OPRA:
A novel invention for 5G Coverage & Capacity

(Orthogonal Polarization Reuse Antenna)
Abstract

In mobile communications, increasing capacity and extending coverage are the most important factors to operators.

KMW implemented OPRA that has applied **Orthogonal Polarization Reuse** to increase capacity and extend coverage simultaneously.

OPRA reuses different orthogonal polarizations on multi-beam, significantly reducing the correlation between beams, and **increasing capacity by 36% and coverage by 39%**. This OPRA technology can be implemented in both the RF domain and digital domain.

OPRA technology gives operators the ability to achieve increased capacity and extended coverage at a low investment cost, and paramourly reducing CapEx and OpEx.

KMW is ready to offer a variety of RU products powered by OPRA technology to global partners and customers.
Introduction

[ Background ]
Operators have continued to demand solutions that simultaneously increase capacity and coverage at a low investment. However, none of the solutions could satisfy these conditions. 5G uses RRH-type products for services coverage improvement and mMIMO RU products for services capacity improvement. This leads to an increase in costs, a significant obstacle to expanding the 5G market.

Therefore, a new solution would significantly reduce the operators’ CapEx and OpEx, contributing to the expansion of the 5G market.

[ Orthogonal Polarization Reuse ]
Efforts to increase capacity and extend coverage have continued through antenna technology advancements. Increasing capacity by dual orthogonal polarization technology and extending coverage by narrow multi-beam are the best examples. However, dual orthogonal polarization technology results in deterioration of capacity due to correlation by the overlap of polarization in multiple MIMO environments, and narrow multi-beam technology has a limitation that extends coverage. However, capacity increases are low due to the correlation between antenna polarizations. The limitations of these technologies occur because the same polarization is used in the same space, at the same time, and at the same frequency.

Orthogonal Polarization Reuse, a technique that reuses different polarizations by separating time, space, and frequency, is a new paradigm that satisfies capacity increase and coverage extension by reducing correlation through existing polarization.

[ OPRA (Orthogonal Polarization Reuse Antenna) ]
OPRA is an Orthogonal Polarization Reuse technology that uses different dual orthogonal polarizations. The representative polarizations used are Slant 45°(±45°) polarization and Vertical / Horizontal(V/H) polarization. OPRA reuses different dual orthogonal polarizations by separating time, space, and frequency to reduce correlation by polarization and increasing capacity, and extending coverage.

RU products that use KMW’s OPRA are expected to reduce operators’ concerns and costs.
How to increase capacity and extend coverage?

The reason is why the coverage and capacity do not double up, even if 3-sectors are subdivided further than 6-sectors, is because capacity is deteriorated as correlation by interference and polarization by adjacent beams between each sector. Similarly, using the Narrow Multi-beam within the same sector does not increase capacity because of the correlation caused by polarization between Narrow Multi-beam if the same antenna polarization is used.

OPRA forms narrow multiple beams in different directions and intersects two different dual orthogonal polarizations between the beams. Because OPRA uses two different pairs of dual orthogonal polarizations between beams in a space-isolated with different directions. It reduces correlation by polarization between beams. Therefore, minimized correlation leads to increasing capacity and extending coverage.
OPRA’s Performance

[ Performance Comparison by Simulation ]

To verify the performance of OPRA implemented by KMW, capacity and coverage are compared by simulating three cases of 4x4 MIMO.

Conventional Antenna Technology uses the same ±45° polarization as a sector beam, and Twin Beam uses the narrow multi-beam with the same ±45° polarization. But as for OPRA, one beam on the narrow multi-beam uses ±45° polarization, and the other beam uses V/H (Vertical/Horizontal) polarization.

Simulation parameters are summarized in the table below.

<table>
<thead>
<tr>
<th>Category</th>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>System Configuration</td>
<td>Carrier Frequency</td>
<td>3.5GHz</td>
</tr>
<tr>
<td></td>
<td>Channel Bandwidth</td>
<td>100MHz</td>
</tr>
<tr>
<td></td>
<td>BS Transmit power</td>
<td>160W(40W/path)</td>
</tr>
<tr>
<td></td>
<td>Conventional ANT Gain</td>
<td>17.5dBi</td>
</tr>
<tr>
<td></td>
<td>Twin Beam ANT Gain</td>
<td>19.5dBi</td>
</tr>
<tr>
<td></td>
<td>OPRA ANT Gain</td>
<td>19.5dBi</td>
</tr>
<tr>
<td>Channel Model</td>
<td>Polarized Channel Model</td>
<td>Urban Macro</td>
</tr>
<tr>
<td></td>
<td>Inter-site distance</td>
<td>500m</td>
</tr>
<tr>
<td></td>
<td>BS ANT height</td>
<td>30m</td>
</tr>
<tr>
<td></td>
<td>UE ANT configuration</td>
<td>4Rx with V/H polarization</td>
</tr>
<tr>
<td></td>
<td>UE ANT height</td>
<td>1.5m~22.5m for indoor UE(80%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.5m for outdoor UE(20%)</td>
</tr>
</tbody>
</table>

**Capacity comparison**

Capacity is increased by 36% in OPRA over Conventional. We can see the effect of OPRA reducing correlation by separating and reusing different orthogonal polarizations as it is extended by 28% compared to Twin Beam that uses the same narrow band within the same polarization.

--- Capacity Comparison ---
**Coverage comparison**
Coverage is extended by 39% in OPRA over Conventional. We can see the effect of OPRA on reducing correlation by separating and reusing different orthogonal polarizations as it is extended by 15% compared to twin beam.

--- Coverage Comparison ---

**Multi-Sectors & Cell Performance**
There are many sectors and cells, which lead to an increase in Inter-cell Interference, resulting in capacity degradation. OPRA is expected to increase capacity performance in Multi-Sectors & Cells due to its effect on reducing interference between beams.

--- 3-Sector, 4x4 MIMO, Full Interference ---
The graph below compares the performance of OPRA in a 3-sector full interference environment.

--- OPRA 3-Sector Capacity Comparison ---

[ Field test comparison ]

The performance of OPRA has also been shown in field tests. The following are the result through 4T4R RU in the n78 band of 5G NR.

The rank index 4 received from the user equipment increased in OPRA over Conventional through the field test.
OPRA achieves capacity increase and coverage extension by narrow multiple beams and orthogonal polarization reuse without adding more signal paths, complex configurations, or calculations.

Therefore we expect that, for example, 8T8R RU powered by OPRA will closely meet the performance of 32T32R mMIMO.

The graph below compares the simulated capacity performance of OPRA and mMIMO RU in Single User MIMO, 4 Layers condition.

Besides, OPRA is expected to broaden the operator’s choices by providing new applications through the extension of time, and frequency.
KMW introduced OPRA technology, and it has been academically published in ISAP2020 and under review on IEEE Transaction Antenna & Propagation. All related patents have also been applied.

OPRA technology has shown the ability to increase capacity and to extend coverage, which can significantly reduce CapEx and OpEx.

KMW is ready to offer a variety of RU products powered by OPRA to global partners and customers.

References

(1) 3GPP, "Study on Channel Model for Frequencies from 0.5 to 100GHz" 3rd Generation Partnership Project (3GPP), TR 38.901 V15.0.0, Jun. 2019


