THz Optoelectronic 2-D Beam Steering Transmitter for Short-Range Communications

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Abstract

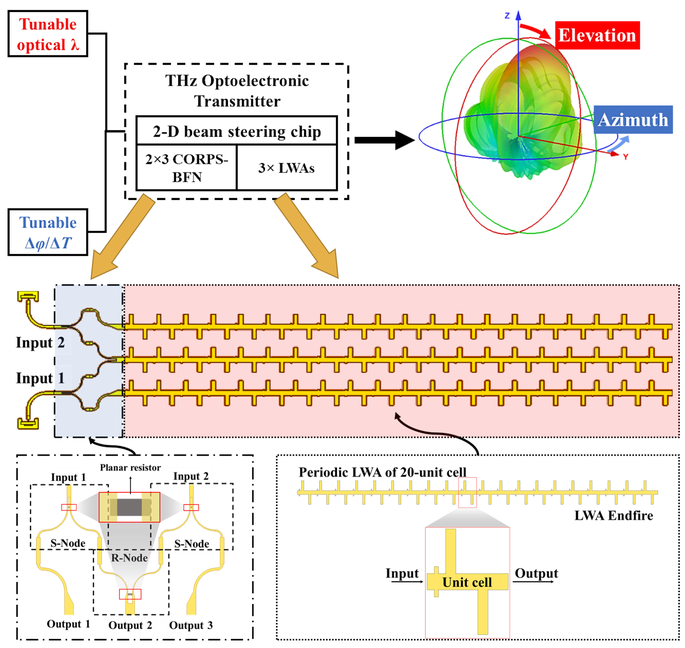
A **THz optoelectronic** beam steering transmitter for future **THz mobile** and **multi-static-users communications** is fabricated. The transmitter of two UTC-PD modules and an InP-based 2-D beam steering chip, which utilizes an array of three LWAs and a CORPS-BFN. The aim is to do **2-D beam steering** using only **two tuning elements**. Experimentally, by sweeping the frequency between 0.26 and 0.32 THz, the beam steers from -12° to +33° in elevation direction, while tuning an ODL between "±0.84" ps changes the azimuth angle between -20° and +19°. Furthermore, data transmission of **2 Gbps over a 15 cm** wireless distance is demonstrated at various angles. For 4-QAM modulation, the BER is below the HD-FEC limit of 3.8×10^{-3} and the highest SNR is 14.84 dB at (El., Az.) of (20°, 5°).

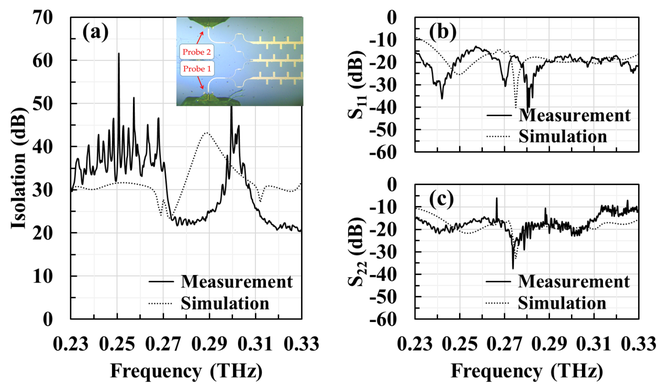
2-D Steering Concept and Chip Integration

- Tuning optical λ/f changes beam's elevation angle (θ)
  - Array of 3 × leaky-wave antennas
- Tuning optical delay line changes beam's azimuth angle (ϕ)
  - Coherently radiating periodic structures beamforming network (CORPS-BFN)

$$\theta(f,\Delta T) = \sin^{-1}\left(\sqrt{\left(\frac{\beta_{\mathrm{uc}}}{k}\right)^2 + \left(\frac{\pi \cdot f \cdot \Delta T}{k \cdot d_{\mathrm{ant\_sep}}}\right)^2}\right)$$

