

# Seamless Connectivity : Exploring the Power of Repeaters for Indoor Cellular Enhancement

White paper



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## Introduction



**Wireless communication has become a necessity for consumers nowadays. The proliferation of mobile devices shows that these devices have an excellent impact on today's society. Individuals, from all walks of life, are becoming more dependent on mobile devices in performing their daily activities.**

Reliance on cellular technology has highlighted the need for seamless and high-quality connectivity in indoor and outdoor environments. Coverage may be relatively easy for outdoor scenarios in well-populated areas. However, when it comes to indoor application, it is expected to hear complaints about dropped calls or spotty reception in certain areas, for example, in the basements, lifts, and staircases. This is mainly due to the poor cell coverage in the affected areas. Signals from the base station located outside of the building are unable to penetrate sufficiently to provide consistent and good coverage inside of the building.

According to the findings from RCR Wireless, it is estimated that 80% of cellular data traffic originates indoors <sup>[1]</sup>. Ericson also states that in urban deployments, most mobile traffic is usually indoors, which is difficult to serve from outdoor base stations <sup>[2]</sup>. Looking at these trends, service providers and building management must take necessary measures to ensure reliable indoor connectivity is available to consumers.

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# Challenges in Cellular Indoor Coverage



It is known that the propagation of the cellular signal can be affected by various factors as it travels from the base station to the end-user equipment. Blockages such as trees, hills, and even bad weather can contribute to transmission degradation. This signal is further attenuated as it penetrates through buildings.

A study conducted in Cyberjaya, Malaysia, shows that the maximum average downlink and uplink data rates from cellular outdoor drive test was 14.3 Mbps and 7.1 Mbps [9]. In contrast, in-building measurements' average downlink and uplink data rates were only 2 Mbps. This shows a significant drop in the cellular network performance between the outdoor and indoor coverage areas.

Several solutions may be considered to enhance indoor coverage. These include using the distributed antenna system (DAS), small cells, and cellular repeater. DAS and small cells are expensive when compared to the latter.

DAS has higher installation and operation costs, while the equipment alone is quite costly for small cells. Although both solutions may have a larger coverage area than cellular repeaters, they come at the expense of more complex setup and maintenance. This paper will show how a cellular repeater can solve indoor coverage issues while leveraging an existing cellular signal as its source.



## Repeater Technology



A repeater system typically comprises a donor antenna, an access antenna, and an active repeater module. For easy understanding, a repeater is a bi-directional amplifier [4] with filtering functions. In the downlink direction, the repeater receives signals from the donor base station, amplifies them, and transmits them to the area of interest. Simultaneously, in the uplink order, the repeater will receive a signal from the user equipment (UE) in the enhanced area and transmit it to the corresponding base station.

For indoor deployment, the donor antenna, also known as the outdoor antenna, is usually placed on the rooftop of the building to ensure a clear line of sight (LOS) with the donor base station. The outdoor antenna receives a weak signal from the base station and sends it to the repeater for amplification. The access or indoor antenna will transmit this enhanced signal to the intended coverage area. With a stronger signal and more extensive coverage area, users can expect fewer dropped calls, uninterrupted services, and improved throughput when using their devices.

Figure 1 shows an example of implementing an indoor cellular repeater for commercial buildings.

