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TERA OPTICS

Cascaded wideband R-o-F links with LWA for enabling mobile 5G base stations

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Motivation

Often, railway communications suffers from connection interruptions due to hard handover process between base transceiver stations (BTS) or simply because of poor coverage. In order to overcome these issues, we propose mounting the BTS on the train and providing backhaul connectivity using a cascaded R-o-F and Leaky-Wave Antenna (LWA) system.

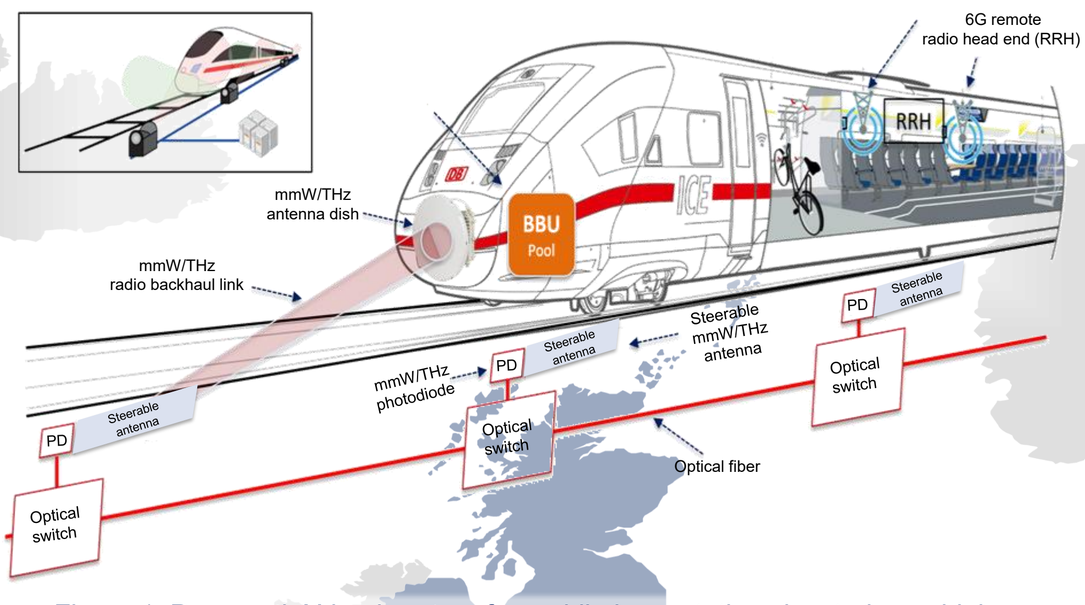

Figure 1. Proposed X-haul system for mobile base stations located on a high-speed-train utilizing a cascaded R-o-F and leaky-wave antennas

3D Localization

- Optical switches are utilized to enable the necessary node which requires tracking of the train
- LWAs are also capable of tracking objects in a joint communication-sensing (JCS) approach
- For 3D localization, two linearly polarized LWAs for azimuth and elevation are used
- FMCW is employed for radar operation in addition to LWA beam steering for target angle estimation
- The LWAs provide beam steering from -20.7º to +18º in the range of 24-33 GHz in the H-plane and -18.9º to +33.3º in the E-plane
- A ranging accuracy of better than 4 cm and an angular accuracy of ~ 0.5º [3]

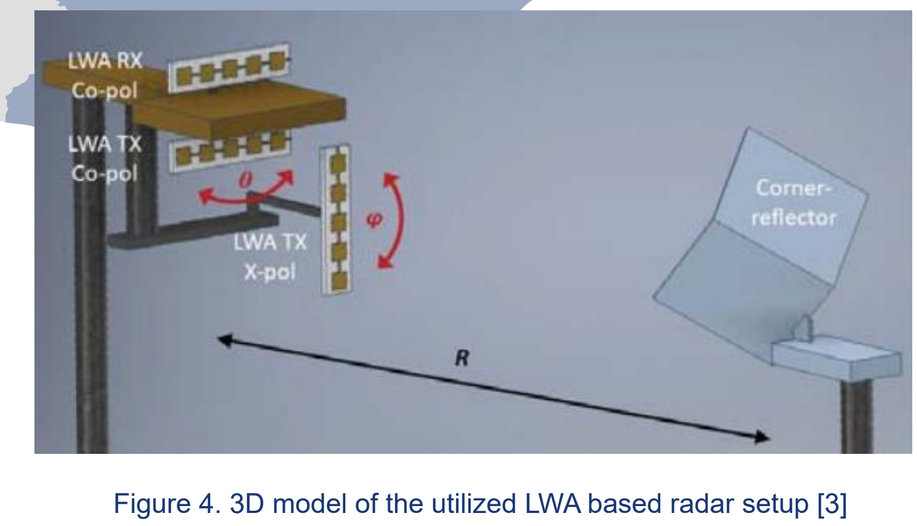

Figure 4. 3D model of the utilized LWA based radar setup [3]

