THE INTEGRATED OPTIC SPECTRUM ANALYZER — A FIRST DEMONSTRATION

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ABSTRACT

This paper reports on the performance of the first fully Integrated Optical Spectrum Analyzer consisting of a GaAlAs semiconductor laser, a $LiNbO_3$ integrated optic chip, and a Si detector/CCD linear array.

This paper will report the first demonstration of a fully integrated optical spectrum analyzer (IOSA) using a GaAlAs semiconductor laser, a $LiNbO_3$ integrated optic chip, and a silicon detector/CCD array chip. The complete device which was delivered to the Air Force Avionics Labroatory is illustrated in Figure 1. This device exhibited a 3 dB bandwidth of 280 MHz with a diffraction efficiency of 5% (at 500 mWRF power and $\lambda_0 = 0.82\mu$). Detailed measurements on bandwidth, single and two-tone RF resolution, dynamic range, RF pulse measurements and other relevant information of the device will be reported.

The interest in this device arises from the possibility of performing RF spectrum analysis over relatively large RF bandwidths in almost real time ($\sim\mu$ secs) using parallel acousto-optic processing. The integrated optics format offers the potential of small size and low cost. Briefly, the IOSA consists of a semiconductor laser and a detector/CCD linear array end-fire coupled to the opposite ends of a Ti-diffused $LiNbO_3$ chip. The $LiNbO_3$ chip has two low loss geodesic lenses fabricated on the top surface, as well as a SAW transducer for generating acoustic wave perturbations on the chip's surface. The first lens serves to collimate the laser light. The acoustic surface wave deflects part of the collimated light at an angle proportional to the RF frequency. The second transform lens focuses the deflected light on to the appropriate cell of the detector/CCD array, where each cell corresponds to a specific input frequency.

All components of the IOSA were first tested individually with the following results. A fully functional (with no dead detector cells) detector/CCD array exhibited a linear dynamic range of 30 dB with a sensitivity uniformity of $\pm$ 1 dB. A measurement of the undeflected zeroth order beam indicates geodesic lens insertion losses of $\lesssim$2 dB each. The acoustic transducer exhibited a 400 MHz 3 dB RF bandwidth. The fully integrated device operating at $\lambda_0 = 0.82\mu$ exhibited the following preliminary performance figures: an acousto-optic bandwidth of 280 MHz, a 3 dB spot size of $\sim$8 MHz as illustrated in Figure 2, a two-tone resolution of 8 MHz, and a linear dynamic range of >25 dB as observed visually on an oscilloscope. The resolution uniformity across the RF bandwidth is presently limited by our inability to mechanically position the semiconductor laser and the detector/CCD array exactly in the focal planes of the collimating and focusing geodesic lenses.

We would like to acknowledge the technical assistance of Jon Myer, Gary Thurmond, and Rudi Bondio, and the fruitful discussions we have had with Luis Figueroa, Charles Slayman and Ron Schmidt. We would also like to thank Mr. Michael Hamilton of the Air Force Avionics Laboratory for fruitful technical discussions.

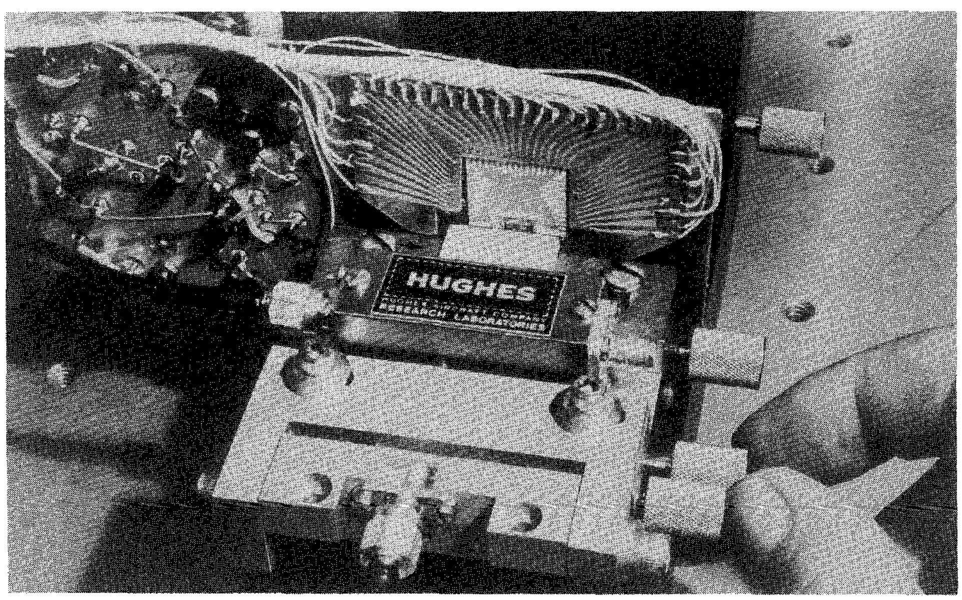

Figure 1. The fully Integrated Optical Spectrum Analyzer.

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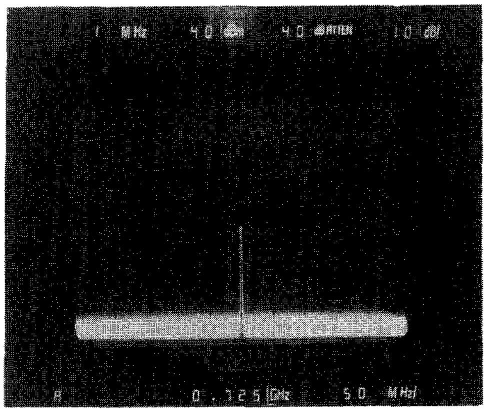
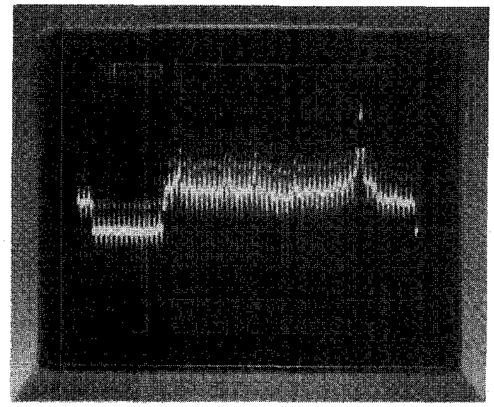


(a)

Figure 2-a. RF spectrum analyzer trace of the signal used to drive the SAW transducer.



(b)

Figure 2-b. Oscilloscope trace of the 100 detector/CCD array output of the IOSA with the signal in 2-a applied to the SAW transducer.
Horz: 56 MHz/Div. or 4 MHz/pixel
Vert: 50 mV/Div.

This work supported in part by Air Force Avionics Laboratory under Contract No. F33615-78-C-1450.