



TRW

DARPA / MTO AOSP Program Kickoff Meeting San Diego, CA

OPTICAL ANALOG PROCESSORS FOR EW SYSTEMS (OAPES)

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OAPES Program Objectives

The TRW / UCSD / University of Arizona Optical Sciences Center Team Proposes to Exploit the Ability of Optical Technology to Achieve Revolutionary Advancements in the State of Military EW Systems by Advancing:

- Optically-Based Time-Domain Techniques, Which are a More Natural Fit Than Frequency-Domain Techniques to EW Problems Such as Adaptive Filtering of Unfriendly Jammers, Sliding Window Correlators for Matched Filtering, and Agile Waveform Generation; and**
- High-Resolution RF Spectrum Analysis for Characterization and Identification of Threats Where Subtle Spectral Distinctions Among Various Battlefield Signatures are Important.**



OAPES Program Approach

During the OAPES Program, the TRW / UCSD / UofA Team Will

- **Define the Requirements for Front-End Processing Functions for EW Missions of Interest**
- **Develop Novel Non-Linear Optical-Based Processors That Offer a Revolutionary Processing Paradigm by Translating RF Frequencies from GHz to the THz Range**
- **Develop Photonic Implementation of a Fully Programmable Transversal Filter with the Capability to Satisfy a Wide Range of Mission Requirements**
- **Investigate Sol-Gel Glass Waveguides Incorporating Chromophores as a Potential Material Base to Significantly Enhance the Filter's Performance.**

