

Optically-Controlled Serially-Fed Phased Array Antenna Systems

David A. Cohen and A. F. J. Levi

Department of Electrical Engineering
University of Southern California

Yian Chang, Boris Tsap and Harold R. Fetterman

Department of Electrical Engineering
University of California, Los Angeles

Irwin Newberg

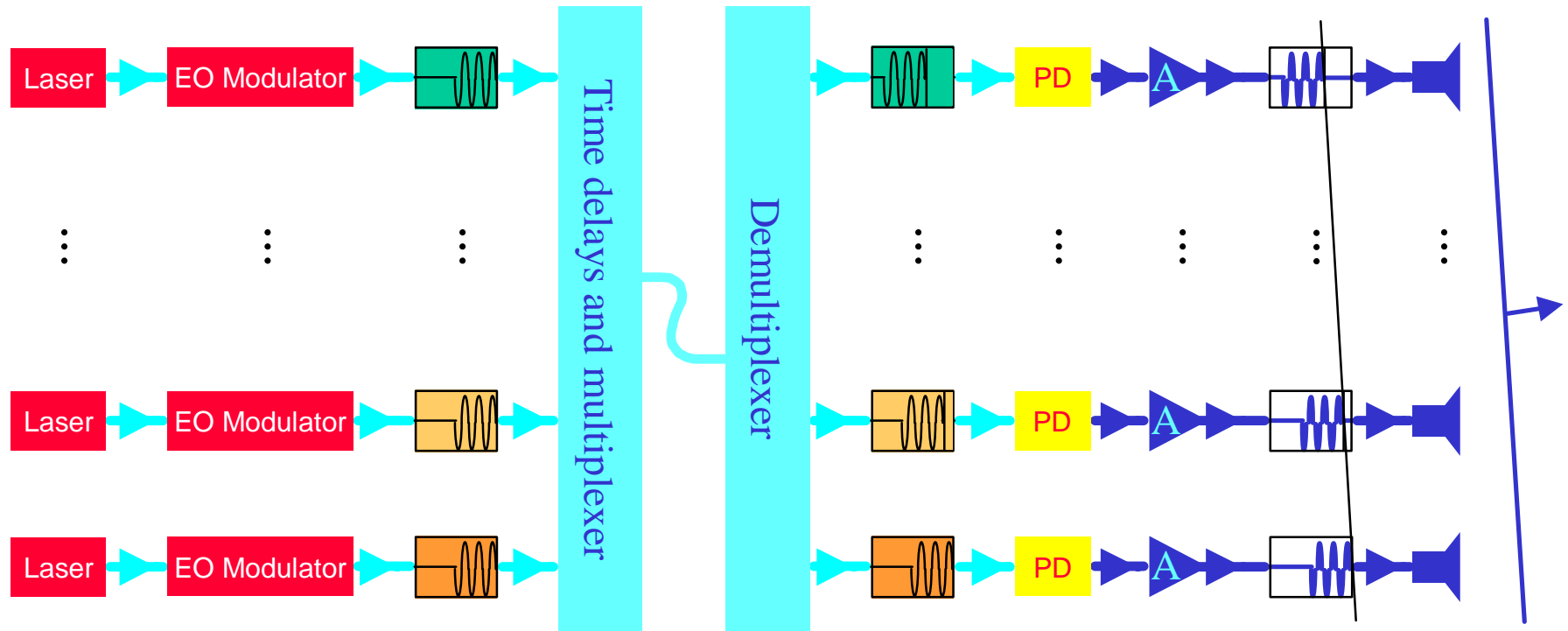
Radar and Communication Systems
Hughes Aircraft Company

