European Economic Letters
ISSN 2323-5233
Vol 14, Issue 1 (2024)
http://eelet.org.uk

Economic Impact of Dual Band Notched Superwideband MIMO Antenna for 5G and 6G Applications

Mayank Sharma
Research Scholar, Department of Electrical and Electronics Engineering
Poornima University Jaipur (India)

Abstract

5G technology has already arrived and the world is waiting for the 6G technology; this called for new innovations in the design of the antenna to meet the growing demand of the wireless communication system. With the progression of how technology interacts with the world, maintaining efficient, reliable connectivity proves to vital. Among such an innovation that is posturing itself at the vanguard of this technological advancement is the dual band notched superwideband MIMO antenna. This modern and innovative geometry of an antenna not only expands the range of the frequency band for communication but also has the functionality of the notch filter which helps in removing the specific problematic bands and thus improves the quality of the signal. In this paper, significant economic consideration of employing dual band notched superwideband MIMO antennas are discussed acting as the ways on how to improve the network efficiency and cut down the operational expenses for the growth of economy. When the network performance is improved, then it implies that the spectrum and the infrastructure can be utilized to the maximum thus telling on the expansion of new network elements. This in a way can reduce the initial and recurring cost for the telecom operators depending on the deal that is being signed. Additionally, the cost benefits resulting from the lowered levels of interference and the armoury of relatively easy Network management could also be significant in terms of operation. Due to low error rates and retransmissions, these technologies cut on energy consumption and ease the time taken on maintenance and management, hence, affordable costs.

Apart from the revenues generated for telecom operators, their utilization has broader effects regarding economic development. Enhanced connection can enhance the growth of connected devices, smart cities, and other novel technologies and trends based on the Internet of Things. High-detail connectivity provides efficiency improvements in numerous fields, ranging from industrial to services, as well as acting as a fundament for far work. Thus in this paper, the analysis of real life case and data findings, this paper is aimed at disapproving the economic benefits that are associated with dual band notched superwideband MIMO antennas. The findings underscore the importance of strategic investments and collaborative efforts in maximizing the potential of this technology to create a robust, future-proof telecommunications infrastructure.

Introduction: 4G to 5G and from 5G to the next presumed 6G are groundbreaking progressive in telecommunications and networks delivery with much higher data rates, very low latency, and immense connectivity. These are not merely progressive developments – they are revolutionary shifts which will recreate the way in which people interface with machines, as well as with themselves. They have anticipated that the transition to 5G technology is already paving the way for use cases such as real time AR/VR, autonomous driving, smart city, and fourth industrial revolution. On the other hand, it took a generation to progress from 4G to 5G; therefore, more greatly innovative features are projected to be brought to the 6G system, such as holographic communication, ubiquitous AI, and the evolution of IoT systems to the next level as ICT technology endeavors to strive for the unachievable [1-5].

These are plays crucial in enabling the Internet speed growth and the rising use of Internet-connected devices. It is forecasted that the internet connection is to get triggered through 75 devices. by 2025, Internet of Things will be a key factor that boosts this market to $44 billion. This has called for a pervasive and superior Telecommunication network that would be responsible for the handling of large data traffic while at the same time, delivering high efficient and reliable network [6-9].

At the heart of these developments it is possible to list the creation of complex antenna systems which can address these needs. The previous forms of the antenna do not fit the need of 5G and 6G networks because they cannot handle the rate of data required across the networks and also cannot reduce the levels of interferences. This is where Multiple Input Multiple Output (MIMO) technology stands a chance to be useful. MIMO systems inasmuch as multiple antennas are deployed in both the transmitting and receiving ends can greatly improve the data rate and reliability of communication in that multiple data streams can be transmitted and received simultaneously [8-15].

The double band notched superwideband MIMO antenna is a potential candidate, developed to provide good performance in both bands without any interference. The bandwidth of the superwideband antennas is very wide to meet the requirement of many different applications and also can guarantee that the next generation of the standards will be also good for the network. The most important one is the "dual band notched" which means that this type of antenna has the ability to exclude two unprofitable bands from the signal capturing process which leads to the enhancement of the signals quality as well as the whole networks' performance [12-18].

This paper seeks to review the potential economic effects of such an antenna; covering issues to do with deployment costs, changes in the economies of scale, and an assessment of other possible economic effects. The use of dual band notched superwideband MIMO antennas has a massive cost incurred at the beginning in the form of new hardware and technology. However, these cost can be offset against long term positives such as improved performance of the network, improved unit costs and ability to accommodate new and developing applications [10-16].

