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# Contents

1 Overview of Base Station Antenna Solutions ................................................................. 3

2 Challenges to Base Station Antenna Solutions ............................................................... 4

3 SBS Antenna Solution ....................................................................................................... 6

   3.1 Overview for SBS Solution ......................................................................................... 6
   3.2 Analysis of the SBS Antenna Coverage Performance .................................................. 7
   3.3 Analysis of the SBS Antenna Capacity Performance .................................................... 7
   3.4 SBS Antenna Evolution .............................................................................................. 9

4 Conclusion ...................................................................................................................... 10
1 Overview of Base Station Antenna Solutions

In the past two decades, radio networks were upgraded from AMPS to GSM/CDMA and then to UMTS/CDMA2000 to achieve larger capacity and higher spectral efficiency. Currently, radio networks are being upgraded from UMTS/CDMA2000 to LTE. At the same time, more frequency bands are used to obtain larger capacity. With the coexistence of multiple modes and multiple frequency bands, a single physical site must support more modes and frequency bands.

Base station antennas evolve to meet development requirements of radio networks. Figure 1-1 shows the development history of base station antennas and a radio network.

Figure 1-1 Development history of base station antennas and a radio network
2 Challenges to Base Station Antenna Solutions

With the rapid development of the multi-band and multi-mode radio system, the installation space of antennas becomes more and more limited. The multi-band antenna replaces the original single band antenna in more and more installation scenarios to reduce installation space or lower the load carried by the tower. In the mobile broadband era, antennas must play a role of increasing network capacity. With the deployment of new radio networks, a multi-band antenna faces the following challenges:

A. The dimensions of a multi-band antenna must meet specific acceptable range.

Table 2-1 lists dimensions of antennas applicable to different frequency bands.

<table>
<thead>
<tr>
<th>Frequency Band</th>
<th>Width (mm)</th>
<th>Length (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single band</td>
<td>150–260</td>
<td>700–2600</td>
</tr>
<tr>
<td>Dual-band</td>
<td>260–350</td>
<td>700–2600</td>
</tr>
<tr>
<td>Tri-band</td>
<td>260–350</td>
<td>700–2600</td>
</tr>
<tr>
<td>Quad-band</td>
<td>260–350</td>
<td>700–2600</td>
</tr>
<tr>
<td>Penta-band</td>
<td>260–350</td>
<td>700–2600</td>
</tr>
</tbody>
</table>

B. The gain of a new antenna must be higher than or equal to the original gain after replacement.

Table 2-2 lists typical gain and length of existing GSM, UMTS, and CDMA antennas.

<table>
<thead>
<tr>
<th>Frequency Band (MHz)</th>
<th>Gain (dBi)</th>
<th>Length (mm)</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>900</td>
<td>≤ 15</td>
<td>Approx. 1400</td>
<td>20%</td>
</tr>
<tr>
<td></td>
<td>= 16</td>
<td>Approx. 2000</td>
<td>70%</td>
</tr>
<tr>
<td></td>
<td>≥ 17</td>
<td>Approx. 2600</td>
<td>10%</td>
</tr>
<tr>
<td>Frequency Band (MHz)</td>
<td>Gain (dBi)</td>
<td>Length (mm)</td>
<td>Ratio</td>
</tr>
<tr>
<td>---------------------</td>
<td>------------</td>
<td>-------------</td>
<td>-------</td>
</tr>
<tr>
<td>1800</td>
<td>≤ 17</td>
<td>Approx. 700</td>
<td>10%</td>
</tr>
<tr>
<td></td>
<td>= 18</td>
<td>Approx. 1400</td>
<td>80%</td>
</tr>
<tr>
<td></td>
<td>≥ 19</td>
<td>Approx. 2000</td>
<td>10%</td>
</tr>
<tr>
<td>2100</td>
<td>≤ 17</td>
<td>Approx. 700</td>
<td>10%</td>
</tr>
<tr>
<td></td>
<td>= 18</td>
<td>Approx. 1400</td>
<td>80%</td>
</tr>
<tr>
<td></td>
<td>≥ 19</td>
<td>Approx. 2000</td>
<td>10%</td>
</tr>
</tbody>
</table>

To minimize impact on the live network, the gain of a multi-band antenna must be higher than or equal to the original gain when the multi-band antenna replaces a single band or dual-band antenna.

C. The new antenna must meet the performance requirements of the multiple-input multiple-output (MIMO) technology.

With the booming demand on radio data services, the multiple-antenna technology develops quickly and the high-order MIMO technology gradually applies to commercial networks.

With the commercial use of the high-order MIMO, an antenna must provide sufficient ports and better MIMO performance to improve the spectral utility.
3 SBS Antenna Solution

3.1 Overview for SBS Solution

In the past decade, base station antennas are developed into multi-band electrical tilt antennas to meet construction requirements of a multi-band and multi-mode site with co-site co-feeder deployment. Meanwhile, the rapid development of the radio broadband services requires more system capacity, which stimulates multiple architectures of base station antennas.

Figure 3-1 shows the schematic drawing of mainstream base station antennas.

**Figure 3-1 Schematic drawing of mainstream base station antennas**

<table>
<thead>
<tr>
<th>Single band</th>
<th>Dual-band Stack</th>
<th>Tri-band SBS</th>
<th>Tri-band Stack</th>
<th>Multi-band SBS + Stack</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low frequency dipole</td>
<td>High frequency dipole</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Mainstream multi-band antennas adopt mainly the SBS (Side by Side) and Stack solutions. These two solutions vary in antenna arrays, resulting in different antenna dimensions, gain, and MIMO performance.

