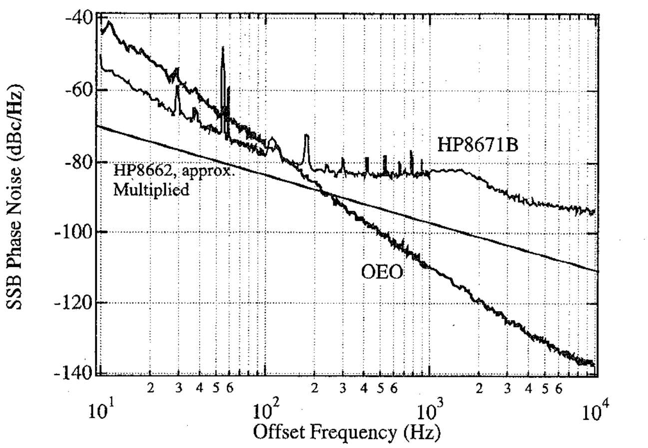

ThT2 **Fig. 3.** The comparison of the measured phase noise of the dual-loop OEO, the measured phase noise of an HP 8617B synthesizer, and the expected phase noise of an HP8662 synthesizer multiplied to 10 GHz.

low phase noise of −140 dBc/Hz at 10 kHz away from the carrier. More than 30 dB close-in phase noise reduction is expected using a novel noise reduction technique. Such a low phase noise oscillator can find wide applications in radar systems, microwave photonic systems, fiber-optic communication systems, and high-speed analog to digital conversion systems.

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ThT3 **4:30pm**

Common transmit/receive module for multiwavelength optically controlled phased array antennas

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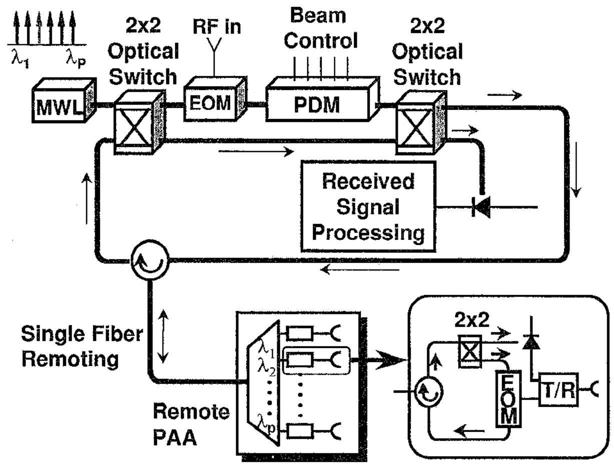
The advance of wavelength-division multiplexins (WDM) photonic technologies has made an impact on recent development of broadband optically controlled phased array antennas.[1–4] For example, we have previously reported a multiwavelength optically controlled phased array antenna (MWOCPAA) transmitter.[4] In this paper, we extend the multiwavelength concept to the MWOCPAA common transmit/receive (T/R) module. The receive mode in MWOCPAA T/R module realizes broadband receiver with true-time delay by optically combining the received signal from multiple optical wavelength carriers.

Figure 1 displays the schematic diagram of the MWOCPAA T/R module. This MWOCPAA T/R module employs a distinctive optical wavelength for each array element. The transmit mode of the module was reported in Ref. 4. The module operates in receive mode when the 2 × 2 optical switches are in CROSS-state. In the receive mode, the optical wavelengths are routed directly to the antenna and demulti-

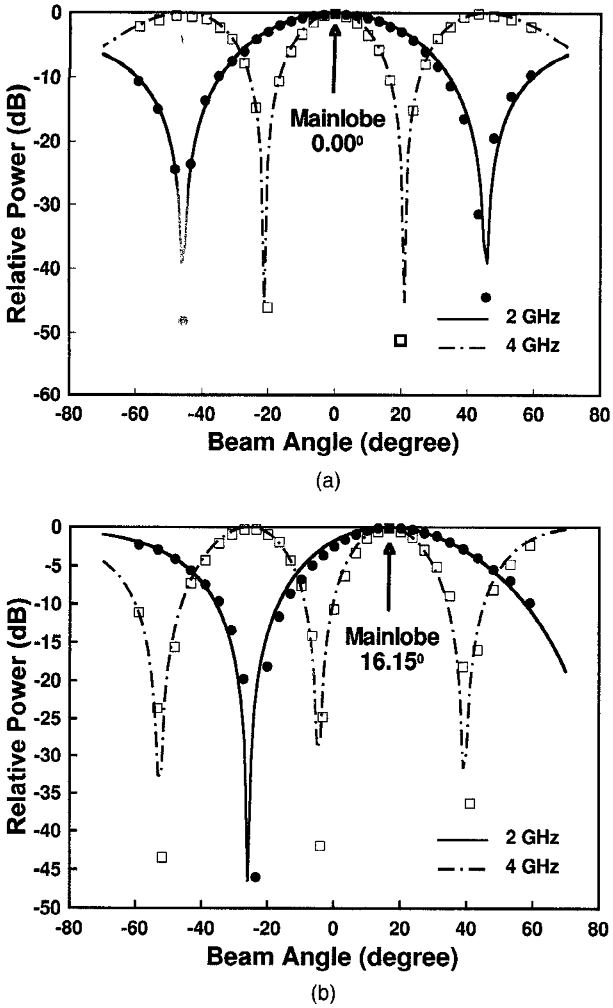


ThT3 **Fig. 1.** Schematic diagram of the MWOCPAA T/R module. The transmit and the receive operation are controlled by the 2 × 2 optical switches.