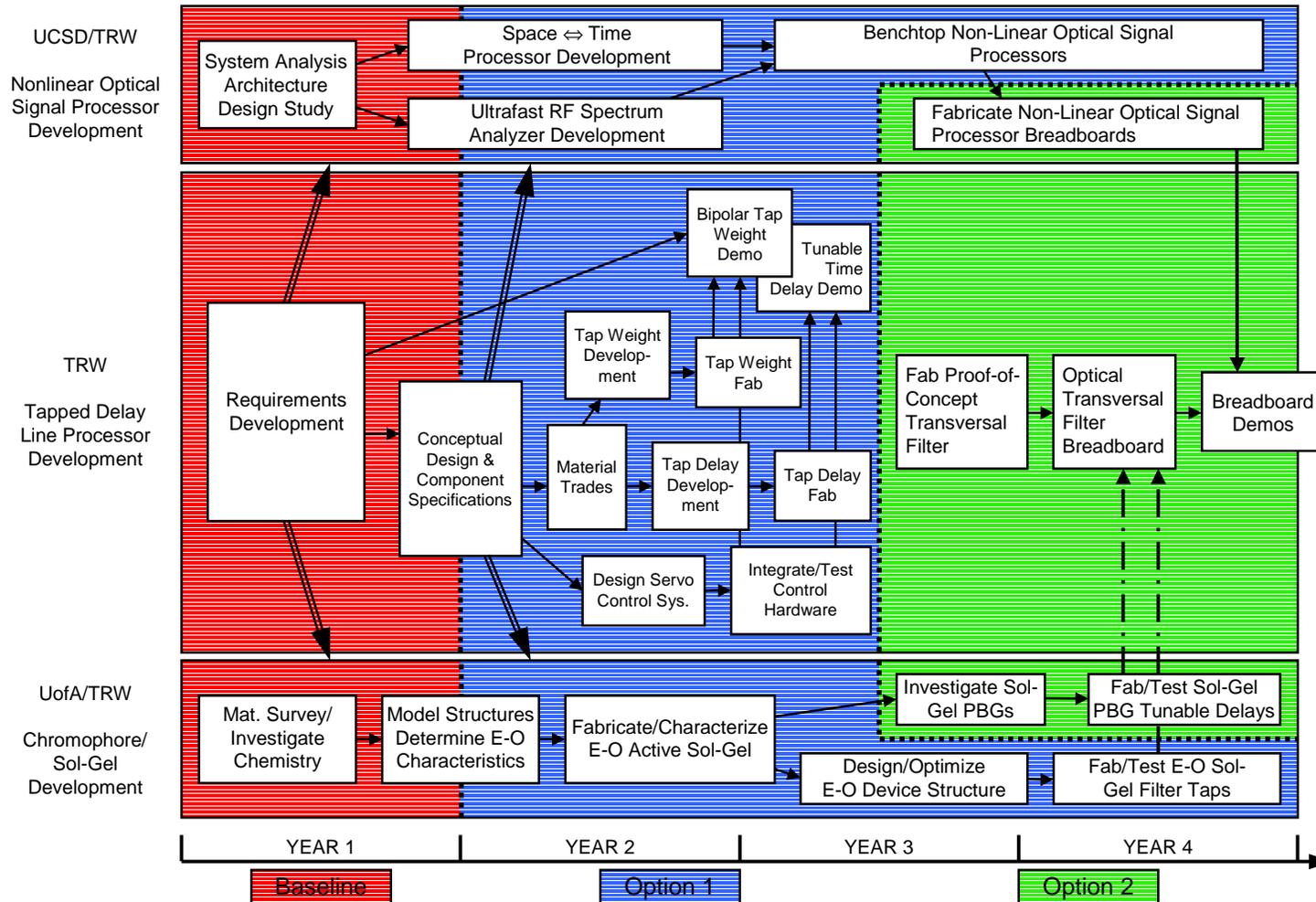


OUTLINE

- **Photonic Transversal Filter**
 - Spatially Addressable True-Time-Delay, Bragg Grating Structures
 - Rapidly Reconfigurable Bipolar Tap Weights
- **High-Speed, Large Space-Bandwidth, Nonlinear Optical Processors**
 - **Ultrafast RF Spectrum Analyzer**
 - 10's of GHz RF Bandwidth, Enhanced Resolution Through Time Compression of Signal
 - **Agile Waveform Generation Using Space to Time Conversion by Femtosecond Pulse Sampling**
 - Ultra-Short Pulses Enable THz Spread Spectrum Waveforms
 - **Wideband, Real-Time Matched Filter Signal Correlation by Time to Space Conversion**
 - Generates a Coherent Spatial Image of the RF Input Signal
- **Chromophore Loaded Sol-Gel Materials**
 - Large E-O Coefficients of Polymers with Enhanced Thermal Stability and Photo-Patternability
 - Electrically Tunable, Photonic Bandgap Delay Lines