Outline of Presentation

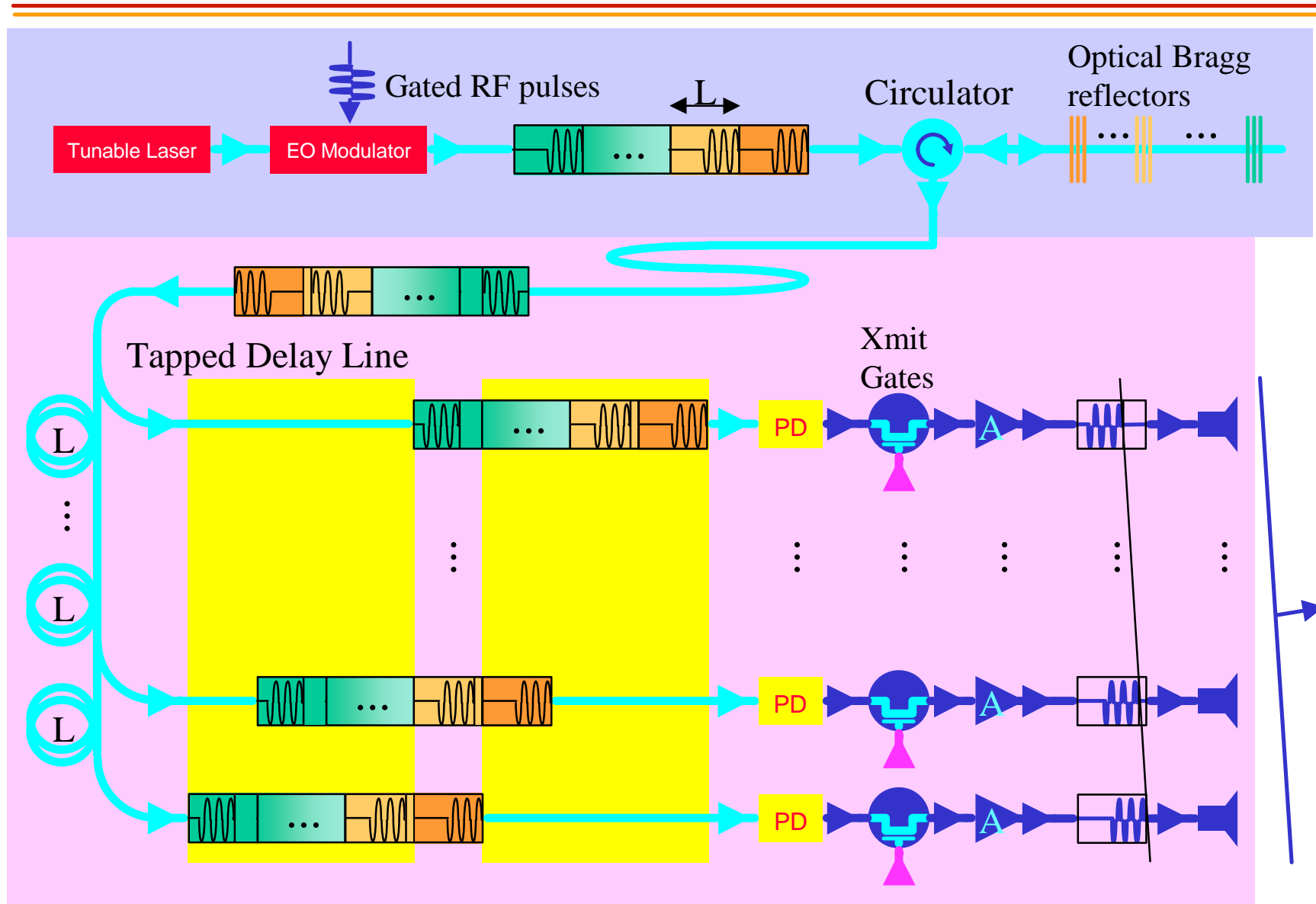
- Introduction
- Serial-feed transmitter concept
- Transmit mode experiment
- Receiver configuration
- Applications
- Conclusions

Introduction: The Conventional Parallel Feed Approach

- Phased arrays: electronic beam steering
- True time delays: wide instantaneous bandwidth, squint-free operation
- Conventional approach: parallel-feed