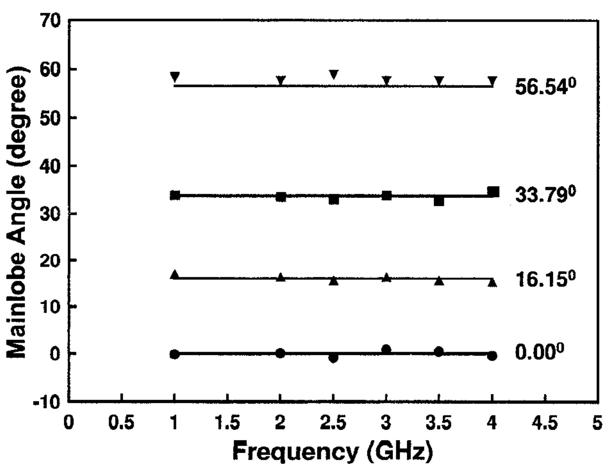
plexed to the array elements by the WDM multiplexer. The optical wavelengths are then modulated by the received microwave signal through the electro-optic modulators (EOM). The modulated optical carriers are then re-multiplexed into one single fiber and fed into the programmable dispersion matrix (PDM). The PDM consists of cascaded 2 × 2 optical switches and dispersive elements such as Bragg fiber gratings. It can generate or offset true time delays among the optical wavelength carriers.[4] The PDM-processed carriers are then optically combined on a photodetector. The received beam angle is determined when the photocurrent is maximized by controlling the time delays among the optical wavelengths created by the PDM. The multiwavelength scheme offers advantages over approaches adopting one tunable single-wavelength carrier because (1) it completely eliminates coherent beating noise, and (2) the WDM multiplexer avoids optical splitting/combining loss.

Experimentally, a two-element prototype array with two-bit scanning resolution is assembled to demonstrate the receive mode of the module. Two wavelengths at 1546.88 and 1547.53 nm are used for the two array elements. Two EOMs are used to modulate the received microwave signal onto the optical wavelengths. First, the PDM is programmed such that no time delay is induced between the two optical wavelengths, the received beam pattern is shown in Fig. 2(a). As expected, the measured beam pattern peaks at broadside and agrees well with the calculation. Figure 2(b) shows the received beam pattern when a time delay of 97.1 ps is generated between the two wavelengths by the PDM. The mainlobe is steered to 16.15°. To demonstrate squint-free beam receiving, the PDM is programmed to steer the mainlobe at 0.00°, 16.15°, 33.79°, and 56.54°. The measured beam angles are independent of the microwave frequency up to 4 GHz and show good agreement with the predicted values, as shown in Fig. 3. The maximum measurable frequency (4 GHz) is limited by the bandwidth of the instrument used in this experiment. In principle, beam receiving over a wide frequency span is possible by optical combining of received beam from different optical wavelength carriers.

In summary, we have proposed a multiwavelength optically controlled phased array antennas transmit/receive module. The receive mode of such module is experimentally demonstrated. Squint-free beam receiving is measured up to a instrument-limited range of 4 GHz.



ThT3 Fig. 2. Measured and calculated beam patterns at 2 and 4 GHz. The mainlobe is located at (a) broadside and (b) 16.15°, when a time delay of 0.00 and 97.1 ps, respectively, is generated between the two optical wavelengths by the PDM.



ThT3 Fig. 3. Beam angle vs. microwave frequency for various PDM settings. Squint-free beam receiving is measured up to 4 GHz.

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ThT4 **4:45pm**

Small ONU module for FM converted multichannel video signal transmission systems

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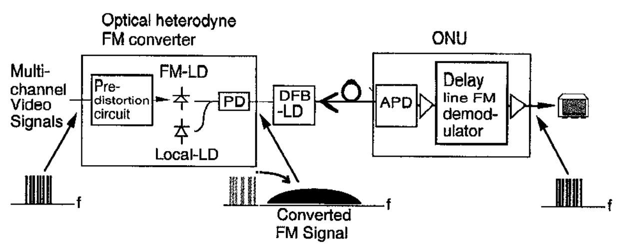
FM converted multichannel video signal transmission systems have a lot of advantages such as large optical power budget and robustness against optical reflection and chromatic dispersion.[1,2] These systems are thus attractive for video signal distribution in access networks, especially for fiber-to-the-home (FTTH). The optical network unit (ONU) must offer low cost, compactness, and low power consumption if the systems are to become practical. To this aim, we have proposed a small ONU module consisting of a superlattice APD and a fully integrated 1-chip Si-IC operating as FM signal demodulator and RF output FDM signal amplifier.

Figure 1 shows the scheme of FM converted multichannel video signal transmission system. In this system, the FM laser is modulated by multichannel video signals and output frequency modulated light. The light from the FM laser is combined with a local laser light and converted into an electrical wideband FM signal. This signal is transmitted by the distributed feedback laser diode (DFB-LD). In the ONU, transmitted signal light is detected by a superlattice APD. The detected wideband FM signal is demodulated into multichannel FDM video signals by a delay-line type FM demodulator.

Figure 2 shows the proposed ONU module. It consists of a superlattice APD and one-chip Si-IC. If the high-speed GaAs-IC is used, the number of amplifier is increased, so the miniaturization of ONU is difficult. Therefore, the silicon bipolar process with $f_T = 40$ GHz transistor was used to fabricate to proposed one-chip Si-IC, which has the linear demodulation range up to 5.5 GHz. Compared with ONU equipment having discrete circuits,[3] it offers lower power consumption and volume. This Si-IC needs only one dc power supply line of -5 V and the power consumption of 1.1 W. The volume of this module is <10 cc. However, the power consumption and volume of ONU with discrete circuits are 6.5 W and 360 cc, respectively. This volume is without the power supply circuit. The output signal level of this module is about 76 dBμV/ch, the impedance is 75 Ω, and can be directly connected to



ThT4 Fig. 1. FM converted multichannel video signal transmission system.