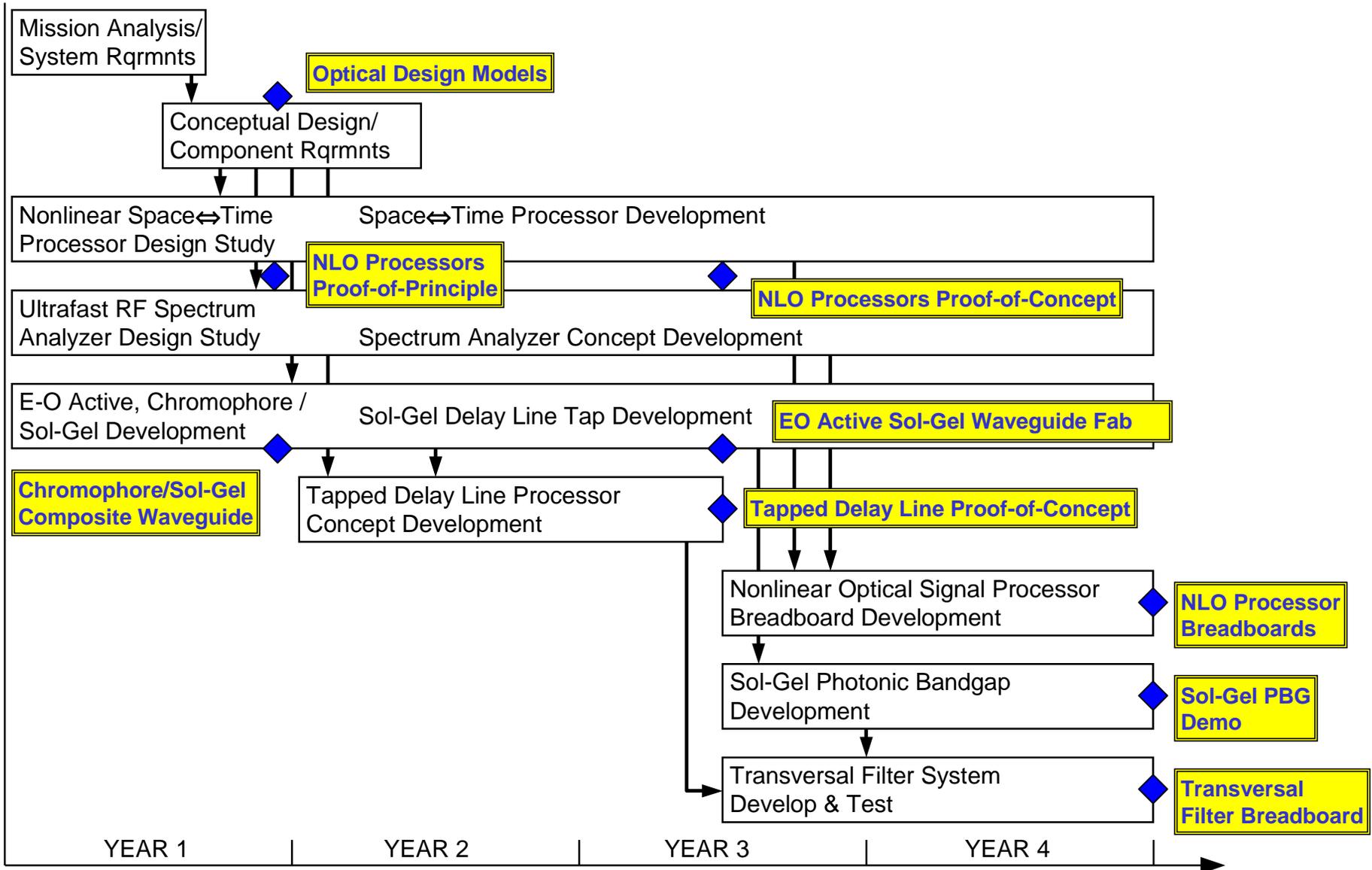


OAPES Program Structure





OAPES Program Roadmap



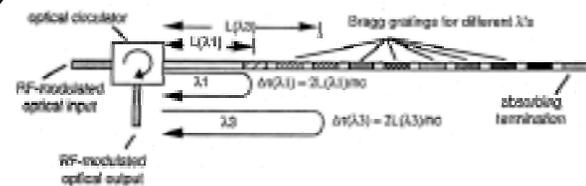


Photonic Time Domain Processing

Mission Need

- Wideband Equalization
- Filtering
- Nulling, multipath cancellation

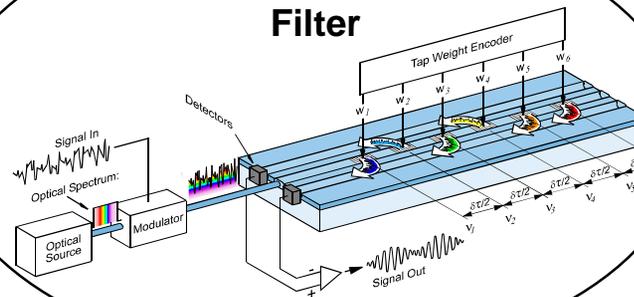
Key Enabling Technology



Optical True Time Delay

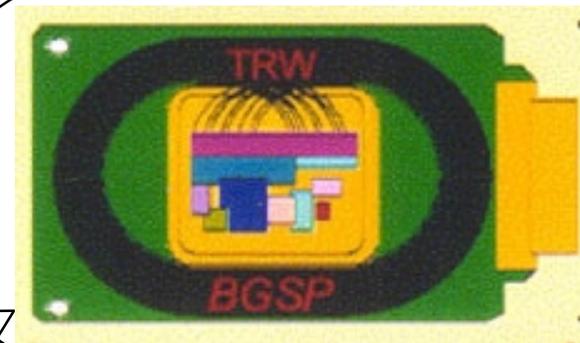
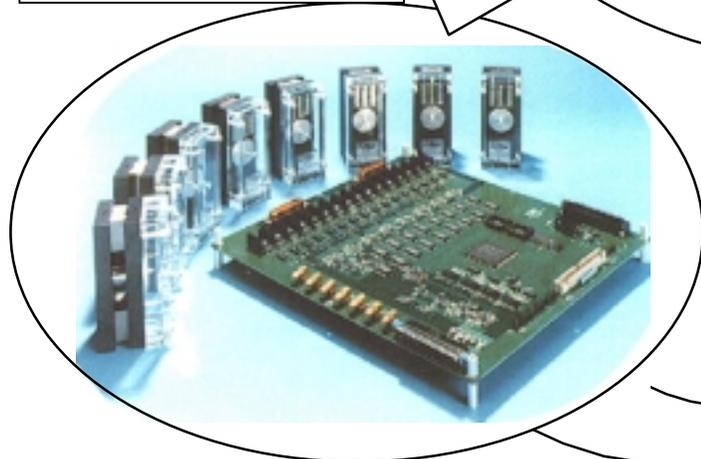
Advanced Processor Architecture

