WHITE PAPER

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Technical Analysis: The Effect of Low-Quality Antennas on Network Backhaul

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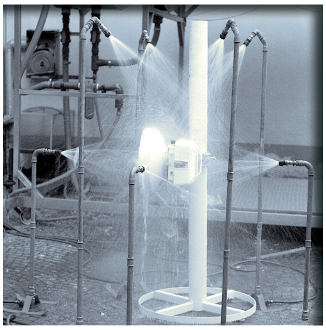
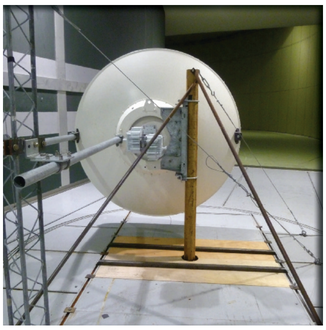
Microwave Antenna Solutions, RFS

June 2016





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The Effect of Low-Quality Antennas on Network Backhaul

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Introduction

When designing a network backhaul, the finest technology is considered for the active components, while the importance of passive components – such as the antenna – is often taken for granted. The antenna has been regularly seen as a cost-saving component where concessions can be made on quality. However, it is unrealistic and can be detrimental to the outcome to consider every antenna as similar in terms of quality and performance.

Mobile network operators often rely solely on data sheets to choose the appropriate microwave antenna for network backhauling. On the surface this may look like a legitimate means of selection but, in actuality, it is not. There are various suppliers offering similar antennas at extremely low prices, but these antennas often fail to meet the desired quality and performance standards claimed in the data sheets. Numerous factors affect microwave antenna performance in the long run that, more often than not, are overlooked in the selection process.

This paper describes the effects of various quality variables on microwave antenna performance, and provides insight into the long-term consequences of using a low-cost/ poor-quality antenna. It is intended to help move the industry forward by demonstrating the effect of operators' preference for low-cost antennas without considering the total cost of ownership and possible ill-effects on their quality of service.

Scope of this paper

- **Impact of poor-quality antennas on capacity and performance of the network/spectrum.**
  Understand how a poor-quality antenna restricts the effective usage of frequency spectrum, and eventually leads to reduction in the operator's revenue.
- **Seeing the unseen: How concessions on quality of the following antenna parts impact the antenna's performance.**
  - Reflectors
  - Feed (Pipe and Dielectric)
  - Absorbing Materials
  - Radome
  - Product Testing
- **The real cost of "low-cost".**
  Re-think! Are you really saving money?
- **A sustainable cost saving strategy.**
  A sustainable way of saving without compromising quality.

The Effect of Low-Quality Antennas on Network Backhaul

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Impact of poor-quality antennas on capacity and performance of the network/ radio spectrum

Network planning engineers consider data sheets as a credible source of information, and use them to calculate the number of links, data throughput, coverage, capacity, and overall performance of the network. Using a low-grade antenna that does not perform as described in the data sheet prohibits the entire system from operating as efficiently as it was designed to do.

Using a low-grade antenna that doesn't perform as per the data sheets specifications prohibits the entire system from operating as efficiently as it was designed. It is just as necessary to couple a high-quality antenna with higher modulation scheme radio to make the most of the network capacity.

To fulfill the ever-growing demand for network capacity, it is now essential for network operators to deploy microwave radios of higher modulation schemes. It is equally necessary to couple a high-quality antenna with higher modulation scheme radios to make the most of the network capacity. If an inferior antenna is used with a microwave radio designed to allow higher modulations, inadequacies in the antenna quality will cause the radio to restrain modulation to a much lower level, resulting in lower capacity and potential congestion, which will unnecessarily waste the money spent on a microwave radio with cutting-edge modulation technologies.

Most countries have regulations to protect users from purchasing substandard telecom equipment and hence, to preserve radio spectrum efficiency. ETSI (European Telecommunications Standards Institute) is one organization that categorizes antennas in various classes based on their performance against standards. This rating is a critical factor in choosing an antenna to deliver the desired performance.

Unfortunately, some antenna suppliers claim to have ETSI Class 3 antennas on their data sheets but fail to provide desired performances. It is estimated that around 30% of antennas globally show false declaration, and are non-compliant with their data sheet specifications. These are low-quality antennas manufactured with inconsistent production standards, poor quality controls and unstable designs. As these antennas are sold at cheaper prices than high-quality antennas in the same class, showing similar values on their data sheets, they look more appealing to the customer.

Around **30%** of antennas globally show false declaration, and are **non-compliant with their data sheet specifications.** The low-quality antennas are manufactured with inconsistent production standards, poor quality controls and unstable designs.

