Analysis of TDM PON using Different Data Rates and Longer Reach

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Abstract
Telecommunication's present need for reliable data transmission is more data rates with longer reach capability. These demands and requirements can be met by implementing optical networks. A passive optical network which reduces the amount of fiber and central office equipment required can give the desired improvements. This work analyzes and estimates the performance of TDM-PON Using Different Data Rates and Longer Reach by the use of 16 Users in the Optical Network Unit at the receiver's side.

Keywords
PON: Passive Optical Network; TDM: Time Division Multiplexing; ONU: Optical Network Unit; OLT: Optical Line Terminal; BER: Bit Error Rate

I. Introduction

Optical fiber communications has undergone a fascinating history. Initially, the technology focused on simple transmission links but then quickly moved to increasingly sophisticated networks. Along the way many new components and communication techniques were tried. Some of these were highly successful, some faded away perhaps because of their implementation complexity.

The bandwidth requirements of the telecommunication network users increased rapidly during the recent years. The emerging optical access network must provide the bandwidth demand for each user as well as support high data rate, broadband multiple services and flexible communications for various end-users [1]. Being considered as a promising access network solution due to the high bandwidth provision and the low operation and maintenance cost, passive optical networks (PONs) represent one of the most attractive access network solutions. TDM and WDM techniques are employed in the PON for higher resource efficiency and capacity, which results in TDM-PON and WDM-PON respectively. TDM-PON provides much higher bandwidth for data application but it has limited availability to end-users.

II. Passive Optical Network

Passive Optical Network (PON) is a telecommunications technology that implements a point-to-multipoint architecture, in which unpowered Fiber Optic Splitters are used to enable a single optical fiber to serve multiple end-points such as customers, without having to provision individual fibers between the hub and customer [1].

In most cases, downstream signals are broadcast to all premises sharing multiple fibers. Encryption can prevent eavesdropping. Upstream signals are combined using a multiple access protocol, usually time division multiple access (TDMA) [3].

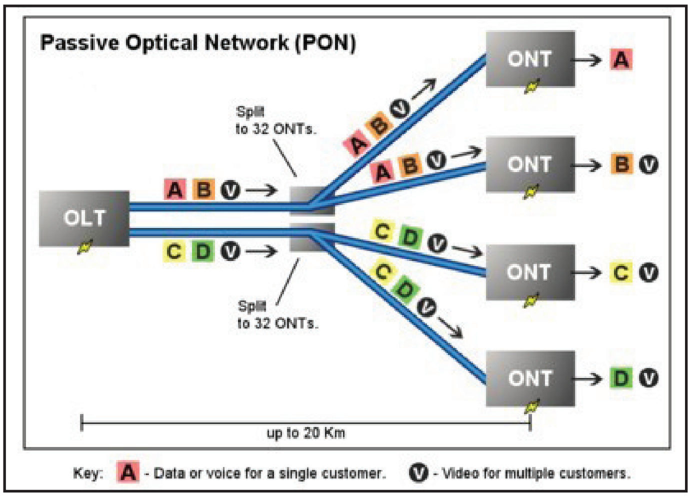


Fig. 1: Block Diagram of PON

III. TDM PON

Fig. 2 shows the he physical tree topology of TDM PON network. At the Central Office (CO) the Optical Line Termination (OLT) transmits the data in the downstream traffic. An optical fiber connects the OLT to the ONU users which is connected through an optical Combiner/ optical Splitter which is a passive component which combines or divides the signal from OLT to ONU [2]. At the user end the ONU used is the optoelectronic component.
The TDM PON is a point to multipoint architecture. In the downstream direction the packets were broadcasted by the OLT. It is passed through a 1: N optical splitter and it is extracted by the designated ONU. The data is sent in the form of packets and each user transmits after a definite time delay. The same time delay is utilized at the destination ONU to distinguish the packets meant for it.