Photonic Transversal Filter



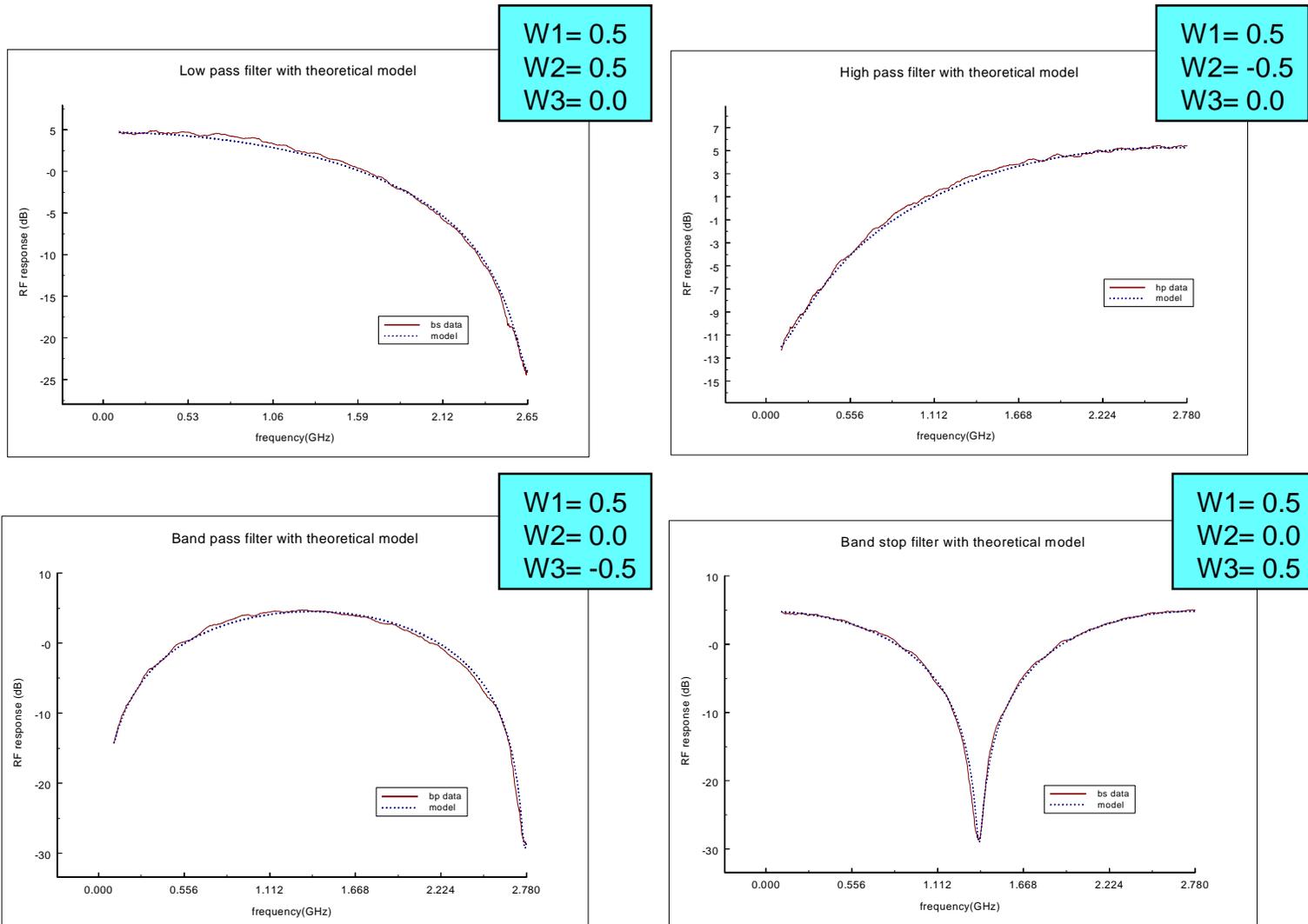
Modular Concept

Proof of Concept Demonstration





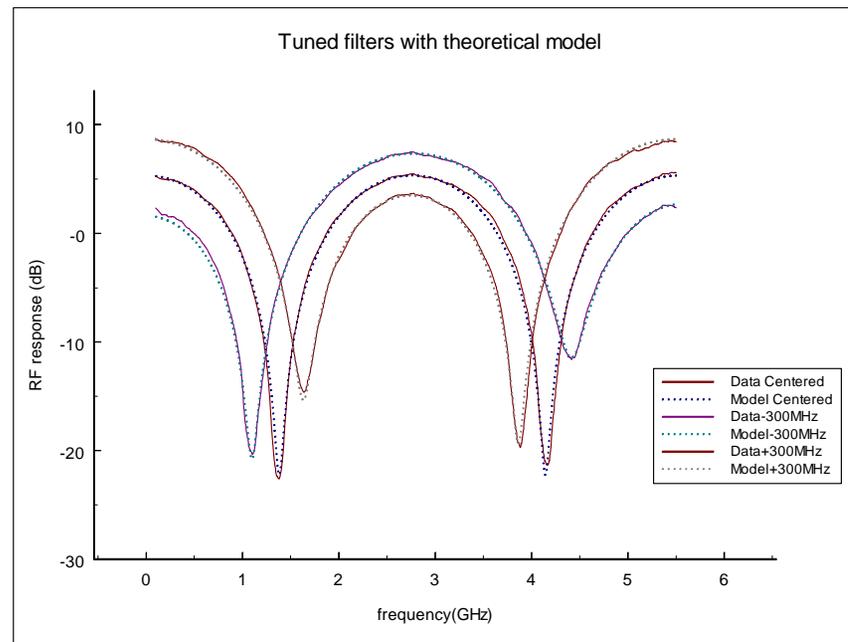
Four Tap Processor Filtering





