Submission Title: [Introduction of vertically connected wireless system]
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Source: [Ami Kanazawa and Hiroyo Ogawa]
Company [Communication Research Laboratory, Independent Administrative Institution]
Address [3-4 Hikarino-oka, Yokosuka, Kanagawa, 239-09847 Japan.]
Voice:[81-46-847-5066], FAX[81-46-847-5079]
E-Mail:[ami@crl.go.jp]

Abstract: [Millimeter-wave vertically connected wireless system]
Purpose: [Contribution to millimeter-wave interest group at January 2004 meeting]
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60GHz band Application
-Millimeter-wave vertically connected wireless link -
Expectation of wireless link for broadcasting
Problems of receiving satellite broadcasting signals

Satellite broadcasting (BS, CS) provides high-quality services. However some apartment buildings can not receive signals, because of obstacles for satellite direction, no balconies for satellite direction, etc.
Demands for wireless re-broadcasting system

- Wide band transmission.
- Flexible extension of contents.
- Easy set up.
- Low cost.
- Un-license system.

60GHz band

- Wide band transmission.
- Small sized devices.
- Un-license band.
Vertically connected wireless link

Re-broadcasting system between the rooftop satellite antenna with individual receivers at balconies

Special features:
- flexible wireless link
- easy set-up
- easy extension
- low cost

60 GHz band is used
Current Standards for un-license band (Japan)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unlicensed band</td>
<td>59-66 GHz</td>
</tr>
<tr>
<td>Output power</td>
<td>≤10 mW (+50 %, -70 %)</td>
</tr>
<tr>
<td>Antenna gain</td>
<td>≤47 dBi</td>
</tr>
<tr>
<td>Frequency stability</td>
<td>Max. 500 ppm</td>
</tr>
<tr>
<td>Bandwidth</td>
<td>≤2.5 GHz</td>
</tr>
</tbody>
</table>
Self heterodyne scheme

- Tx transmits modulated signals with local signal.
- Rx obtains BS-IF signals by using the received local signal.

Special features:
- Rx can cancel the phase noise problem.
- Tx can use low cost local oscillator. / Rx does not need local oscillator.
Definitions for Link Budget Calculation

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmission power</td>
<td>10 mW</td>
<td></td>
</tr>
<tr>
<td>Antenna Gain (Tx, Rx)</td>
<td>23 dBi</td>
<td></td>
</tr>
<tr>
<td>Transmission distance</td>
<td>33 m</td>
<td>10 F building is assumed</td>
</tr>
<tr>
<td>Loss</td>
<td>98.4 dB</td>
<td></td>
</tr>
<tr>
<td>k</td>
<td>1.38e-23 JK</td>
<td></td>
</tr>
<tr>
<td>T</td>
<td>300 K</td>
<td></td>
</tr>
<tr>
<td>NF</td>
<td>6 dB</td>
<td></td>
</tr>
<tr>
<td>C/N for BS</td>
<td>26 dB</td>
<td>at BS satellite antenna</td>
</tr>
<tr>
<td>C/N for CS</td>
<td>19 dB</td>
<td>at CS satellite antenna</td>
</tr>
</tbody>
</table>
Link Budget

Two examples of transmission media are shown here.

Type A: transmission of BS signals

Type B: Transmission of BS and CS signals

<table>
<thead>
<tr>
<th>Type</th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bandwidth</td>
<td>300 MHz</td>
<td>780 MHz</td>
</tr>
<tr>
<td>NF deterioration</td>
<td>9 dB</td>
<td>9 dB</td>
</tr>
<tr>
<td>CNR cut off (BS)</td>
<td>14 dB</td>
<td>14 dB</td>
</tr>
<tr>
<td>CNR cut off (CS)</td>
<td>–</td>
<td>8 dB</td>
</tr>
<tr>
<td>Margin for BS</td>
<td>11 dB</td>
<td>9.7 dB</td>
</tr>
<tr>
<td>Margin for CS</td>
<td>–</td>
<td>9.8 dB</td>
</tr>
</tbody>
</table>

From link budget, 33 m ( = 10F building ) transmission is possible.
Developed Prototype

For BS signal transmission

<table>
<thead>
<tr>
<th>Description</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>RF frequency (RF)</td>
<td>59.01-60.345 GHz</td>
</tr>
<tr>
<td>Local tone (Lo)</td>
<td>59.01 GHz</td>
</tr>
<tr>
<td>IF frequency</td>
<td>1032.23-1335.25 MHz</td>
</tr>
<tr>
<td>Total power</td>
<td>10 mW</td>
</tr>
<tr>
<td>Antenna gain</td>
<td>23 dBi (Tx, Rx)</td>
</tr>
<tr>
<td>Diameter</td>
<td>11 cm</td>
</tr>
<tr>
<td>Weight</td>
<td>600 g (include the metal fittings)</td>
</tr>
</tbody>
</table>
Antenna pattern

23 dBi antenna (beam width is about 5 degrees)
Frequency Arrangement

BS-IF signals

10.10562 1126.96 1241.28 1318.00MHz

10.056GHz

60.06GHz

60.33GHz

Local signal

ARIB STD-T69
Measurement in an apartment building

Distance:
- 14.7 m
- 36.5 m

Diagram shows:
- External environment
- Indoor environment
- Transmitter and receiver locations

Ami Kanazawa, CRL
Measurement condition

Transmitter

Receiver
CIR characteristics

![Bar chart showing CNR for different BS channel numbers and floor levels]

- 14 dB (Analog)
- 11 dB (Digital)

Enough quality signals were received for all floors.
CIR characteristic

Condition: two transmitters are set.

CIR >12 dB is required when plural transmitters are set in the apartment.
Conclusion

Vertically connected wireless link is introduced.
• CRL developed prototypes for BS transmission.
• Link Budget is calculated.

In the measurements, we confirmed that
• BS-signal transmission with high quality in 5F apartment
• CIR > 12 dB is required when multiple transmitters are set.