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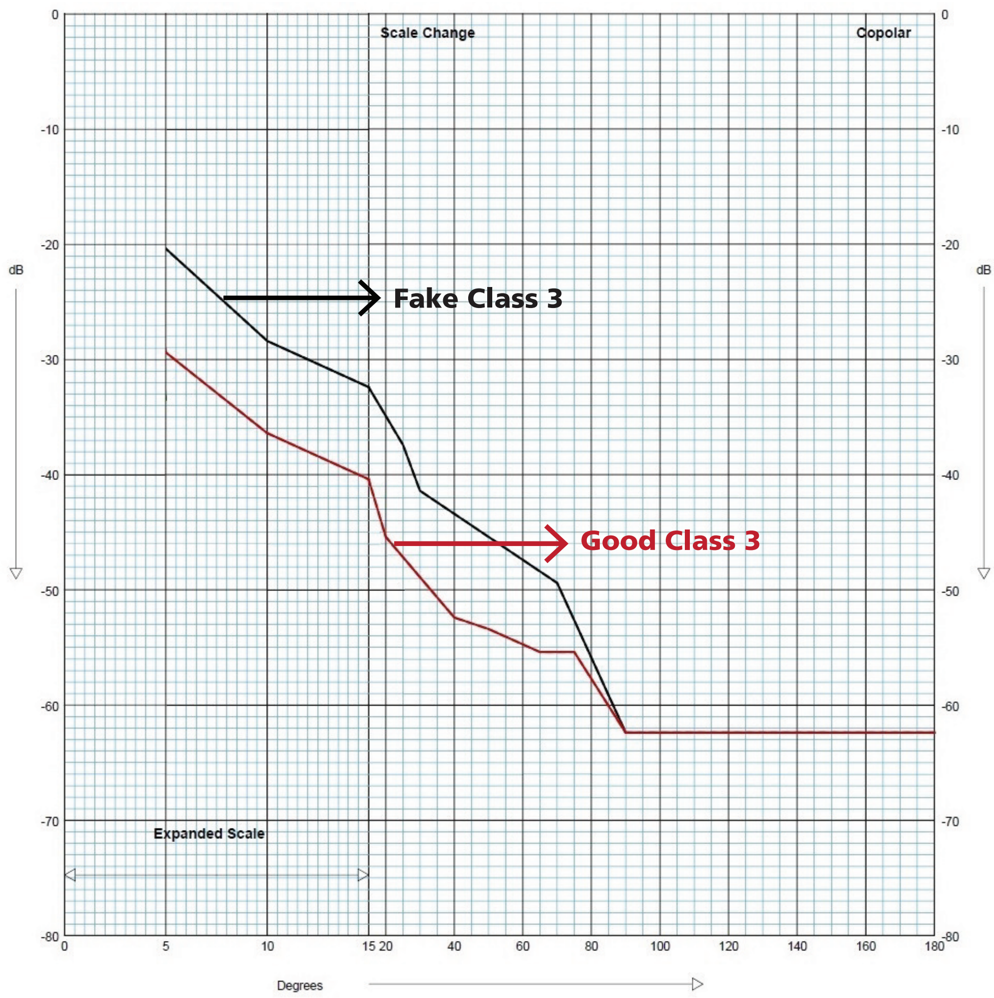
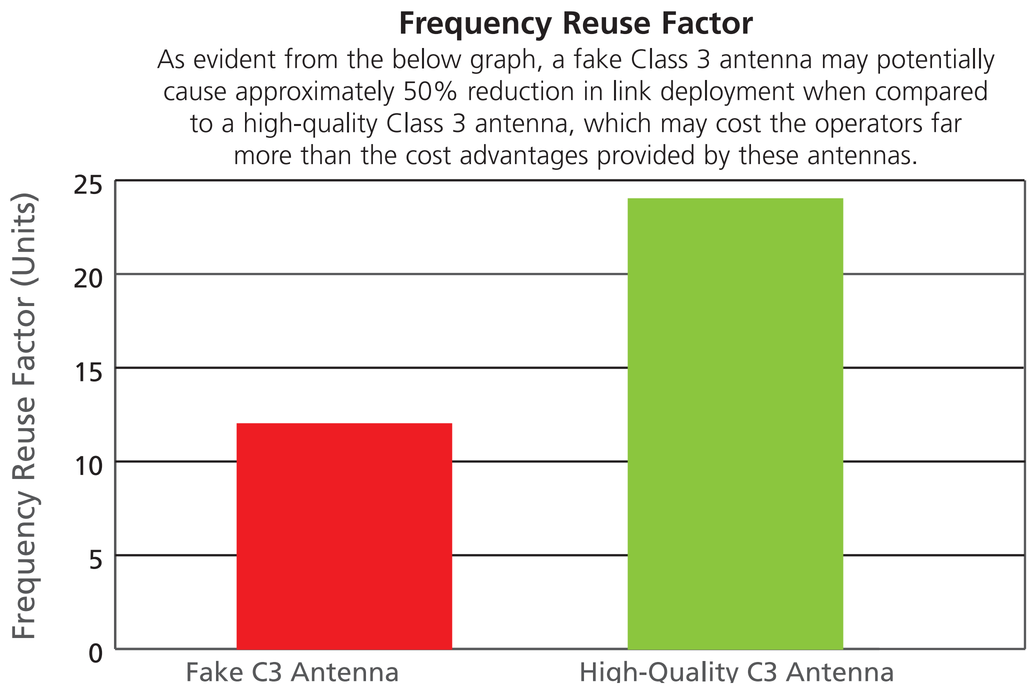
R&D teams spend considerable time researching and testing for the best spectral efficiency, scalability, and capacity, to perform as promised. When poor-quality antennas are used, the design objectives for radio links are not met, and hence, many networks do not perform in accordance with their designed capacity as the data throughput demands rise.