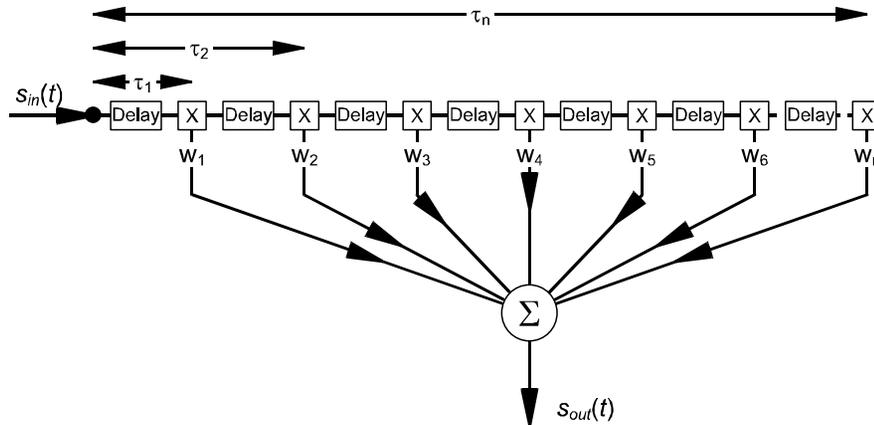
Tunable Filter Characteristics

A Notch Filter Was Tuned Over a Range of Frequencies by Having Taps 1 and 3 Held Constant and Tap 2 Adjusted Over a Range of +/- 10%.



