THz Point-to-Point Links:

>100 GHz; >100 Gbps

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Contents

• Background
• Spectrum Horizon
• Challenges
• Ex. D-band research and development
• Some future perspective
Global mobile traffic growth (based on measurement):
Transport networks

Evolving in:

• Network dimensioning, architecture and topology
• Capacity
## Future transport needs

<table>
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<tr>
<th>Backhaul capacity per site in Distributed RAN</th>
<th>C2 (eCPRI) capacity in Centralized RAN</th>
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<tr>
<td><strong>2018 Low — high cap sites</strong></td>
<td><strong>2022 Low — high cap sites</strong></td>
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<tr>
<td>Urban</td>
<td><strong>2025 Low — high cap sites</strong></td>
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<tr>
<td>150 Mbps — 1 Gbps</td>
<td>Massive MIMO (1 sector)</td>
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<tr>
<td>100 Mbps — 350 Mbps</td>
<td>10 — 15 Gbps</td>
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<tr>
<td>50 Mbps — 150 Mbps</td>
<td>Massive MIMO (3 sector)</td>
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<td>450 Mbps — 10 Gbps</td>
<td>15 — 25 Gbps</td>
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<td>200 Mbps — 2 Gbps</td>
<td>25 — 40 Gbps</td>
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<td>75 Mbps — 350 Mbps</td>
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<tr>
<td>100 Mbps — 600 Mbps</td>
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<td><strong>Towards 2025</strong></td>
<td><strong>2025 Low — high cap sites</strong></td>
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<tr>
<td>600 Mbps — 20 Gbps</td>
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<td>300 Mbps — 5 Gbps</td>
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<tr>
<td>100 Mbps — 600 Mbps</td>
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</table>

Source: Ericsson (2018)
Spectrum Horizon

In commercial use

W-band, to be commercialized

D-band, to be commercialized

5G candidate band

5G candidate band but prioritized for backhaul

Microwave backhaul 0–180GHz

0–90GHz (in use today)

WRC–19 candidate 5G bands

Frequency [GHz]

0  10  20  30  40  50  60  70  80  90  100  120  140  160  180

Microwave backhaul 0–180GHz

5G candidate band

5G candidate band but prioritized for backhaul
The W-band and D-band

46.5 GHz for wireless communication

Deployment share per frequency
(Source Ericsson 2017)

(a) Bands based on rules similar to E-band (70/80 GHz), totally 36 GHz

(b) Bands for licensed fixed wireless operations, totally 66.2 GHz

(source: Ericsson/Yinggang Li)
Technical challenges when approaching sub-mmW:

• Output power varies generally as $1/f^{\alpha}$, $\alpha=2\sim3$
• Packaging becoming increasingly difficult
  — if possible: integrate the antenna on-chip or in package
• Unwanted resonance modes may easily develop in MMIC substrate
• Modeling increasingly difficult at high frequency
• Phase noise increasing (typically 6 dB per frequency doubling)
• Receiver noise figure increasing

➔ General statement: S/N degrades fast with frequency!
How to transfer the “precious” mmW power from MMIC to antenna port?

The solution must be:

- Volume manufacturable
  - Automatically assembly, repeatability (yield), tolerance insensitive, etc.
- Commercially affordable
Example, D-band transceiver modules for PtP links

• M3TERA, a H20202 project
• PoC demonstrator: *D-band Tx/Rx module*
• MMICs in 130nm SiGe from Infineon (B11)
• Micromachined Si substrate as an heterogenous platform for system integration
Heterogenous integration based on micromachined Si substrate

- Micromachined low-loss Si waveguide
- Non-gavanic transition between MMIC and the waveguide
- Embedded components, e.g. BPF, duplexer and phase shifters
Link test setup
CW test

- Peak gain position (frequency) depend strongly on bias
- Bandwidth depends strongly on bias
Real-time data transmission based on Ericsson’s Modem
Measurement results

- Channel width: 250 MHz
- QPSK
- 16QAM
- 64QAM

BER vs. Received power to RXM (dBm)

- For 16QAM
  - 125MHz
  - 250MHz
  - 750MHz
100 Gbps microwave link is not a dream any more today but a reality!

- Demonstrated by Ericsson in Gothenburg, Feb. 2019
- Based on Ericsson’s existing commercial product
- Line-of-sight MIMO plus H/V polarization
Purposely removed!
Looking forward

- > 100 GHz
  - Short-term: W- & D-band
  - Longer term: towards sub-mmW (275 GHz)
- > 100 Gbps
  - Microwave solutions available today to meet the need for 5G towards 2025
  - 100 Gbps for beyond 5G towards 2030 (Tbps from even longer-term perspective ?)
- Compact and simplified site solution for MIMO and high-gain antennas towards sub-mmW
- Challenges with THz MMIC interconnect and packaging
  - Heterogenous system integration
  - Antenna-in-package and SiP

➡️ Continuous and sustained research effort is necessary to commercialize the mmW-THz spectrum