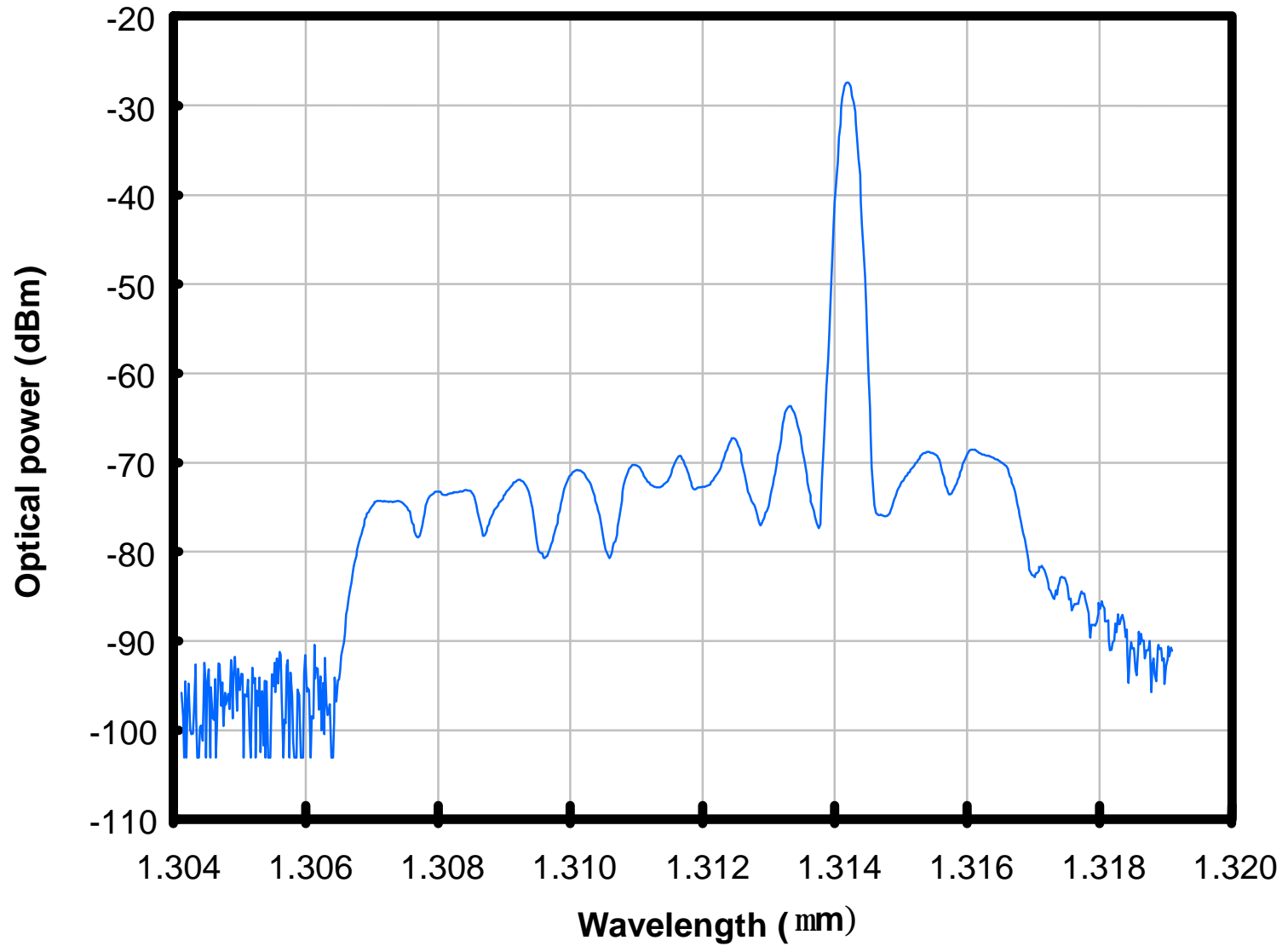
The Serial-feed Transmitter Approach



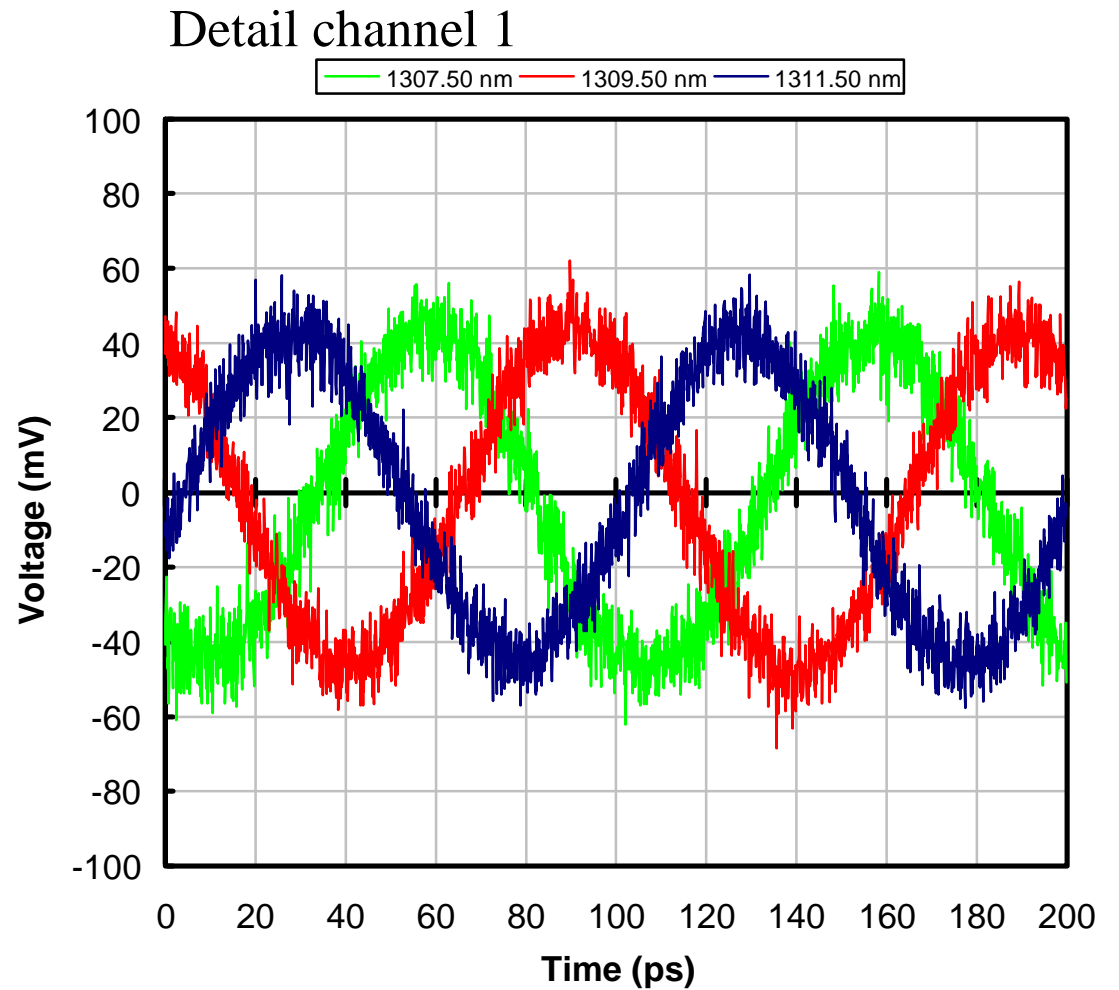
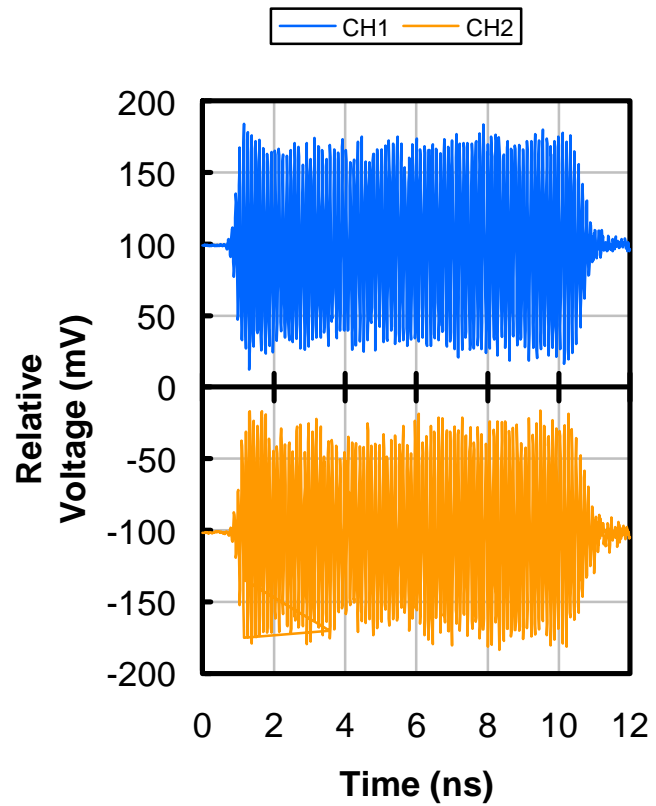
Advantages of Serial-feed Optically Controlled Antenna Systems

- Minimum number of optical components:
 - One laser, one EO modulator, one delay element controls sub-array.
- True time delays:
 - Broadband, multi-frequency operation.
- Fully programmable at a remote source:
 - Form any wave-front by programming amplitude and time delay for each element.
 - Dynamic focusing and targeting.
 - 2D beam steering.