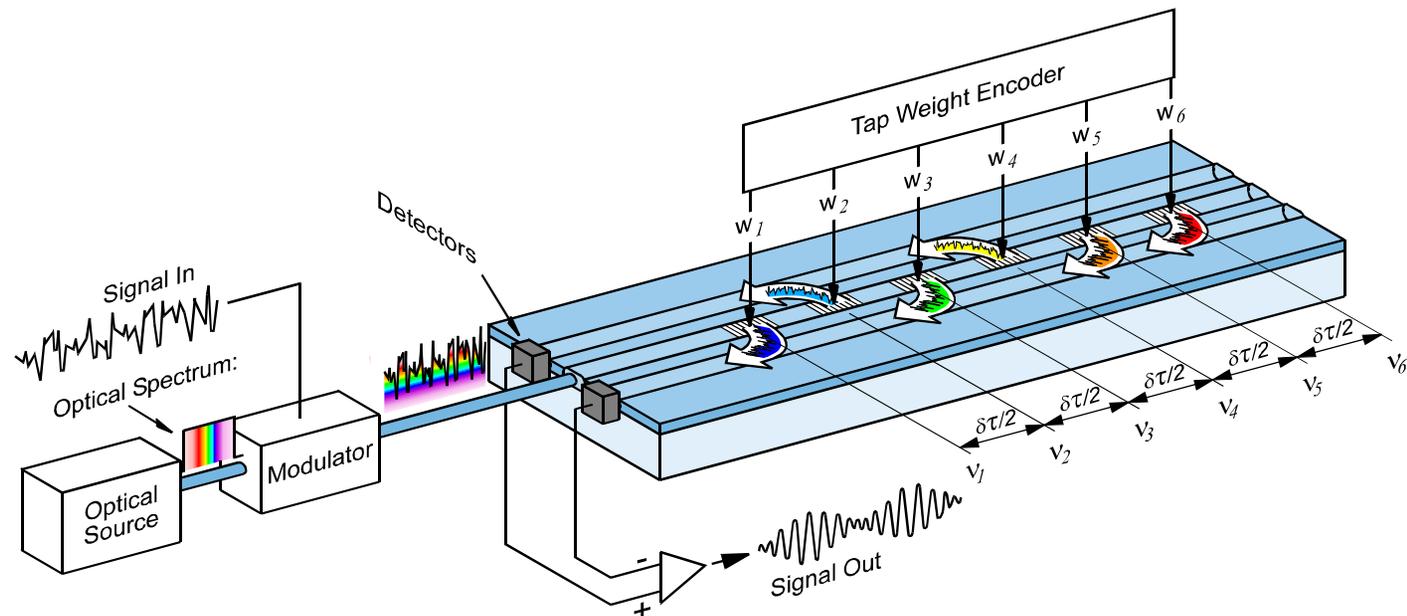


Photonic RF Transversal Filter Concept



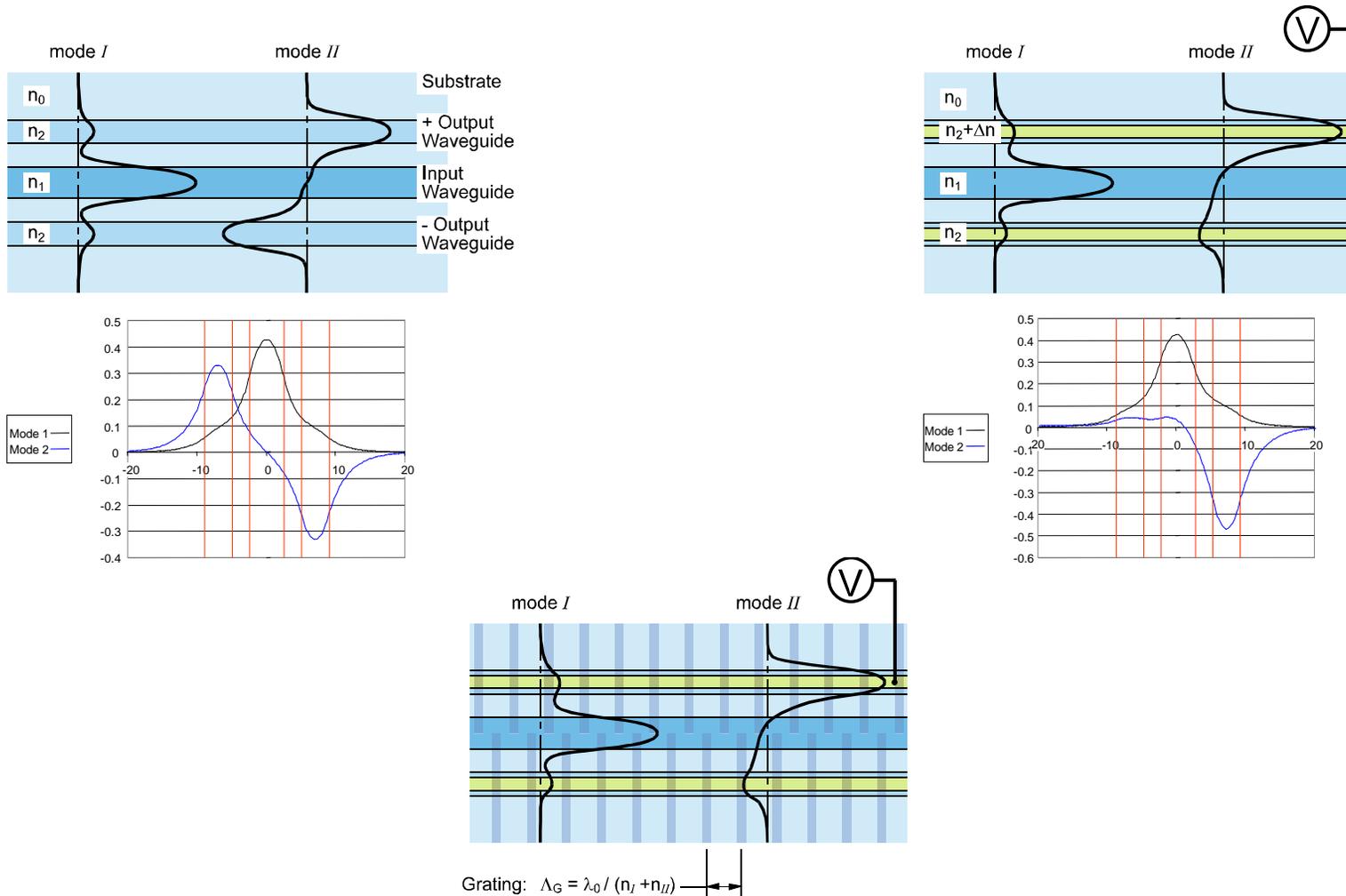
$$s_{out}(t) = \sum_n h(\tau_n) s_{in}(t - \tau_n) \cong \int h(\tau) s_{in}(t - \tau) d\tau$$

A Transversal Filter Provides a Discrete Sum Approximation to a Desired Filter Impulse Response



