“Millimeter wave ITS Radio Communications”

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National Institute of Information and Communications Technology (NiCT)
Study on MM-ITS Wireless Communications

Millimeter wave ROF road-vehicle communication system
- Multi-service
- High speed data transmission

Millimeter wave inter vehicle communication system
- Integrated radar communication system
- Safety operation support
Driving Support using Inter-Vehicle Communication

- Collision avoidance
- Platoon travel
- Driving support for merging / seceding
- Broadcasting of approach of emergency

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Why millimeter wave (MM wave)?

- High-efficiency of frequency reuse due to high attenuation compared with microwave
- Low attenuation caused by rain, fog, and snow compared with light-wave
- Potential of wide-band transmission
- Small size of RF unit
Research on IVC in NICT

- Measurement of propagation characteristics of 60 GHz millimeter wave on the road, expressway, e.t.c.
  - Propagation model between vehicles on the road
- Estimation of inter-vehicle transmission between running vehicles.
  - Characteristics of received power vs. bit error rate,
  - Effect of space diversity
- System design for IVC system
  - Feasibility study of IVC system in millimeter wave,
  - Radar with communications function
Experimental facility

Transmitting Side
- D-GPS
- TV Camera
- PN DATA Generator
- Modulator
- SG
- IF 140MHz
- RF (A)
- 59.1GHz
- Laser Radar

Receiving Side
- D-GPS
- TV Camera
- Master Controller
- Spectrum Analyser
- Demod.
- Control
- AGC Voltage
- AGC
- Received Power Meas.
- BER Measurement
- Vehicle Motion Meas.

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Test course
## Experimental condition

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Center frequency</td>
<td>59.1 GHz</td>
</tr>
<tr>
<td>Transmitted power</td>
<td>+9 dBm</td>
</tr>
<tr>
<td>Data rate</td>
<td>10 Mbps</td>
</tr>
<tr>
<td>Modulation</td>
<td>DFSK</td>
</tr>
<tr>
<td>Detection</td>
<td>Differential</td>
</tr>
<tr>
<td>Antenna</td>
<td>Standard Horn</td>
</tr>
<tr>
<td>Antenna gain</td>
<td>24 dBi</td>
</tr>
</tbody>
</table>
Two ray model

Received power

\[ P_r = \frac{P_t G_t G_r}{L(d)} \left( \frac{\lambda}{2\pi d} \right)^2 \sin^2 \left( \frac{2\pi h_t h_r}{\lambda d} \right) \]
Two ray model (assumption)

- Reflection coefficient of pavement = -1
- Roughness of pavement was ignored
- Directivity of antennas was ignored
- Absorption of Oxygen @60 GHz = 16 dB/km
Results (V-pol)

![Graphs showing received power and BER vs horizontal distance for V-pol transmission.](image)

- Power (Measured) vs. Power (Model)
- BER data is also plotted for reference.

**Parameters:**
- Txh = 46 cm
- Rxh = 38 cm
- V-pol orientation

**Observations:**
- The received power decreases with distance, as expected.
- BER values are observed at various points, indicating the quality of the signal reception.
- The graphs suggest a comparison between measured data and model predictions, highlighting discrepancies or agreements.

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Results \((\text{Rxh = diversity, V-pol})\)
Radar with Communications Function and Transponder system (Vehicle Safety System)

- Radar unit with Communications Function (Scanning Antenna)
- Transponder unit

Sign post
Radar and Transponder trial system

- Transmission rate: 100kbps
- BER : less than $10^{-4}$
- Comm. range: 100m
- Frequency: 60GHz
- Antenna beam width:
  - 3deg. (Radar)
  - 30deg. (Transponder)
- Rader type: FM-CW
- FM sweep range: 100MHz
radio wave markers (sign post)
support for safe driving in converging traffic

Transponder
intersection safety system

Transponder
rear-end collision avoidance alarm
Road-Vehicle communications

Features:

- Millimeter-wave hot-spot access system
- Broad band wireless transmission
- Multi-service
- Radio over Fiber transmission
Specification of RoF hot-spot access trial system

- down link: 59.0-60.0 GHz
- up link: 61.0-62.0 GHz
- RF power: 10 dBm
- antenna gain: 14dBi(BS), 11dBi(MS)
- modulation: D-BPSK
- band width: 270MHz
- data rate: 155.52Mbps
Configuration of access network
Image of a service scene and the configuration of mobile terminal unit
ROF spot communication system

Control station

Base station

Mobile station

Antenna

12cmx18cmx6cm
Experiment

Base station

Base station

2.5m

4.5m

18.3°
Received power

![Graph showing received power over distance](image)

- Power [dB]
- Distance [m]

- Received power values ranging from -120 to 0 dB
- Distance values from 0.00m to 5.00m

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Packet Error Rate

15m 0.5m

down link  up link
International Standardizations

- ITU-R SG8 WP8A WG2(ITS)
  MM ITS for inter-vehicle communications and road to vehicle communications

- ISO-TC204 WG16.1 CALM-MM
  Protocol for interface between MM-communications and ITS network architecture
International conference on IT telecommunications

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