Low-quality antennas can significantly limit the frequency reuse factor due to their "high" sidelobe levels. Hence, fewer links can be deployed without interference. Graph 1 shows the corresponding RPEs of fake Class 3 and high-quality Class 3 antennas (for 2-foot antennas in the 38 GHz frequency band).



Graph 1 RPEs of fake Class 3 and high-quality Class 3 Antennas

To better understand the effect of these antennas on capacity and efficiency of spectrum utilization, assume that the above-mentioned antennas (with RPEs shown above) are deployed in a random network with desired attenuation in the same channel hops of 40 dB. The calculation of frequency reuse factor indicates considerable differences, as shown in Graph 2.



Graph 2 Maximum frequency reuse factor of fake Class 3 and high-quality Class 3 antennas

Seeing the unseen: How concessions on the quality of antenna parts affect its performance

A microwave antenna is basically a passive mechanical device that has an electrical application and function. A high-quality antenna requires the assembly of several high-quality parts, as well as decent control over their mechanical dimensions during manufacturing and for their operational lifetime. The qualities of every constituent part of an antenna are highly relevant to the electrical performances, so concessions on the quality of these parts directly affect overall antenna performance.

> **Low-cost vendors** compromise on the quality of various key components of the antenna, which are not visible initially, but affect overall system performance.

The low-cost antenna suppliers, generally, compromise on the quality of various key components in order to reduce costs. These quality differences are not initially apparent to operators, but have severe effects on total system performance over time. The following comparison sheds light on the importance of various antenna parts, and how these impact the overall performance of the backhaul system.