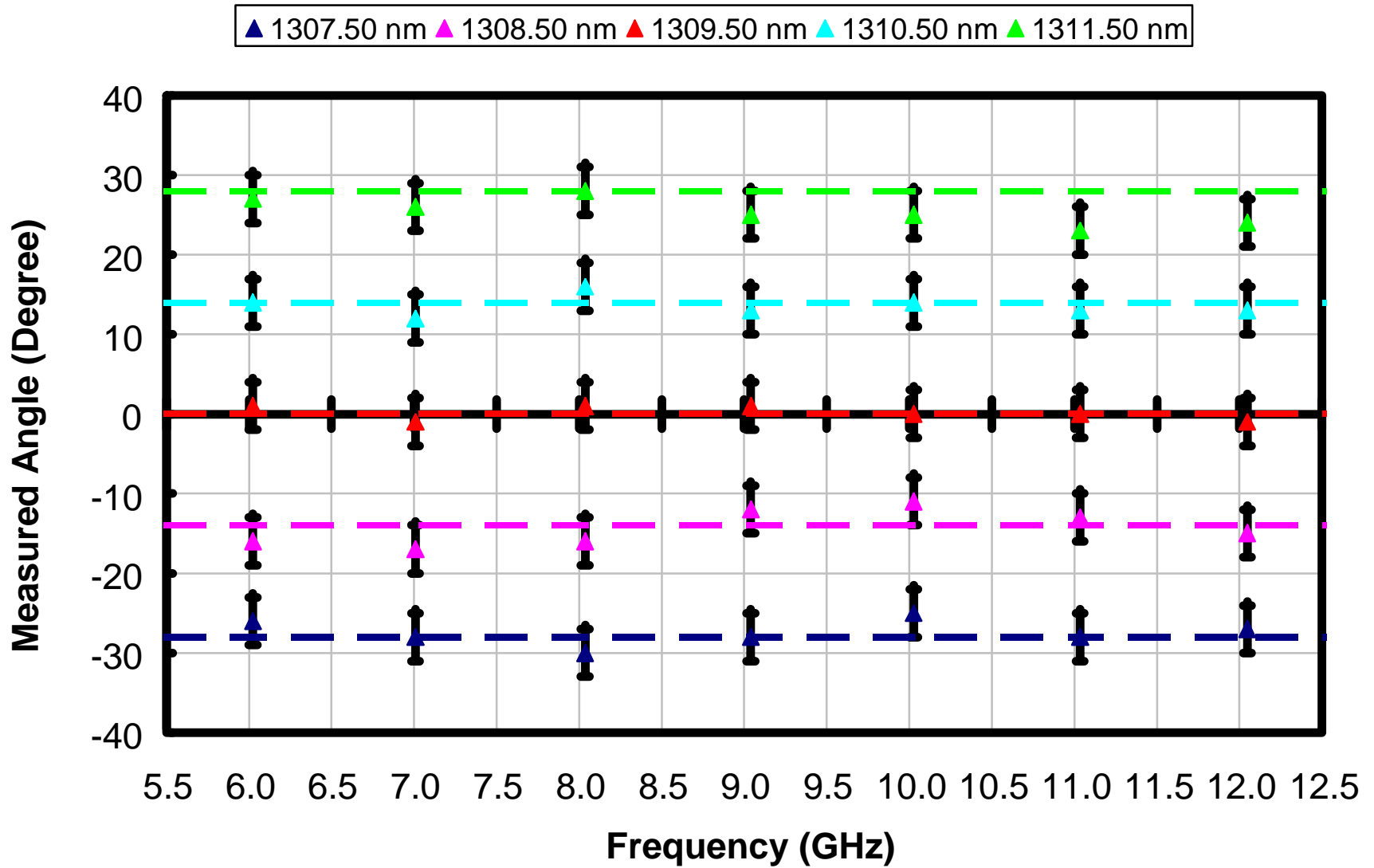
Reflection Spectrum of a Fiber Grating



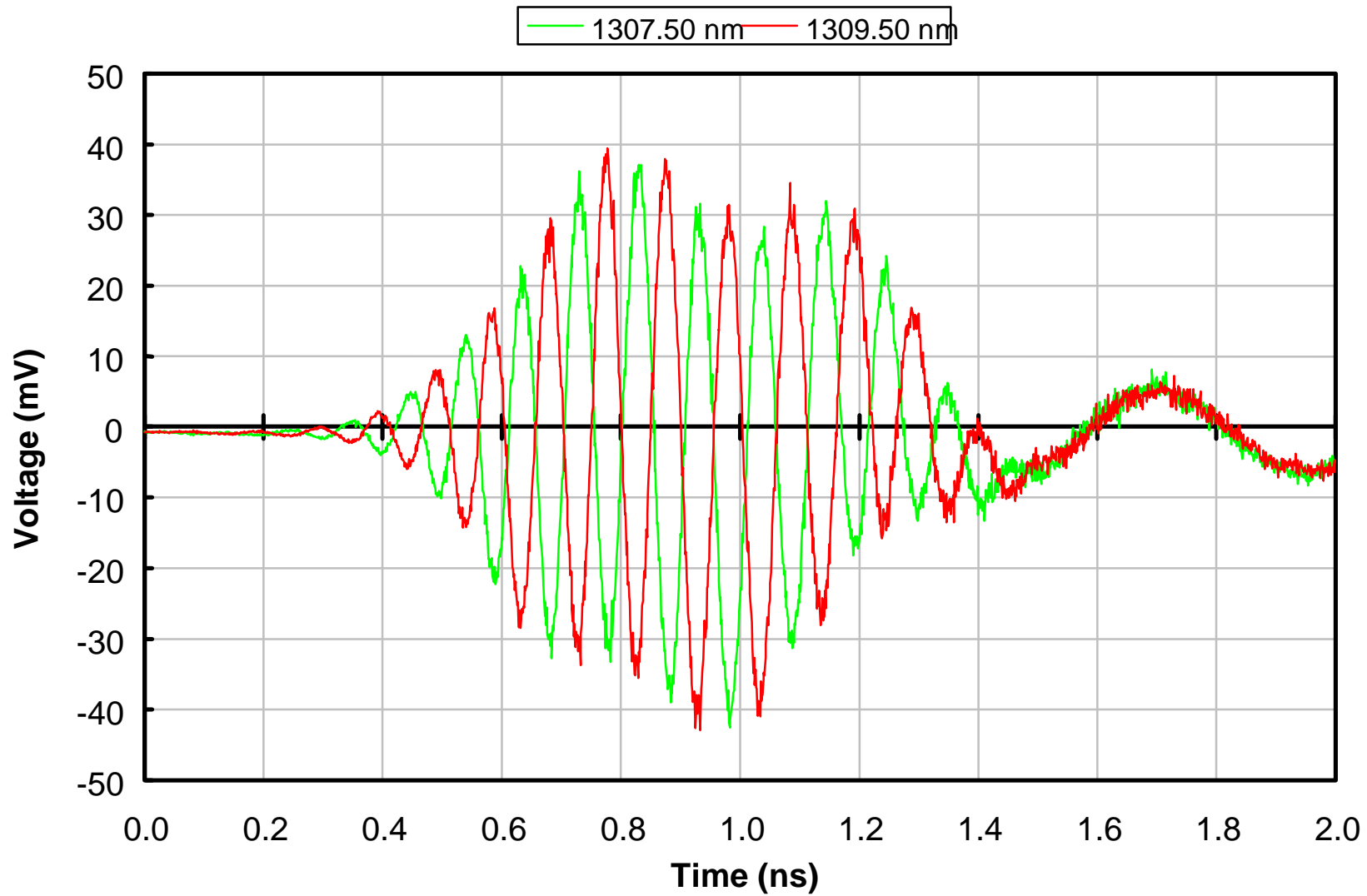