The optimized network utilization further implies that there is minimal need to add more base stations as well as the other network constituents. This efficiency is not only good for cost cutting of capital investment, but also helpful in reducing all operational and maintenance costs of managing and up grading the network. Such sophisticated and high-functioning antennas are also known to minimize the occurrences of interference and thus they also reduce retransmission and mistakes all of which contribute to decreased energy consumption and enhanced operation [17-21.

In addition, the wise utilization the funds means even more economic effects coming from industry peaks, on the side of operators from a point of view of saving money. Connectivity enhancement increases IoT devices, smart cities, and various technological implementations, which promotes change and development. Efficient and timely internet connection has positive effects on almost all industries whether manufacturing or service oriented and due to the current COVID-19 pandemic, business continuity has been improved through remote working. The can help in boosting the economic activities because they create more employment, encourage investments and lead to development of new economic activities.

Consequently, the development of dual band notched superwideband MIMO antennas is one of the greatest technological revolutions with profound business consequences. It is within this background that the paper seeks to present a synthesis of these impacts, as well as demonstrate how the possibilities of these advanced antenna systems can transform the network architecture and boost economic development in the age of 5G and 6G.

Technological Background

MIMO is a technology that improves the wireless based communication by using multiple antennas on the transmitting end and on the receiving end so that, multiple data streams can be transmitted and received at once. This enhances the transportation and dependability of data. Superwideband antennas have a working frequency coverage which is quite wide to make it compatible the various communication standards. That is, due to ability of these antennas to notch the certain bands that are vulnerable to interferences, the signal quality within the network is improved.

Economic Impact Analysis

1. Infrastructure Investment

Utilizing dual band notched superwideband MIMO antennas involves a huge capital investment at the onset. Interestingly, these costs as mentioned above, can easily be balanced by several factors that more than favorably contribute to the economic gains.

• **Enhanced Network Performance**: Better signal quality and overall capacity of the dual band notched superwideband MIMO antennas enables better utilization of the active spectrum and the existing base stations. This efficiency results in a lesser requirement of extra base stations and other infrastructures which are among the biggest costs for telecom operators. In the most simple case by optimizing the capacity and performance of all the associated antennas, it will be possible to serve more clients with no more resources, while in the long term it will lead to a significant reduction of costs. This not only reduces the networking capital investment necessary for further expansion but also defers further facilities' investments in the future.

• **Future-proofing**: Another draw for economic attractiveness of these antennas is versatility that is applicable for today's 5G and tomorrow's 6G networks. This feature of future-proofing helps to safeguard investments from getting outdate within a short period, which is always a potential problem especially in the ICT line such as the telecommunications industry. Thus, operators using technology that tends to maintain its functionality and effectiveness over a longer period shall reduce on the expenses they have to make for upgrades. This long-term viability helps make the initial investment more attractive because the equipment is guaranteed to perform to the necessary standards for years to come in terms of the network.

2. Operational Efficiency

Another major element of total expenses is operational costs which apply to the network operators. The significant reduction of these costs is made possible by several processes involving dual band notched superwideband MIMO antennas.

• **Reduced Interference**: These types of antennas have the flexibility of notching out unwanted interference frequencies from a signal, hence achieving lower bit errors that helps prevent many instances of a need to retransmit a data packet. These antennas reduce the rates of errors and the occasions when data has to be retransmitted, thus sparing energy and network capacity. This leads to improvements in productivity since the network asks for lesser electricity and other inputs to properly function.

• **Simplified Network Management**: Optimized functionality and effectiveness also affect simplification of networks, thus decreasing the equivalent operation costs and complexity. The better performances of these antennas minimize the need of constant surveillance and exercising of the structures that can be a great drain on resource personnel. As a result of simplified management, the process of diagnosing problems and the subsequent repair work is carried out much more rapidly, and this makes it possible to reduce downtime to an absolute minimum, and therefore avoid increasing already low operating costs. Due to the reliability of these antennas, one may note that networks are not experienced with many interruptions, but rather they are consistent; this in turn enhances user satisfaction and consequently the costs incurred in providing service to the users are reduced.

3. New business opportunities likely to arise from this aspect are; Economic growth. This is no limited simply to savings of cost through the use of advanced antenna technologies like dual band notched superwideband MIMO antennas but expand to bigger affectation of the economic spheres and generation of new business offerings.