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1. Reflector

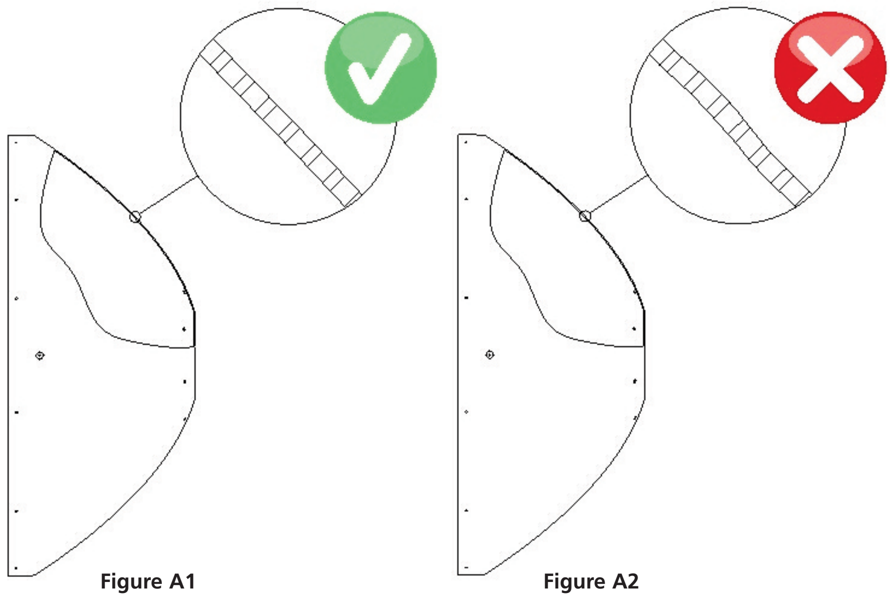
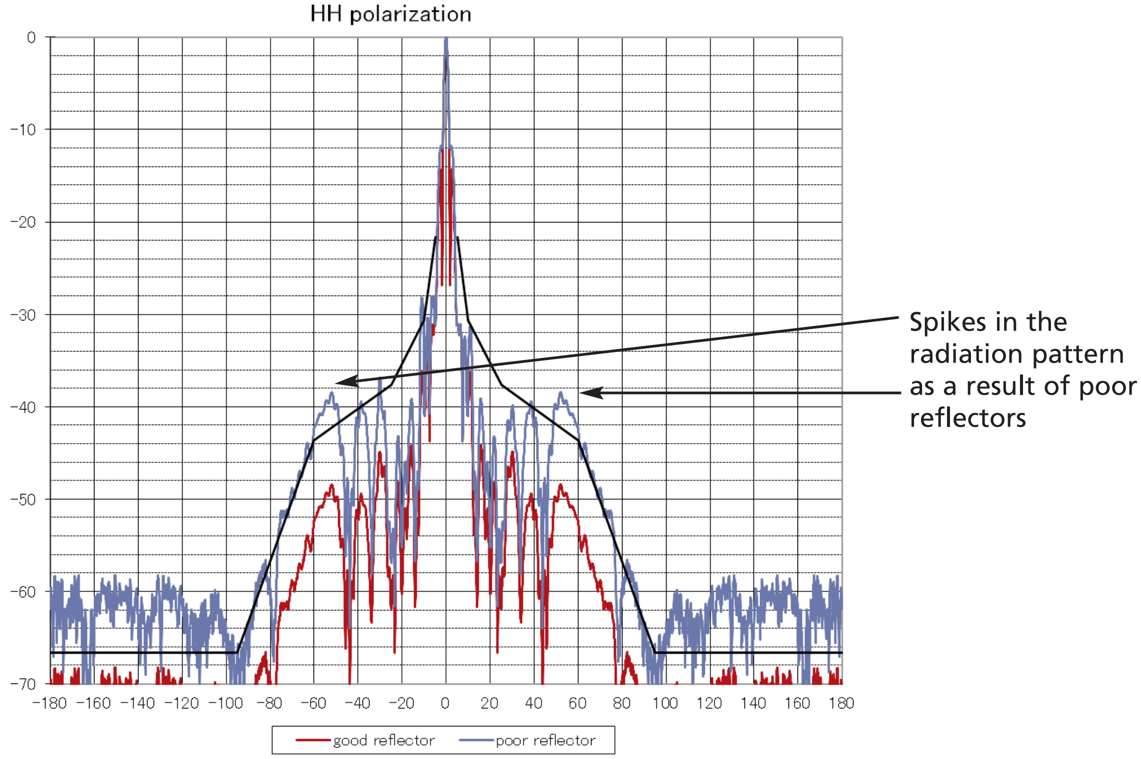


Figure A1 Figure A2

The reflectors may look alike at first glance but the imperfect curve resulting from poor quality controls directly impacts the radiation pattern of the antenna. The inconsistent curves of the reflectors result in unexpected spikes all over the radiation pattern. The following graphs (Graph 3 & Graph 4) indicate the effect of poor-quality reflectors on radiation pattern.



Graph 3 Effect of poor reflector on radiation pattern

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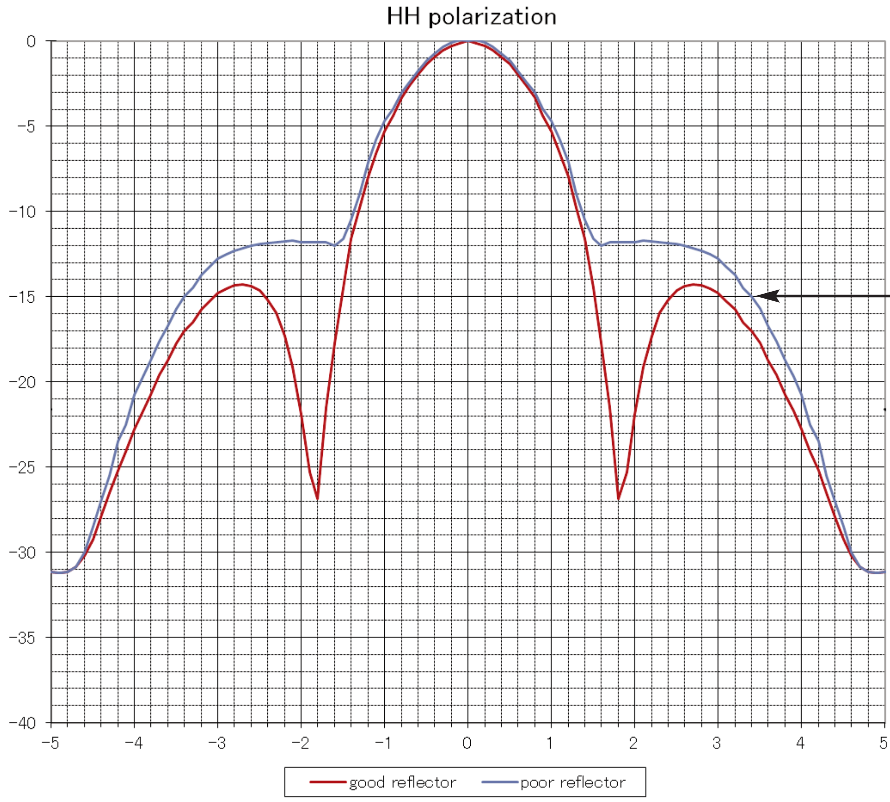


The poor reflectors also result in poor sidelobe (shown in blue color) or off-axis gain performance that causes interference with other links, and limits the link capacity, leading to poor service quality.