True-time Delay vs. Optical Wavelength



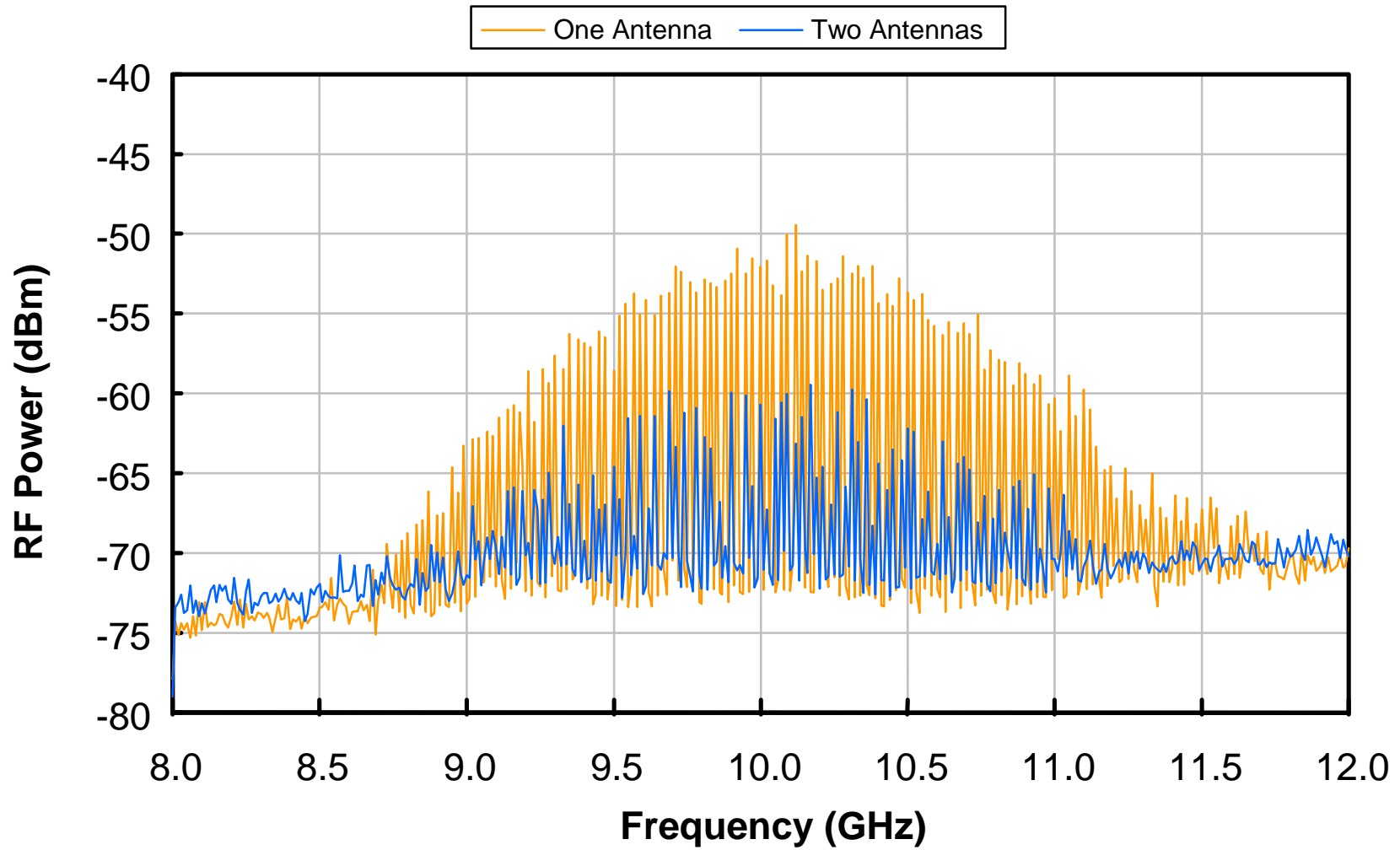
Transmitted Beam Angle vs. RF