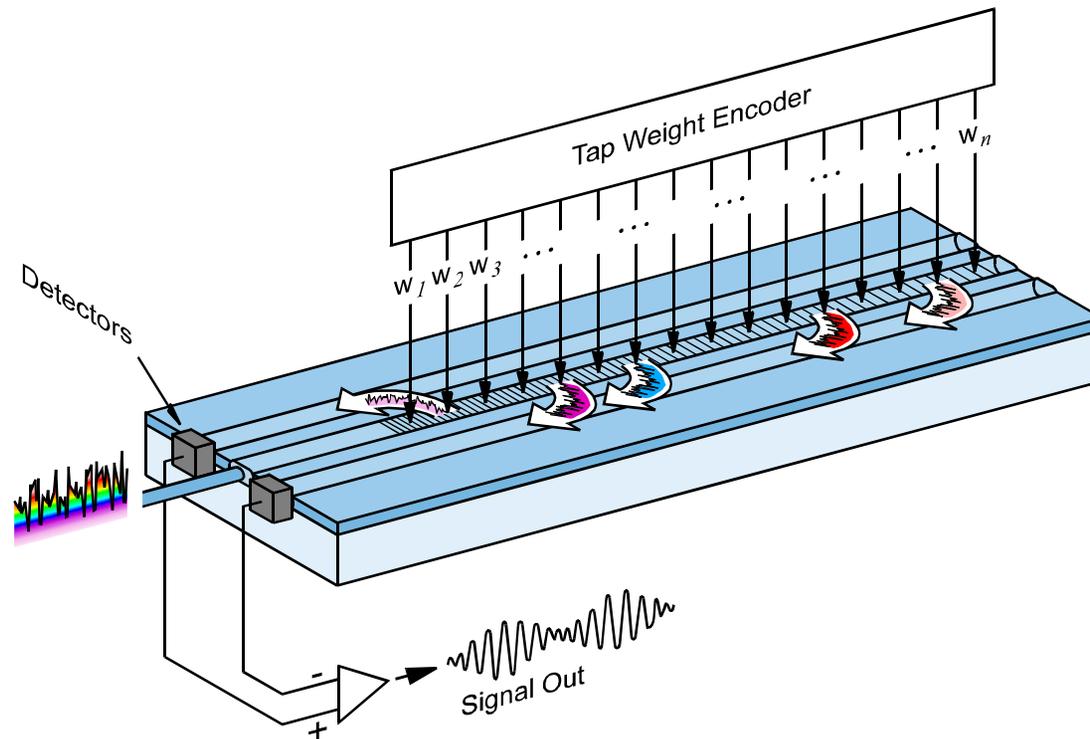


Principle of E-O Cross-Mode Coupler

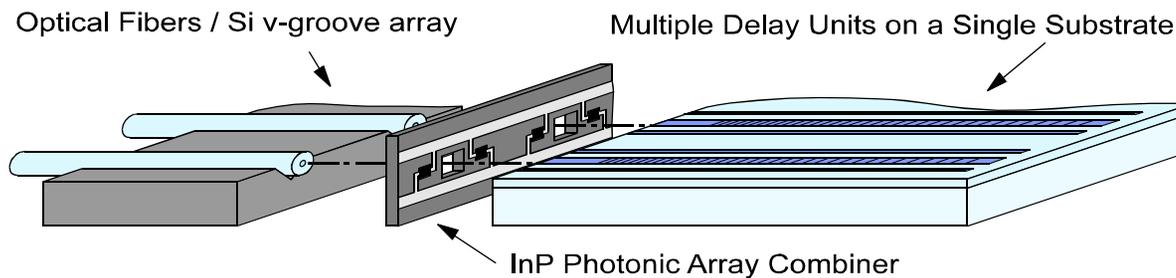
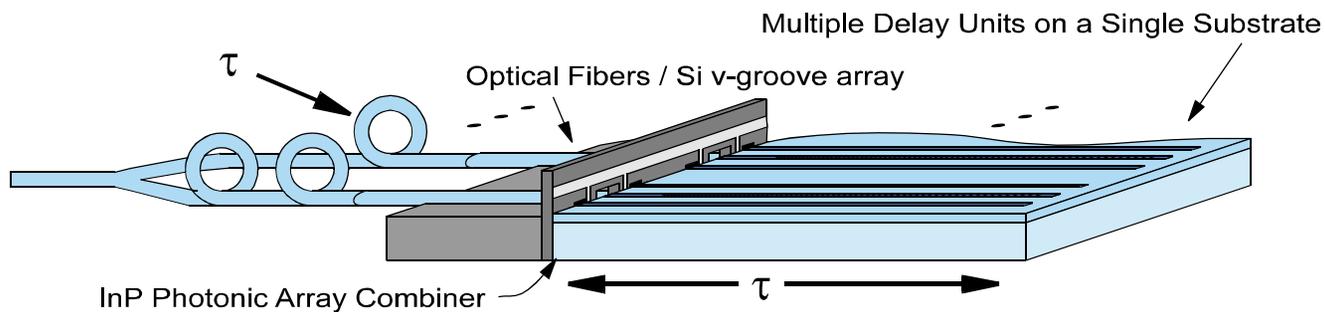