Graph 4 Poor sidelobes due to poor reflector

2. **Antenna Feed System**
   A. Pipe Quality
   B. Dielectric

Feed

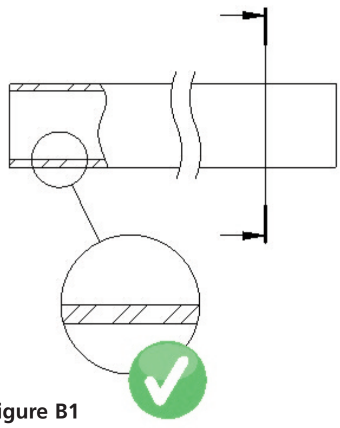


Figure B1

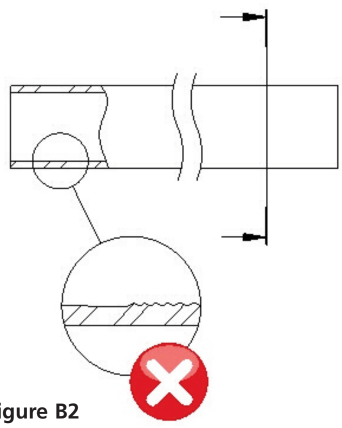


Figure B2

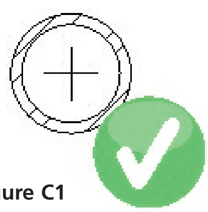


Figure C1

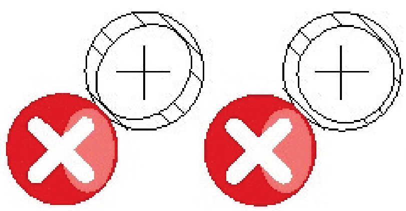
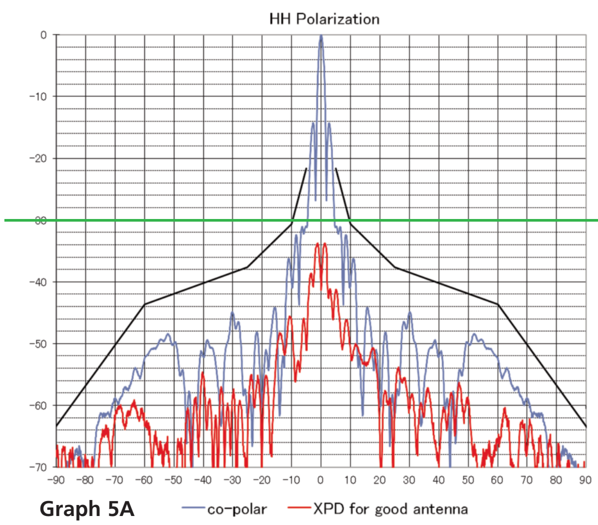


Figure C2

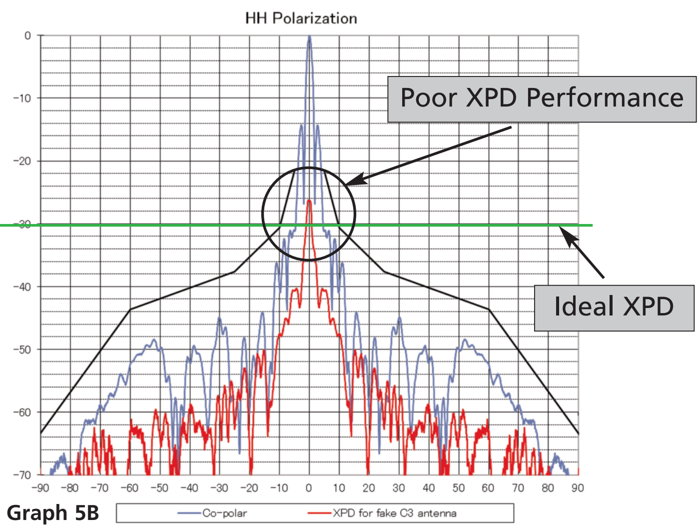
The Effect of Low-Quality Antennas on Network Backhaul

The quality of pipe in the antenna feed system directly impacts the antenna's cross-polarization performance. The smooth finishing of pipe and proper concentricity are essential to achieve high XPD performance. A poorly manufactured pipe with rough finishing and improper concentricity (Figures B2 & C2) may result in poor cross-polar discrimination* (XPD) performance with continuous usage.