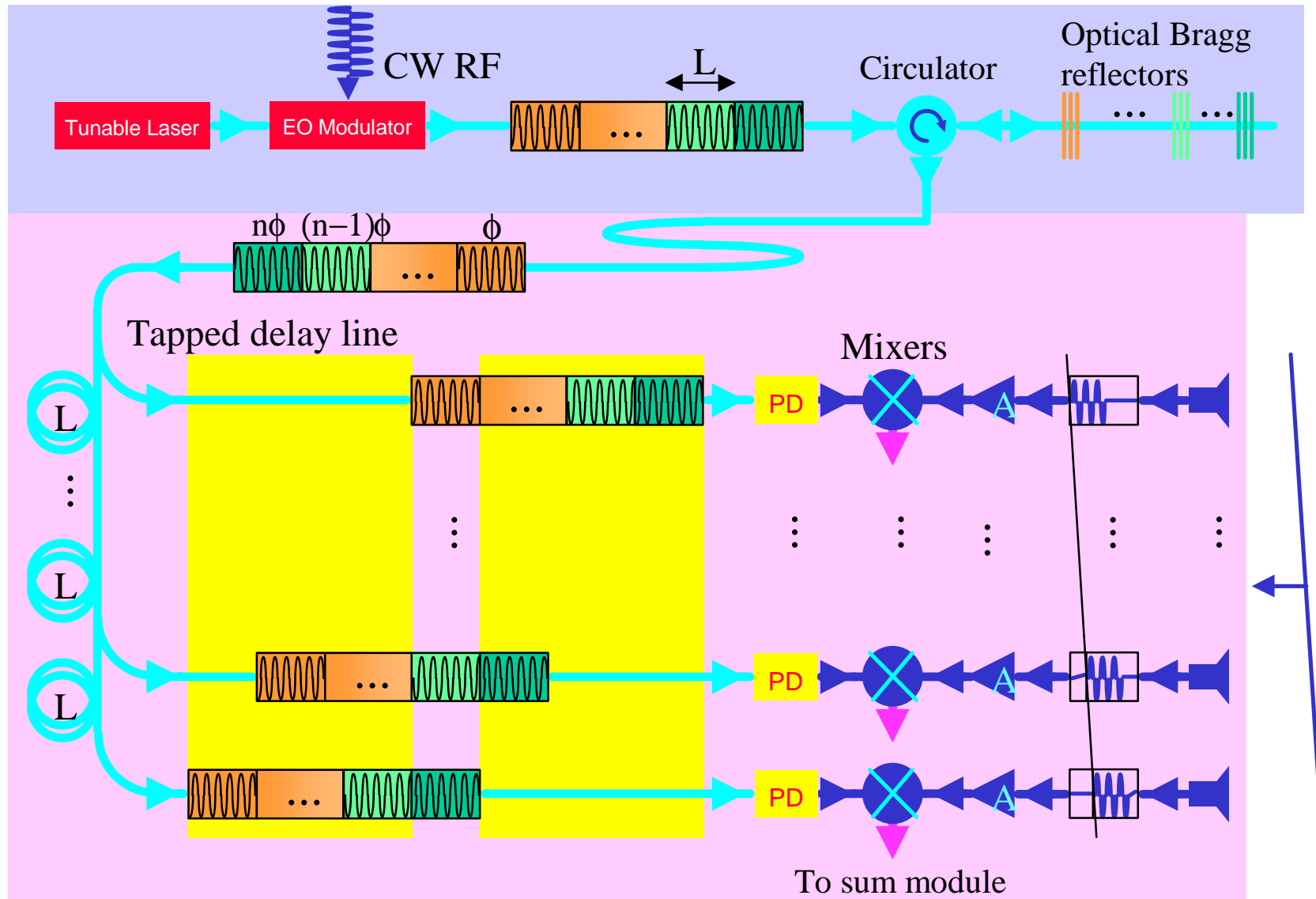
Broadband Radiation with 1 ns Pulses and True-time Delay