X-haul Concept

In this approach, the RF signals are modulated onto optical signals using an Electro-absorption Modulated Laser (EML) and then the modulated RF signals are transmitted over optical fiber (R-o-F) which are deployed along the railway track. Subsequently, RF signals are recovered using a photodiode (PD) and radiated to the train via a low-cost LWA.

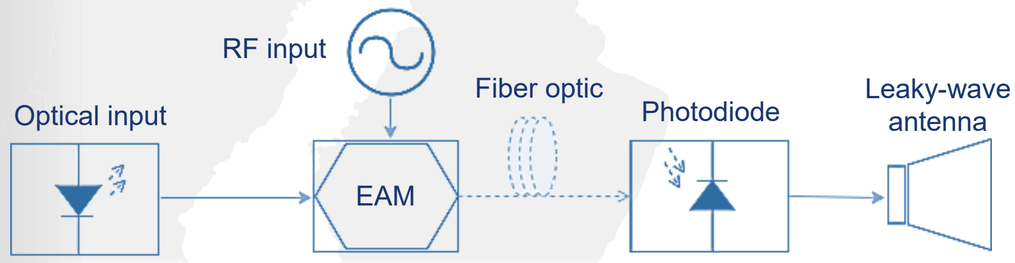

Figure 2. Block diagram of the proposed cascaded R-o-F and leaky-wave antenna system

LWA Communications

- mm-wave (V-band) operation is foreseen
- The designed LWA yields:
  - a steering angle of 40º in the H-plane
  - a peak gain of 15.4 dBi
  - a gain flatness of 1.5 dB
- In multi-user 60 GHz hot-spot scenario, data rate of up to 2.5 Gbps per user is achieved [1].

The concept for the monolithic integration of the LWA proposed by UDE OE Department is shown in Figure 3.

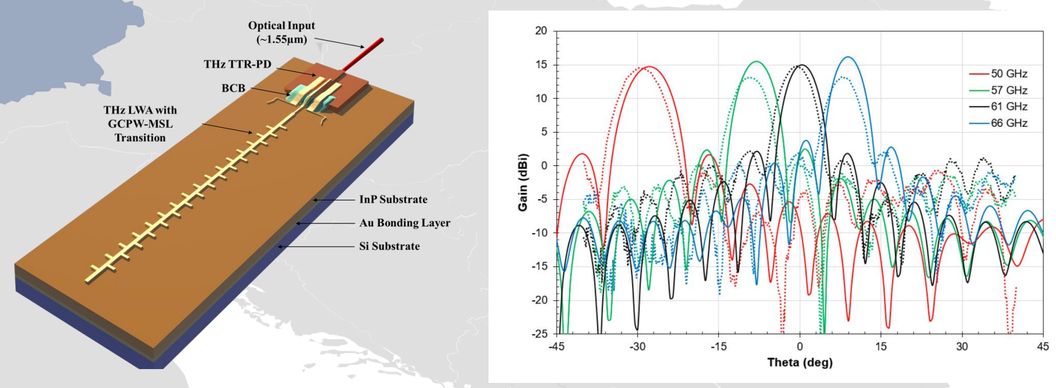

Figure 3. On the right-hand side, the beam steering capabilities in H-plane are depicted for the fabricated V-band LWA [1]. On the left-hand side, the concept of monolithic integration of LWA and PD offering a compact device with beam steering by photonics means is shown [2].

Future Work

- System specifications for realistic distances and steering angles
- Communication protocol analysis considering modem locking time
- Fabrication of the proposed monolithic integrated LWA with the required system's specifications

References

[1] Steeg, M.; Yonemoto, N.; Tebart, J.; Stöhr, A. Substrate-Integrated Waveguide PCB Leaky-Wave Antenna Design Providing Multiple Steerable Beams in the V-Band. Electronics 2017, 6, 107.

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[3] M. Steeg, J. Tebart, K. Neophytou, M. A. Antoniades, S. Iezekiel and A. Stöhr, "3D Radar Localization via Photonic Chirp Leaky-Wave Antenna Beam Scanning," 2019 International Topical Meeting on Microwave Photonics (MWP), 2019, pp. 1-4.

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