The following graphs (Graphs 5A & 5B) show a comparison between the XPD performances of a high-quality antenna vs. a fake Class 3 antenna. As evident, the XPD of the fake Class 3 antenna shows poor XPD in comparison with the high-quality antenna. The poor XPD performance is due to poor sidelobe performance, and the poor quality of feed material.



Graph 5A



Graph 5B

Similarly, as shown in Figures D1, D2 & E1, E2, uncontrolled manufacturing procedures result in dull or curved finishing of the dielectric, which limits antenna gain. Also, the lack of concentricity in dielectrics makes it difficult to align the antenna after installation.

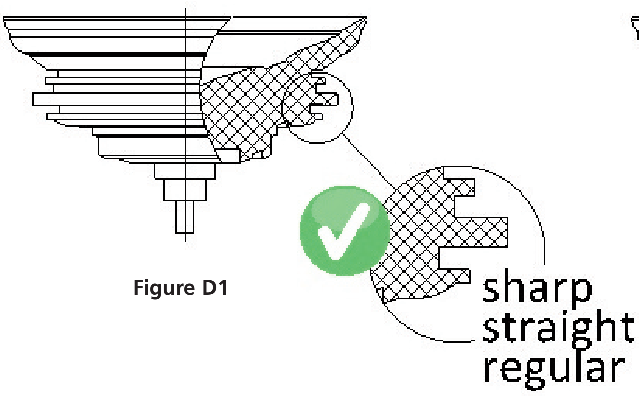


Figure D1

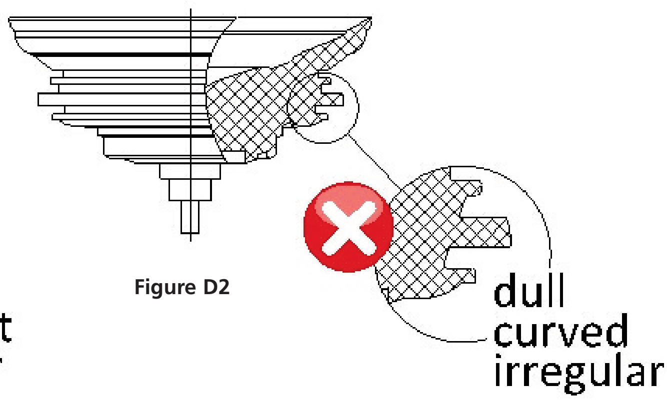


Figure D2

* The difference between the peak of the co-polarized main beam and the maximum cross-polarized signal over an angle twice the half power beamwidth of the co-polarized main beam.

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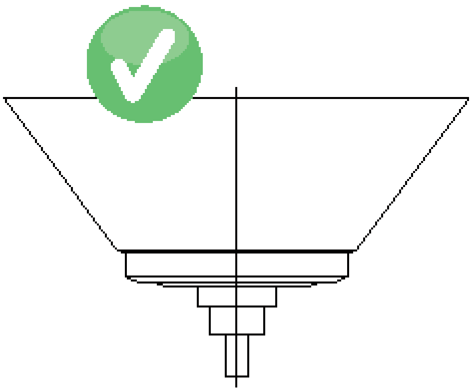

Figure E1 Concentric dielectric

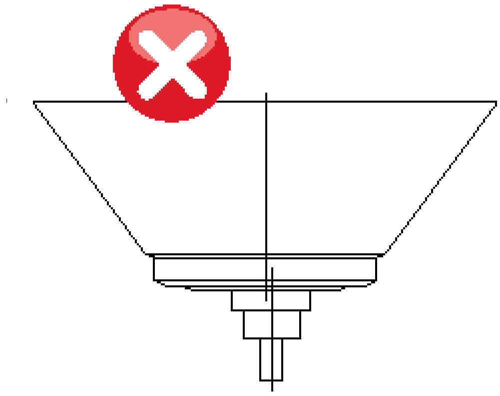

Figure E2 Non-concentric dielectric

3. Radomes

Radomes are used to enclose the antennas; their basic function is to form a protective cover between the antenna and the environment with minimal impact to the antenna's electrical performance. An ideal radome should have enough mechanical strength to protect from wind, rain and ice, and should be electrically transparent to deliver good RF performance.

Considering these requirements, selection of radome materials is of utmost importance. Low-quality antenna manufacturers generally cut costs while compromising on radome quality and data sheets are often published without radome measurements. MNOs are often misled by this practice, and ultimately receive lower field performance as a result.