RF Spectra of Broadband Radiation



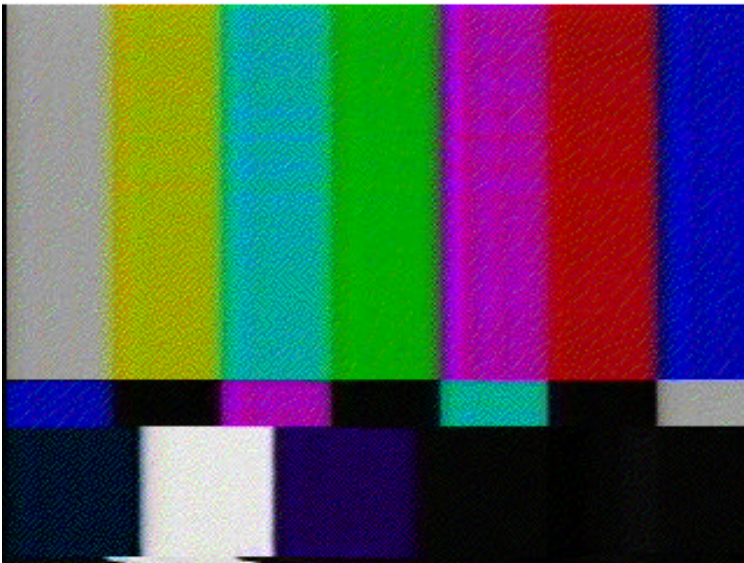
The Serial-feed Receiver Approach



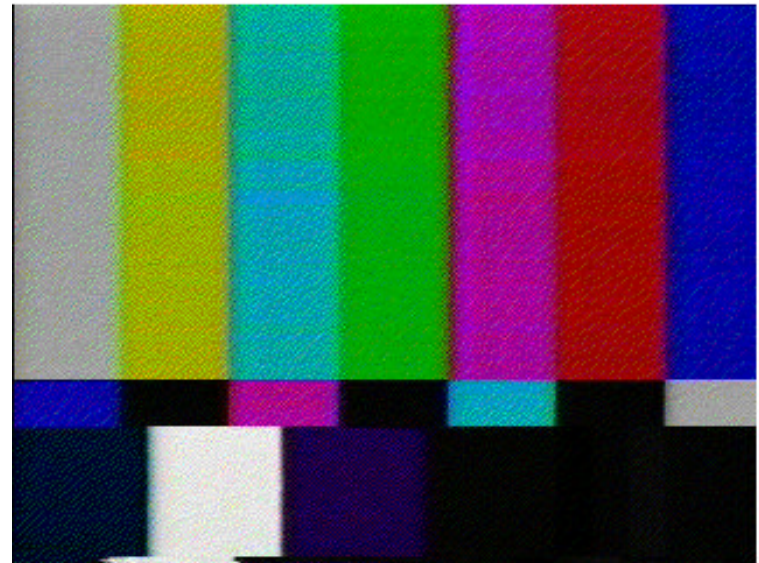
Applications

- Phased array antenna for radar
- Phased array antenna for communication systems
 - Mobile satellite communications
 - Dynamic or multi-directional transceivers
 - Example: TV signal transmission

Original



Received



Conclusions

- New serial-feed technique to optically control phased array antenna
- Uses only a single wavelength tunable laser, EO modulator, and time delay element
- Provides low cost remote beam steering for phased array antennas
- Concept demonstrated with a 2-element 5-pointing direction transmitter
- Directional analog transmission has also been demonstrated
- **Publications:**
 - Optically-controlled serially-fed phased array sensor, D. Cohen, Y. Chang, A. F. J. Levi, H. Fetterman, and I. Newberg, *IEEE Photonics Technol. Lett.* **8**, 1683-1685 (1996).
 - Video broadcast using an optically-controlled serially-fed phased-array antenna, D. Cohen, A. F. J. Levi, Y. Chang, H. R. Fetterman, and I. Newberg, *Proceedings of the SPIE - The International Society for Optical Engineering, Photonics and Radio Frequency*, Chair/Editor, B. M. Hendrickson, 7-8 August, 1996, Denver, Colorado, Vol. **2844**, pp. 258-268, (1996). (ISBN 0-8194-2232-0).
 - Optically-controlled serially-fed phased array transmitter, Y. Chang, B. Tsap, H. Fetterman, D. A. Cohen, A. F. J. Levi, and I. Newberg, *IEEE Microwave and Guided Wave Lett.* **7**, 69-71 (1997).
 - Phased-array optically controlled receiver using serial feed, B. Tsap, Y. Chang, H. Fetterman, A. F. J. Levi, D. A. Cohen, and I. Newberg, *IEEE Photonics Technol. Lett.* **10**, 267-269 (1998).