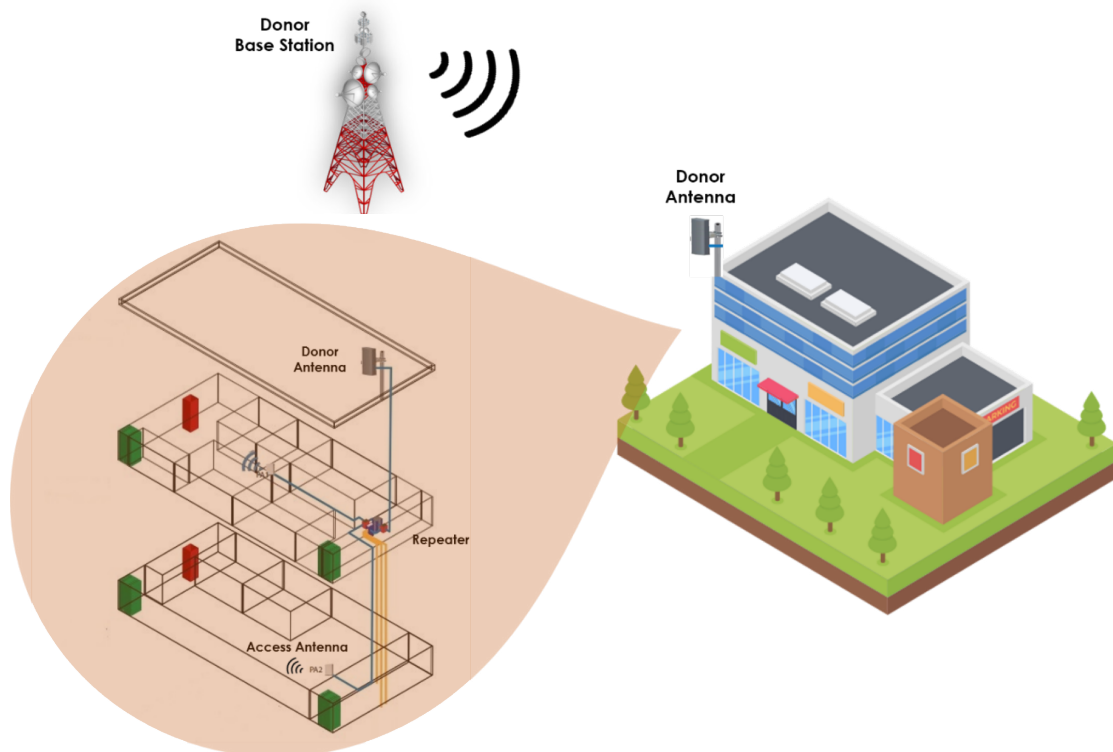


Figure 1: Repeater implementation in extending coverage for indoor application

# SiERA – Signal Enhancer for Remote Area



SiERA is an innovative repeater solution developed by TM R&D that provides a cost-effective and fast rollout for 4G coverage extension. The target market is Mobile Network Operators (MNOs), which aim to solve coverage gaps and user complaints about 4G network performance. SiERA repeater has been tested in both indoor and outdoor applications. Currently, SiERA works for LTE FDD Band 5 and LTE TDD Band 40.



Figure 2: SiERA Repeater

## SiERA Indoor Use Case



In June 2023, SiERA was successfully deployed at a POC (proof-of-concept) site at the TM CBJ2 office building in Cyberjaya, Selangor.



Figure 3: TM CBJ2 Building

In the POC, SiERA was installed at the 4-level office building to improve the 4G indoor coverage for UNIFI mobile users. The POC's objective was to ensure good coverage was obtained in the targeted area. In addition, the download speed obtained at the targeted area must be above 2.5Mbps, per the requirement stated in the MCMC's Mandatory Standards for Quality of Service (Wireless Broadband Access Service) in 2021 [5]. In this POC, the access antenna was installed at Level 3 and Level 2 of the building.



Figure 4: Donor Antenna installed at the rooftop



Figure 5: Access Antenna installed at Level 2 and Level 3

The coverage improvement obtained in Level 2 is shown in Figure 6. Before installation of the repeater, most of the signal measured (RSRP) at Level 2 was lower than -95 dBm. VoLTE (voice over LTE) call and throughput test were both unsuccessful. After the repeater installation, the signal level improved, whereby most areas obtained an RSRP level higher than -95 dBm. VoLTE call was successful, and the top download and upload speeds recorded were 33.1 Mbps and 9.75 Mbps respectively.