<table>
<thead>
<tr>
<th>Platform</th>
<th>Frequency Band (MHz)</th>
<th>Length (mm)</th>
<th>Gain (dBi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SBS</td>
<td>790–960/1710–2690</td>
<td>Approx. 2600</td>
<td>17/18/18</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Approx. 2000</td>
<td>16/18/18</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Approx. 1400</td>
<td>15/17/17</td>
</tr>
<tr>
<td>Stack</td>
<td>790–960/1710–2690</td>
<td>Approx. 2600</td>
<td>17/17/17</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Approx. 2000</td>
<td>16/16/16</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Approx. 1400</td>
<td>15/15/15</td>
</tr>
</tbody>
</table>

### 3.2 Analysis of the SBS Antenna Coverage Performance

Coverage of the SBS and Stack solutions is affected by the antenna gain. Figure 3-2 shows the relationship between the coverage and antenna gain in the typical LTE 2600 MHz scenario.

**Figure 3-2** Relationship between the coverage and antenna gain in the typical LTE 2600 MHz scenario

As shown in Figure 3-2, the coverage radius of the SBS solution (18.5 dBi) is larger than that in the Stack solution (16 dBi) by 15%, resulting in the increase of the coverage area by 30%.

### 3.3 Analysis of the SBS Antenna Capacity Performance

The tri-band antenna is taken as an example to accurately describe the performance difference between an SBS antenna and a Stack antenna. The tri-band antenna is configured with a low band and two high bands. The low band is 796–960 MHz and the high bands are both 1710–2690 MHz. Figure 3-3 shows the high frequency bands of the two solutions. In the Stack solution, low-band antennas and high-band antennas are deployed coaxially, and high-band antennas are mounted vertically. In the SBS solution, low-band antennas and the
antenna array marked by +x are deployed coaxially and the high-band antennas are deployed horizontally in parallel.

**Figure 3-3** High frequency bands of two solutions

<table>
<thead>
<tr>
<th>SBS</th>
<th>Stack</th>
</tr>
</thead>
<tbody>
<tr>
<td>+x</td>
<td>-x</td>
</tr>
</tbody>
</table>

Difference of the two solutions:

1. The dipole quantity of the Stack solution is less than that of the SBS solution due to limited total length.
2. Antenna relevance of the Stack solution is smaller than that of the SBS solution. (The relevance is determined based on the distance between two antennas. The longer the distance is, the smaller the relevance is.)

The LTE simulation is conducted for the two solutions based on case 1 of the 3rd Generation Partnership Project (3GPP).

![LTE 4x2 Adaptive MIMO, 3GPP Case1: SBS vs. Stack](image)

The simulation result shows that:

1. The SBS solution is better than the Stack solution on the cell average throughput (CAT) and cell edge throughput (CET).
2. The CET gain is higher than the CAT gain.

Therefore, the SBS solution can provide higher capacity on the high-order MIMO LTE network.
3.4 SBS Antenna Evolution

The SBS solution features the powerful evolution capability. An antenna is more and more complex with the deployment of multi-layer networks on the MBB network. The SBS solution ensures excellent coverage and capacity performance. In addition, the SBS solution enables SBS evolution-based multi-band products to provide excellent network performance. The SBS solution is the optimum solution to meet high capacity and network performance requirements. Table 3-1 lists the evolution of the SBS solution.

Table 3-1 Evolution of the SBS solution

<table>
<thead>
<tr>
<th>Platform</th>
<th>Evolution</th>
<th>Frequency</th>
<th>Gain</th>
<th>Frequenc y</th>
<th>Gain</th>
<th>Providing the Optimum 4R MIMO Performance or Not</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tri-band SBS solution</td>
<td>Quad-band</td>
<td>790–960</td>
<td>16/18/18</td>
<td>790–960</td>
<td>16</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1710–2690</td>
<td></td>
<td>1710–2170</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2490–2690</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1710–2690</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Penta-band</td>
<td>790–862</td>
<td>16</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>880–960</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1710–2170</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2490–2690</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1710–2690</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>Tri-band Stack solution</td>
<td>Quad-band</td>
<td>790–960</td>
<td>16/16/16</td>
<td>790–960</td>
<td>16</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1710–2690</td>
<td></td>
<td>1710–2170</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2490–2690</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1710–2690</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Penta-band</td>
<td>790–862</td>
<td>16</td>
<td>No</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>880–960</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1710–2170</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2490–2690</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1710–2690</td>
<td>16</td>
<td></td>
</tr>
</tbody>
</table>

The evolution capability allows the SBS solution to fulfill scenarios with four bands or above. Products based on the SBS evolution provide the highest gain and capacity performance. The SBS solution represents an important development trend of base station antennas in the MBB era.
4 Conclusion

With rapid development of radio networks, antennas must be adaptive to new frequency bands and multi-band and multi-mode networks, and need to improve the capacity performance of radio networks. The SBS antenna solution can achieve balance among antenna dimensions, gain, and performance. With meeting the installation requirements, the SBS antenna solution can provide higher network capacity on the LTE high-order MIMO networks and is adaptive to the evolution of multi-band antennas in the future.