RFS chooses high-quality radome materials with low dielectric constant and dissipation factors, which minimizes various losses (insertion loss, reflection loss & absorption loss) and optimizes thickness to meet desired RF performances.

Typical Radome High-quality materials minimize various losses

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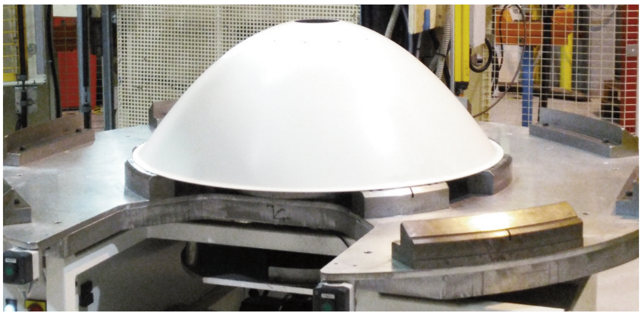
4. Product testing

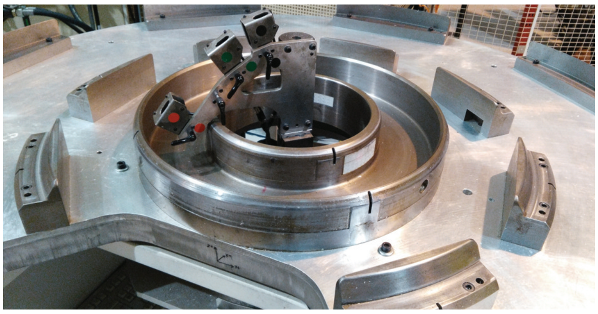
Antenna testing is essential to ensure that it provides the desired performance under every possible condition. Because antenna testing is expensive, low-cost manufacturers tend to avoid it. Often these antenna manufacturers only show test results from a "golden sample," which does not truly represent the overall production product.

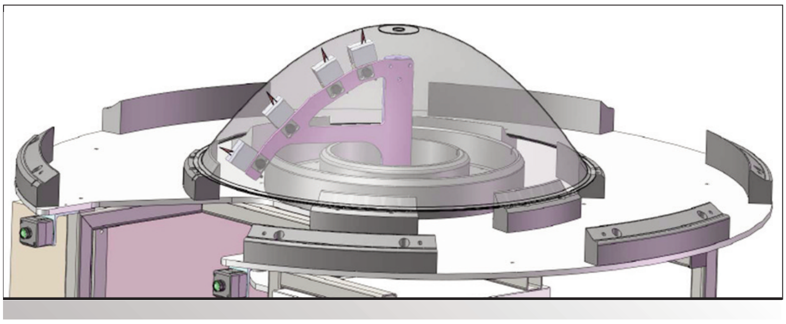
To ensure that every single antenna leaving the factory is of the highest quality, every RFS product goes through stringent quality tests during manufacturing, such as RMS optical measurements (Figure F), RF tests and leakage tests to name a few. RFS also performs rigorous qualification tests for antennas such as far field range tests, wind tunnel tests, and salt mist test, to make sure the antennas perform as desired under any environmental conditions.

Figure F shows the testing setup for Root Mean Square (RMS) optical measurement testing of the reflectors in the antennas' automatic production line. All of the reflectors undergo this stringent test to ensure that the critical parameters of every reflector are precisely controlled to provide the desired electrical performance.

Quality compromises in various antenna parts, such as those detailed above, produce differences in the RPE. Graph 6 compares the radiation pattern of an ETSI Class 3 RFS antenna with a similar antenna from one of the low-cost vendors. As seen in the graph, the radiation pattern of the fake Class 3 antenna is significantly poorer than the RFS antenna.







Figures F RMS or Root Mean Square optical measurement setup in the RFS antenna production line.

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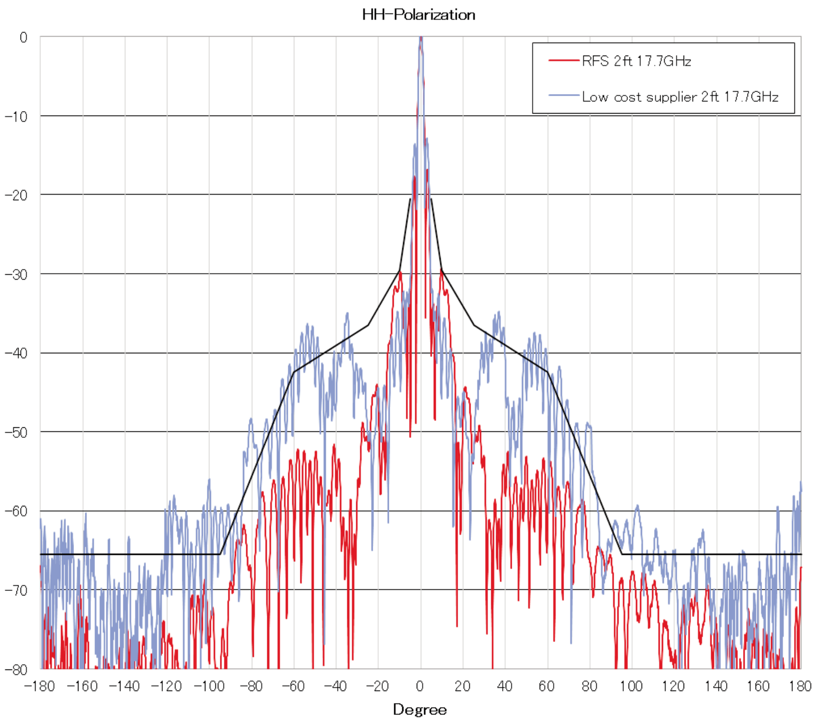

