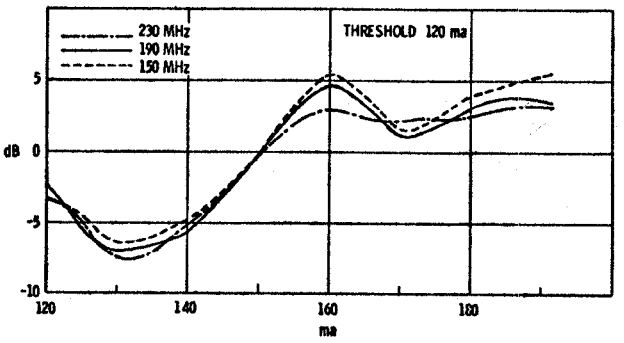

Figure 3. NEC Laser Diode Noise versus Bias

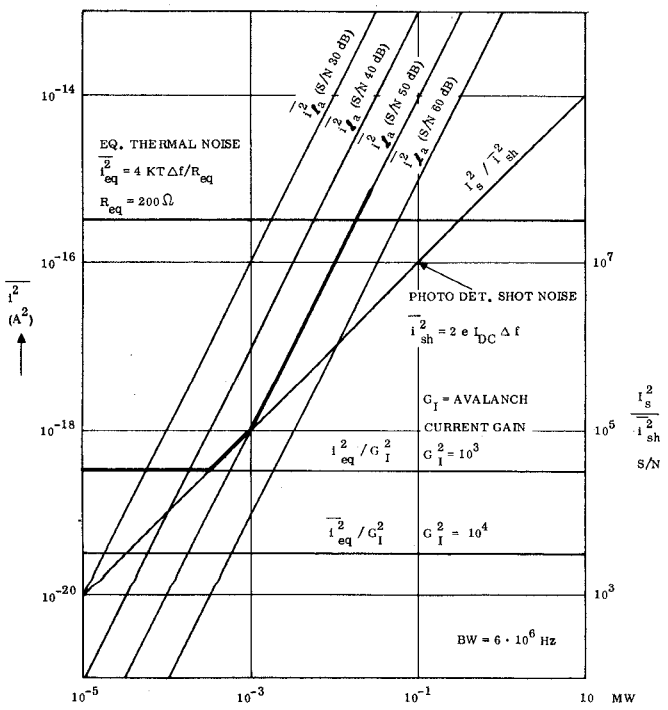

Figure 2. Noise and S/N versus Photodetector Input Power

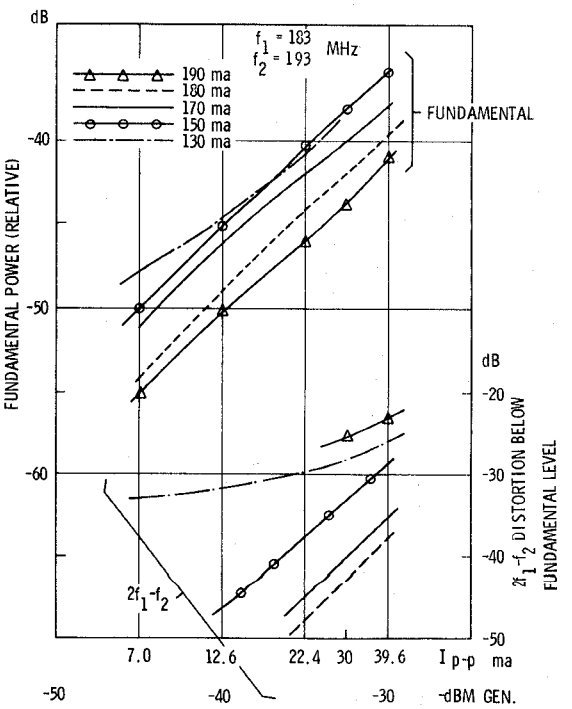

Figure 4. Laser Diode Non-linear Characteristic