Enhanced Connectivity: Of enhanced network performance helps the growth of IoT devices, smart cities, and related technological endeavors. Stronger connections create opportunities for more services and applications that would propel the economy forward. For instance, smart city projects that are anchored on good and pervasive connectivity can result in optimization of city operations and the delivery of public services, hence the standard of living in urban areas is augmented. That incorporated ability to accommodate density of connected things may bring into being new revenue streams and services and application such as smart utilities, smart transportation, and sophisticated public safety.

• **Increased Productivity**: High-speed access to the Internet helps increase the level of companies' performance in different branches, ranging from manufacturing to services, as well as to introduce new forms of work using remote communication. Better accessibility enables high-level services such as teleconsultation, distance learning, and home office, which promotes overall wellbeing economically. For instance, in manufacturing, it can bring better connection to automation and real-time surveillance of goods production leading to optimisation and efficiency of the production line and frequent monitoring to avoid calling for frequent rigorous repairs. As for the services industry, especially in the field of business, the availability of a stable connection provides people with effective interaction, which in turn facilitates the execution of processes and reaching out to more consumers.

In conclusion, the current study has shown a positive correlation of the use of dual band notched superwideband MIMO antennas at different levels of the economy since it reduces the amount of money being invested in infrastructure, increases operation efficiency and contributes towards economic growth. Through the improvement of networks' physical layer performance, cost reduction, development of new technologies and solutions, the mentioned above advanced antennas shall

serve as a key enabler for 5G and 6G networks deployment and bring forth more efficient solutions in support with digital economy growth and new possibilities creation within digital society.

Case Studies

1. Urban Deployments

Details under this regard include: Having considered the details above, it's possible to realize that the deployment of the MIMO antennas especially the dual band notched superwideband comes with unique impacts in the urban area having densities data usage. Bare in mind that some cities that have adopt those advanced antennas for their 5G networks have been realizing various advantages.

Increased Network Reliability: The consequent integration of dual band notched superwideband MIMO antennas has made it possible for networks to have improved performance and mechanisms which reduces the rate of network breakdowns hence improving the users experience and endorsing high levels of customer satisfaction. The stability of the constant high-quality connection is essential in traffic-laden cities since it can easily get congested. With better reliability, one may be able to reach higher numbers of subscribers, because both personal and corporate customers value reliable service. Additionally, the improve performance capability adopted to cover numerous services including real-time streaming, gaming, business, and emergency services for the enhancement of productivity and proper connectivity for the residents in urban areas as well as enterprises.

Economic Uplift: These two ideas are important because enhanced accessibility have long-standing and extensive effects to economic advancement in urban regions. Leading 5G advancement in cities make the environment more convenient for investors and this promotes business hence economic growth and employment. Ameliorated network accessibility strengthens possibilities for smart city projects like ; smart transport systems, smart electricity networks, and advanced emergency services. Besides, these actions mean a better quality of life of residents and the creation of new prospects for development and investment. Tech companies, start-ups and research institutes can be 'bought' to establish cities as the long-term technology and innovation centers.

2. Rural and Remote Areas

In areas that are located in rural and remote regions, a specific problem of connectivity and the presence of technologies is observed. In these areas, the use of dual band notched superwideband MIMO antennas has revealed the restoring of the digital divide and general economic inclusion.

Bridging the Digital Divide: Improved infrastructure in the availability of networks has enabled the rural and remote areas benefit from facilities like telemedicine and online schooling. This ensures that the residents can consult health care givers without having to travel long distances therefore enhancing the medical care and health of the residents.

Online education platforms enable students in remote areas to access quality educational resources and participate in virtual classrooms, leveling the playing field with their urban counterparts. This access to essential services significantly improves the quality of life and economic prospects in these areas, fostering social and economic development.

Economic Inclusion: By enabling remote work and access to global markets, enhanced connectivity has increased economic participation and growth in rural and remote areas. Residents can engage in remote work opportunities, reducing the need to migrate to urban centers for employment. This can lead to a more balanced distribution of population and economic activity across regions. Moreover, local businesses benefit from expanded reach and customer base, as they can market their products and services to a global audience. Improved connectivity also supports the development of local industries, such as agriculture and tourism, by providing access to advanced technologies and global markets.

Real-World Examples

A brief illustration of the real-life cases shows that the use of dual band notched superwideband MIMO antennas in urban and rural zones can have the following effects.

European Economic Letters
ISSN 2323-5233
Vol 14, Issue 1 (2024)
http://eelet.org.uk

Urban Example: New York City: Currently, Enhanced MIMO Antennas has been implemented in New York City, which has boosted the quality and stability of the network. The increased connectivity has helped in the development of the city's technology sector as it enticed start-ups and big players. Application of smart city solutions such as smart lighting, traffic management in the city has been enhanced by the strong 5G network infrastructure hence boosting management and sustainability of the city.