Concept for Producing Arbitrary Variable Tap Delays

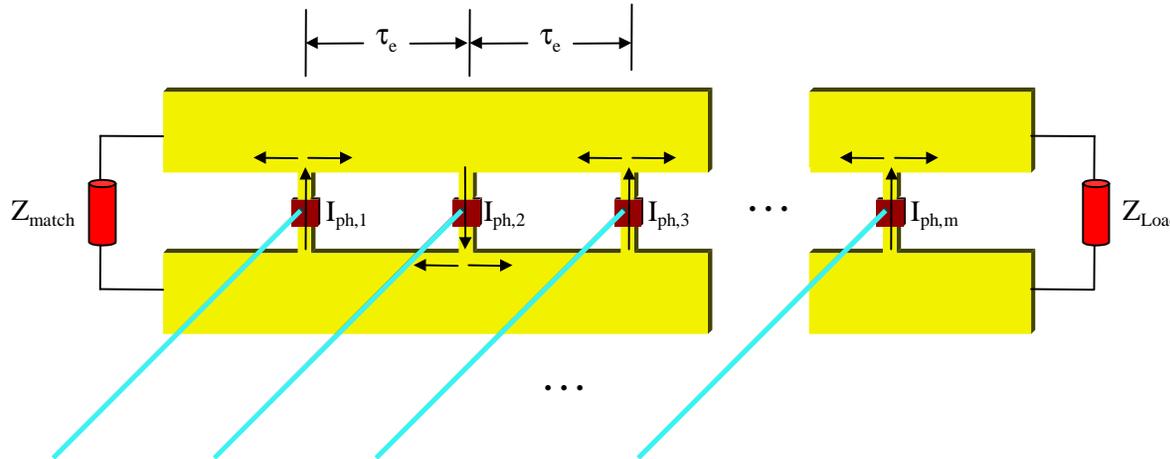


Basic Transversal Filter Approach is Integrable and Scalable to Large Numbers of Taps



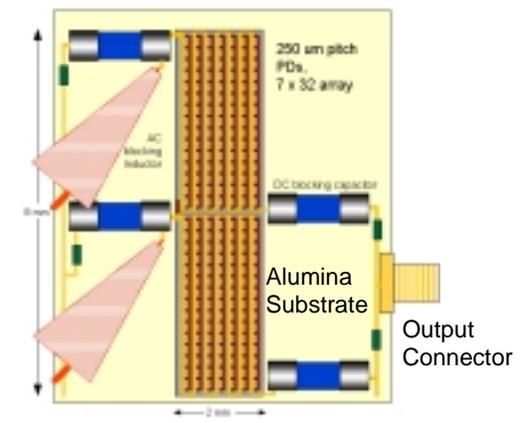
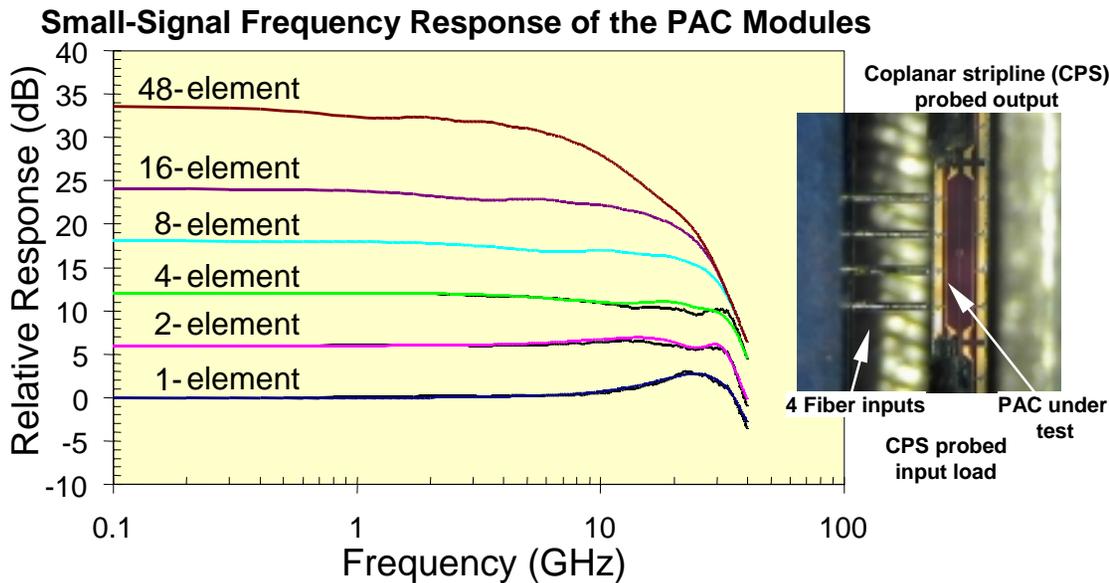


Photonic Array Combiner (PAC) Coherently Sums the RF Signals



$$P_{RFout} = \frac{1}{2} \frac{m^2 n^2 R^2 P_{opt}^2}{4} Z_{Load}$$

PAC Comprises a Serial Array of Photodetectors Periodically Loading a Transmission Line



224 Element Serpentine Array Currently is Under Development at TRW