Graph 6 A comparison between the radiation patterns of a fake Class 3 Antenna vs. RFS Class 3 Antenna

The real cost of “low-cost”

The Total Cost of Ownership of a network backhaul system is driven by five key cost factors: frequency spectrum cost, transportation and logistics cost, installation cost, maintenance cost and operation cost. Out of these five key costs, the spectrum and maintenance costs are relatively high expenditures.

For obvious reasons, low-quality antennas cost less upfront, but they can create an overflow of signals, causing interlink interference and lowering the signal-to-noise ratio performance that ultimately produces lower capacity. To compensate for the lower capacity, additional spectrum will be required to establish the link without interference, which will lead to higher total cost of ownership (TCO). Low-cost antennas may appeal to operators considering their performance claims on the data sheets. However, as the previous section explains, their low performance quality significantly negates the initial cost benefits after only a few years of operation. The inferior antenna costs more to the network operator in terms of capacity and quality of service.

It has been observed that a significant proportion of antennas do not comply with their published specifications, mainly the sidelobe gain performance and cross-polar performance. The sidelobe or off-axis gain performance degrades with time, which causes interference and affects the capacity of the link (as shown in Graph 4). It has a negative impact on quality of service as it restricts the ability to reuse the frequency spectrum, and limits the number of links that can be deployed for a given amount of spectrum, reducing operators’ revenue.

Mechanically, low-cost antennas are more prone to rust and carry a risk of faster degradation because of the poor quality of hardware used for manufacturing. Due to poor design, inconsistent quality controls, and insufficient testing, low-quality antennas also carry a high risk of dropping down in the event of inclement weather conditions.

The cost of frequency spectrum, excessive expenditure on maintenance, and diminished product life of low-quality antennas often prove more costly than buying a high-quality antenna at a slightly higher price initially.

A sustainable cost saving strategy

In the current scenario, businesses are under ever-increasing competitive pressure, while markets are more global than ever. Consumers are demanding more and more, and the pressure to reduce prices is high. The telecom industry is in a similar situation with high demand for services, and pressures to reduce the cost of telecom infrastructure. Under these conditions, cost saving is a proven means to enhance profitability and enhance cash flow.

To reduce costs, it is essential to look for certain criteria when choosing a microwave antenna:

- The quality of the antenna – as per the data sheets and real-time performances
- Low Total Cost of Ownership (TCO) – Including frequency spectrum cost, transportation and logistics cost, installation cost, and maintenance cost
- Flexibility to upgrade/change

A few suppliers in the market supply high-quality antennas with lower TCO that essentially reduces costs in the long run. It is also important to have the flexibility to change various parts of an antenna individually instead of changing the whole antenna when upgrades or modifications are needed.

RFS satisfies these criteria for sustainable and strategic cost savings by offering high-quality antennas with a unique, flexible feed design for the CompactLine® and CompactLine® EASY family of antennas. The flexible feed design allows changing of specific antenna parts, and thereby, significantly reduces redesign, upgrade or optimization costs.

Conclusion

All antennas are not equal, and antenna quality plays an important role in determining the efficiency of the overall network backhaul system. Various factors affect antenna performance, which should be assessed carefully before its selection. Deployment of inferior antennas limits a network's capacity and coverage, and eventually reduces the operator's revenue and quality of service.

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Company Profile

Radio Frequency Systems (RFS) is a global designer and manufacturer of cable, antenna and tower systems, plus active and passive RF conditioning modules, providing total-package solutions for wireless infrastructure.

RFS serves OEMs, distributors, system integrators, operators and installers in the broadcast, wireless communications, land-mobile and microwave market sectors.

As an ISO compliant organization with manufacturing and customer service facilities that span the globe, RFS offers cutting-edge engineering capabilities, superior field support and innovative product design. RFS is a leader in wireless infrastructure.