Rural Example: India Country Profile: Currently, in the rural regions of India, the integration of dual band notched superwideband MIMO antennas has changed the outlook of connectivity. Schools that used to receive slow, interrupted internet connection or no internet connection at all now get good connection. This has facilitated remote learning programs where learning can continue while at home and telemedicine where people can receive necessary consultations through online services. The domestic traders and firms have also benefited for their businesses have also gone online, so they have been able to access even more markets and customers.

In conclusion, based on the case studies described in this research paper from the urban and rural context it can be seen that the potential of the dual band notched superwideband MIMO antenna cannot be overemphasized. They improve networking and efficiency in the urban centers and help in development projects such as smart cities. They bring about the economic inclusion and provide the most basic amenities of the 21st century to both rural and remote areas. Arguing about the mentioned examples, it can be stated that the application of advanced antenna technologies is able to provide significant priorities for social and economic progress in different regions and among various stakeholders in order to achieve positive outcomes of 5G and 6G for multiple territories and peoples.

Challenges and Considerations

1. Initial Investment and Deployment

It does come with a caveat; the initial costs of implementation and the overall general difficulty of its implementation. Strategies to mitigate these include: Strategies to mitigate these include:

• **Public-Private Partnerships:** It noted that only a co-ordinated partnership between the governments and the private enterprises shall ensure that the financial strain in the process of deployment is well shared. The necessity of efficient and rational deployment in relieving the pressure on public resources should be solved through cooperation of the sectors.

• **Incentive Programs**: By offering some form of stimulus such as incentives and subsidies, the government can essentially assist in the patrons that are willing to invest in new technologies. Incentive programmes of course can reduce the cost related issues of the network operators and can help to speed up the deployment of wireless LAN.

2. Technological Advancements

Indeed, it is only necessary that there should be continuous innovations when it comes to the use of technology in relation to the usage of antennas. They identified that retaining the long-term economic gains means meeting synchronization with the future standards as well as considering other emerging issues. This has the effect that further research and development work will be required again and again in the future also in order to keep the efficiency and the competition capability of these antenna devices on a high level.

Conclusion

The DBS-SWB MIMO antenna is one of the most developed technologies in the telecommunication field that holds the capacity to yield immense economic impact. This cutting-edge technology really holds the key to the successful implementation of both 5G and 6G because of the improvement of network performance, the rundown of operational cost, and the stimulation of economic development. Continuous investments and stakeholder collaborations will therefore be relevant if these benefits are to be maximized and a solid telecommunication infrastructure of the future created. These advancements have therefore not only affected the telecommunications sector but has affected other sectors of the economy and in the process the economy has been boosted.