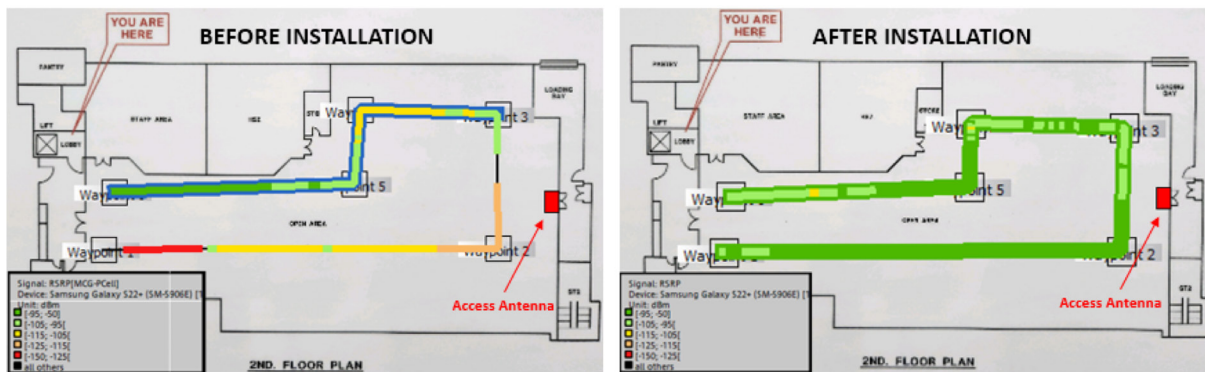


Figure 6: Coverage improvement obtained in Level 2

Similarly, in Level 3, the cellular signal was significantly improved after the repeater was installed. This can be seen in Figure 7. VoLTE and throughput tests that could not be carried out before the installation had also been rectified after the installation. Download and upload speeds as high as 39.4 Mbps and 7.3 Mbps were recorded during the POC.

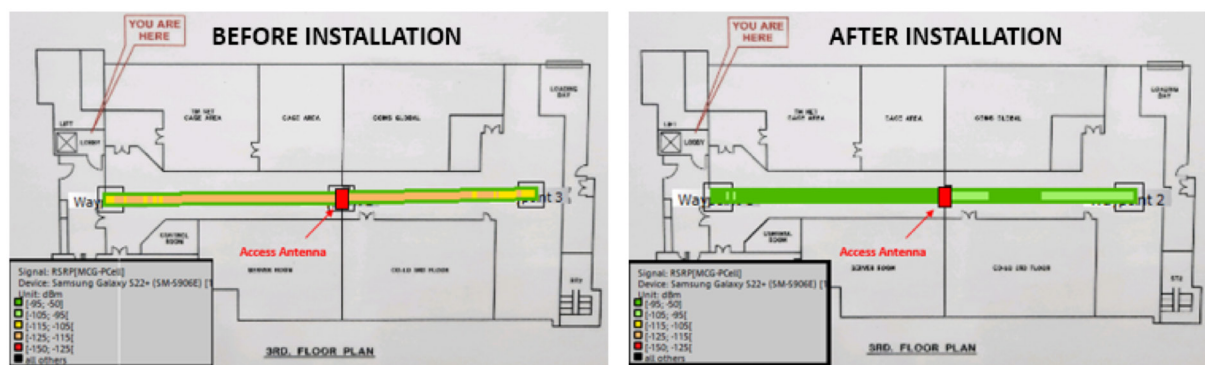


Figure 7: Coverage improvement obtained in Level 3

Based on the coverage improvement observed during the POC, it can be concluded that the indoor repeater solution had effectively improved the indoor cellular coverage in the TM CBJ2 building.

## Conclusion



Reliable indoor cellular connectivity is crucial, especially concerning public safety. Proper planning at the initial stage of building development is required between building owners and service providers to ensure good cellular indoor coverage exists in the area.

When it comes to extending 4G coverage for in-building applications, SiERA is a promising solution. Its fast deployment and cost-effective features make it practical and beneficial to building owners, service providers, and users.

## Reference

1. <https://www.rcrwireless.com/20201124/5g/three-reasons-that-5g-indoor-systems-will-be-needed>.
2. "Planning in-building coverage for 5G: from rules of thumb to statistic and AI", [ericsson.com/mobility-report](https://ericsson.com/mobility-report), June 2021.
3. "Measurement analysis and performance evaluation of mobile broadband cellular networks in a populated city", Alexandria Engineering Journal, Vol. 66, 1 March 2023, pages 927 – 946.
4. Drucker, E. H., "Development and Application of a Cellular Repeater", 38th IEEE Vehicular Technology Conference", USA, 15-17 June 1988.
5. Malaysia Communication and Multimedia Commission, "Jendela: 1st Quarterly Report as of 16 December 2020", 2020.



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Growing from strength to strength since 2016, TM R&D has won multiple global awards and generated more than 2,800 Intellectual Property Rights (IPRs) and 1,400 digital assets to-date.

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