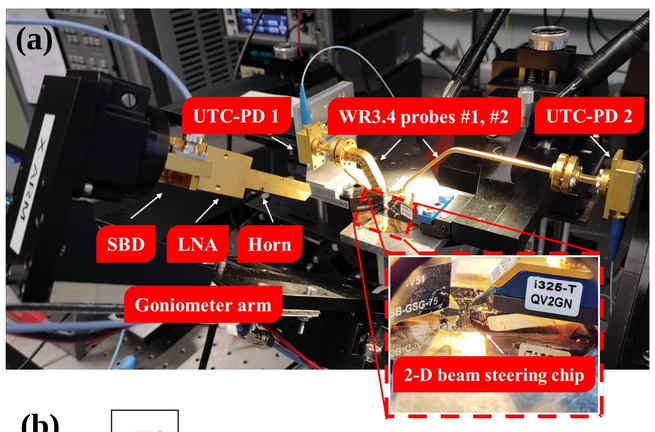
$$\phi(f,\Delta T) = \tan^{-1}\left(\frac{\pi \cdot f \cdot \Delta T}{\beta_{\mathrm{uc}} \cdot d_{\mathrm{ant\_sep}}}\right)$$

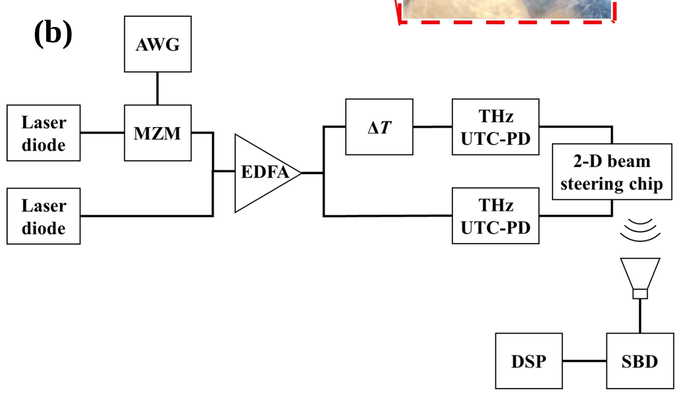




S-parameters of the integrated chip, (a) isolation between port #1 and port #2, (b) and (c) reflection coefficients at the inputs.

Experimental Results





(a) Optoelectronic THz transmitter and receiver, (b) THz communication setup

2-D Beam Steering Capabilities

- Maximum steering range is 92° and 69.18° in elevation and azimuth
- Experimentally demonstrated at nine angles
  - Distance between transmitter and receiver is 15 cm

Short-range THz communications

- BER of HD-FEC below 3.8×10^{-3}
- Maximum SNR = 14.84 dB
- Data rate = 2 Gbps
  - Symbol rate 1 Gbaud
  - 4 QAM modulation scheme

Elevation	Azimuth: ϕ = 0°, ΔT = 0 ps	ϕ = 5°, ΔT = 0.6 ps	ϕ = 10°, ΔT = 1.2 ps
θ = 10°, f = 290 GHz	SNR = 9.85 dB, BER = 2.2 E-3	SNR = 13.39 dB, BER = 4.05 E-4	SNR = 13.74 dB, BER = 5.79 E-5
θ = 20°, f = 300 GHz	SNR = 14.49 dB, BER = 1.74 E-4	SNR = 14.84 dB, BER < E-6	SNR = 11.38 dB, BER = 1.74 E-4
θ = 30°, f = 310 GHz	SNR = 10.74 dB, BER = 9.26 E-4	SNR = 11.84 dB, BER = 2.31 E-4	SNR = 9.13 dB, BER = 1.74 E-3

Table 1: Characterized constellation diagrams at different (θ, ϕ)

Literatures:

[1] T. Haddad *et al.*, "Photonic-assisted 2-D Terahertz Beam Steering Enabled by a LWA Array Monolithically Integrated with a BFN," *Optics Express,* vol. 30, no. 21, pp. 38596-38612, 2022.

[2] C. Biurrun-Quel *et al.*, "Design and Characterization of Terahertz CORPS Beam Forming Networks," *Journal of Infrared, Millimeter, and Terahertz Waves,* vol. 44, pp. 431-457, 2023.

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