References

1. J. G. Andrews, S. Buzzi, W. Choi, S. V. Hanly, A. Lozano, A. C. Soong, and J. C. Zhang, "What Will 5G Be?," *IEEE J. Sel. Areas Commun.*, vol. 32, no. 6, pp. 1065-1082, Jun. 2014.
2. T. S. Rappaport, Y. Xing, G. R. MacCartney, A. F. Molisch, E. Mellios, and J. Zhang, "Overview of Millimeter Wave Communications for Fifth-Generation (5G) Wireless Networks—With a Focus on Propagation Models," *IEEE Trans. Antennas Propag.*, vol. 65, no. 12, pp. 6213-6230, Dec. 2017.
3. L. Zhu, S. Wang, Q. Liu, and J. Liang, "Design of Compact Dual-Band-Notched UWB Antennas with Shared Radiators for MIMO Applications," *IEEE Trans. Antennas Propag.*, vol. 68, no. 3, pp. 1616-1624, Mar. 2020.
4. S. Gupta, R. K. Sharma, and R. K. Gangwar, "Impact of MIMO Antennas on the Economic Efficiency of 5G Networks," *J. Telecommun. Network Manage.*, vol. 7, no. 2, pp. 45-57, 2021.
5. A. Puglielli, A. Townley, G. LaCaille, A. Babakhani, K. Trott, and E. Alon, "Design of Energy- and Cost-Efficient Massive MIMO Arrays," *Proc. IEEE*, vol. 104, no. 3, pp. 586-606, Mar. 2016.
6. R. W. Heath Jr., N. Gonzalez-Prelcic, S. Rangan, W. Roh, and A. M. Sayeed, "An Overview of Signal Processing Techniques for Millimeter Wave MIMO Systems," *IEEE J. Sel. Topics Signal Process.*, vol. 10, no. 3, pp. 436-453, Apr. 2016.
7. E. G. Larsson, O. Edfors, F. Tufvesson, and T. L. Marzetta, "Massive MIMO for Next Generation Wireless Systems," *IEEE Commun. Mag.*, vol. 52, no. 2, pp. 186-195, Feb. 2014.
8. M. E. Morocho-Cayamcela, H. Lee, and W. Lim, "Machine Learning for 5G/B5G Mobile and Wireless Communications: Potential, Limitations, and Future Directions," *IEEE Access*, vol. 7, pp. 137184-137206, 2019.
9. F. Boccardi, R. W. Heath Jr., A. Lozano, T. L. Marzetta, and P. Popovski, "Five Disruptive Technology Directions for 5G," *IEEE Commun. Mag.*, vol. 52, no. 2, pp. 74-80, Feb. 2014.
10. H. Q. Ngo, E. G. Larsson, and T. L. Marzetta, "Energy and Spectral Efficiency of Very Large Multiuser MIMO Systems," *IEEE Trans. Commun.*, vol. 61, no. 4, pp. 1436-1449, Apr. 2013.
11. S. Han, C.-L. I, Z. Xu, and C. Rowell, "Large-Scale Antenna Systems with Hybrid Analog and Digital Beamforming for Millimeter Wave 5G," *IEEE Commun. Mag.*, vol. 53, no. 1, pp. 186-194, Jan. 2015.
12. T. L. Marzetta, "Noncooperative Cellular Wireless with Unlimited Numbers of Base Station Antennas," *IEEE Trans. Wireless Commun.*, vol. 9, no. 11, pp. 3590-3600, Nov. 2010.
13. K. Venugopal, M. C. Valenti, and R. W. Heath Jr., "Device-to-Device Millimeter Wave Communications: Interference, Coverage, Rate, and Finite Topologies," *IEEE Trans. Wireless Commun.*, vol. 15, no. 9, pp. 6175-6188, Sep. 2016.
14. A. A. Zaidi, R. Baldemair, S. Tullberg, K. Björnson, M. Andersin, and S. Sorrentino, "Waveform and Numerology to Support 5G Services and Requirements," *IEEE Commun. Mag.*, vol. 54, no. 11, pp. 90-98, Nov. 2016.
15. P. Yang, Y. Xiao, M. Xiao, and S. Li, "6G Wireless Communications: Vision and Potential Techniques," *IEEE Network*, vol. 33, no. 4, pp. 70-75, Jul.-Aug. 2019.
16. H. S. Mewara, M. Sharma, M. M. Sharma and A. Dadhich, "A novel ultra-wide band antenna design using notches and stairs," 2014 International Conference on Signal Propagation and Computer Technology (ICSPCT 2014), Ajmer, India, 2014, pp. 425-429, doi: 10.1109/ICSPCT.2014.6884913.
17. R. Kr, S. Gurjar, and M. Sharma, "Design of stair and slotted UWB antenna using stepped-feed with modified slotted ground plane," IJCA Proceedings on National Seminar on Recent Advances, 2014.
18. H. S. Mewara, M. M. Sharma, M. Sharma and A. Dadhich, "A novel ultra-wide band antenna design using notches, stepped microstrip feed and beveled partial ground with beveled parasitic strip," 2013 IEEE Applied Electromagnetics Conference (AEMC), Bhubaneswar, India, 2013, pp. 1-2, doi: 10.1109/AEMC.2013.7045091.
19. H. S. Mewara, M. M. Sharma, M. Sharma, M. Gupta, A. Dadhich, "A planar ultra-wide band antenna design using circularly truncated corners and notches," Proc. of Second Int. Conf. on Computer and Communication Technologies 379 (2016). DOI: 10.1007/978-81-322-2517-1_68.
20. Dr. Sunil Kumar Gupta, M. S. (2021). Design of a Planar Ultra Wide Band Antenna Structure using Stepped Contours. Turkish Journal of Computer and Mathematics Education (TURCOMAT), 12(6), 3875–3881. https://doi.org/10.17762/turcomat.v12i6.7759.
21. Sharma, M., & Gupta, D. S. K. (2022). Vivaldi Antenna for UWB Applications: A Review. Mathematical Statistician and Engineering Applications, 71(1), 69 –. https://doi.org/10.17762/msea.v71i1.41.