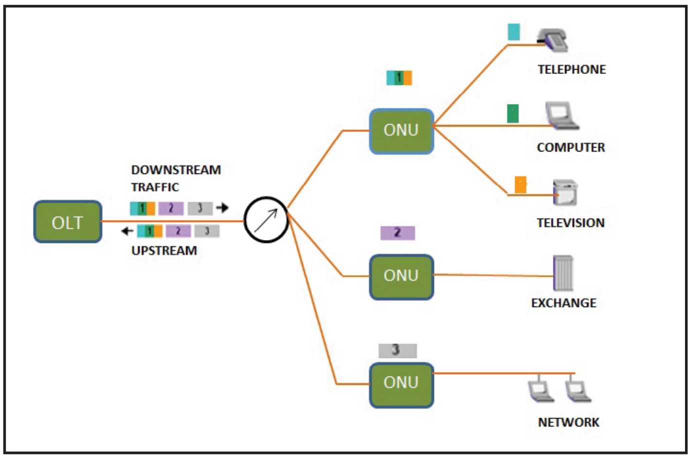


Fig. 2: TDM PON Model

IV. System design

The performance is evaluated using the simulation done in the OptiSystem.13 simulation tool of OptiWave Corporation. To compare the performance of the network we have analyzed BER performance, fiber length and different data rates. The PON network simulated support 16 users with the objective to determine the Q factor and min BER achievable at different data rates and different fiber lengths. Then the comparison of the min BER and max Q factor with the different SMF lengths is done.

A. TDM PON Simulation

The architecture consists of 16 transmitters, a CW laser with a frequency of 193.1 THz, a time delay circuit which provides specific time delay for each transmitter at OLT. The data is sent in the form of packets, with each user transmitting at a specific time interval. Fig. 3(a), shows the TDM architecture. The transmitter consists of a PRBS generator set at 1 Gbit/sec. the bit sequence is modulated using a RZ MachZehnder modulator. The optical signal from each user is then combined using a power Combiner and is sent through the optical fiber (Single Mode Fiber) of length varying from 20 to 100km. At the receiver's end a Power Splitter is used, which directs the optical data signals to each one of the ONU and is synchronized with the specific time delay as given at the OLT. The ONU signals are multiplexed in time sharing basis during the upstream traffic, therefore each ONU transmitter has a fixed time slot with different delay times, by which the ONUs are allowed to transmit data.

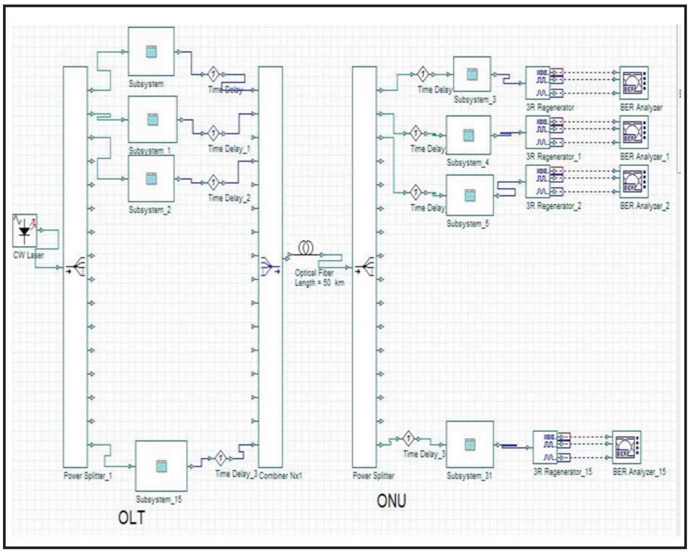


Fig. 3(a): TDM PON Simulation Setup

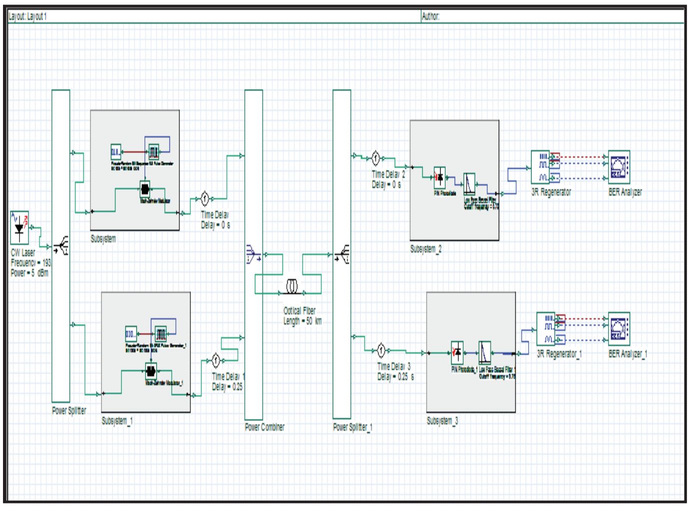


Fig. 3(b): TDM PON Consisting of Only Two Users

The transmitter and the receiver subsystem can be illustrated as:

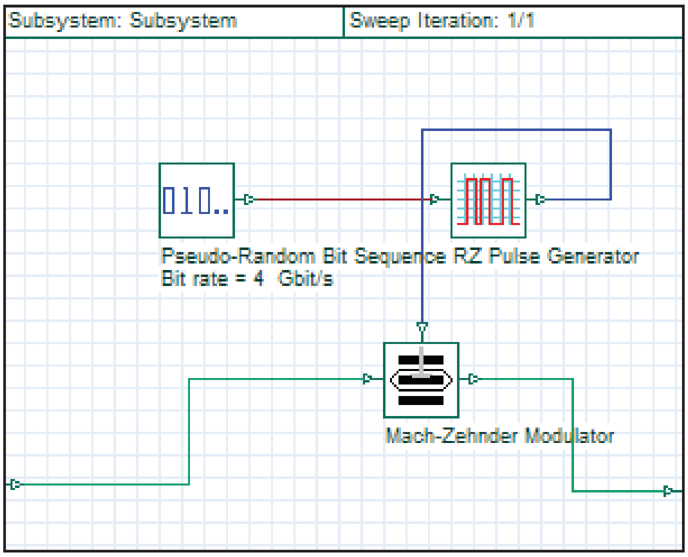


Fig. 3(c): Transmitter Subsystem Block

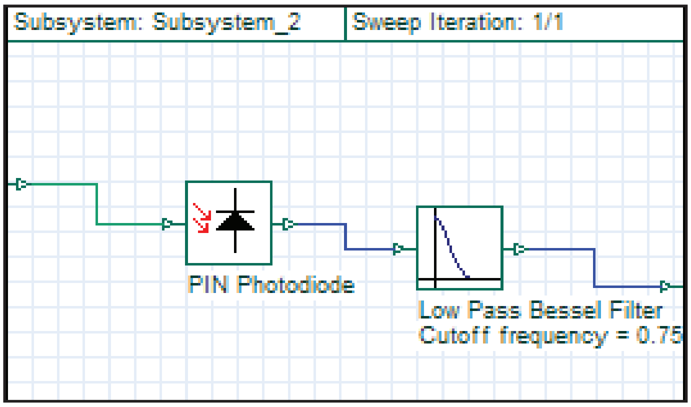


Fig. 3(d): Receiver Subsystem Block

Parameters Required:

Table 1: Parameters and their Values for TDM PON Network

Components	Parameters	
	Type	**Value**
Light Source	Frequency	193.1 THz
	Power	5 dBm
PRBS Generator	Bit rate	2-10 GBPS
Photo Detector	Responsitivity	1 A/W
	Dark Current	10 nA
Modulator	Modulation format	RZ
Time Delay	OLT-1	0 sec
	OLT-2	1/(Bit rate)*1/16 sec
	OLT-3	1/(Bit rate)*2/16 sec
	OLT-4	1/(Bit rate)*3/16 sec (and so on)
Optical Fiber	Fiber length	20-100 km

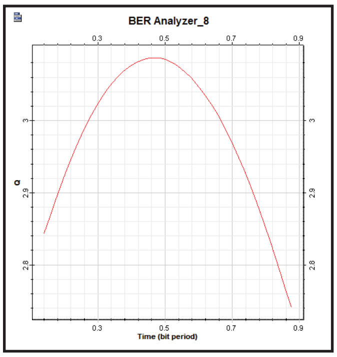
V. Results

We have analyzed the performance of TDM PON for 3 different data rates at two different distances reach. The data rates used are 2.5Gbps, 5Gbps and 10Gbps at 50km and 80km range. The comparison is done on the basis of minimum BER value and maximum Q factor and the best results are recorded.

A. Data rate = 2.5 Gbps

Table 2: Analysis of TDM PON At 2.5 Gbps

Parameters↓ Length →	50km	80km
Time Delay	0.2s	0s
Max Q factor	3.087	3.13306
Min BER value	0.000556362	0.000851925
Eye height	2.23893e-007	6.21219e-008
Threshold	8.77035e-006	2.04612e-006



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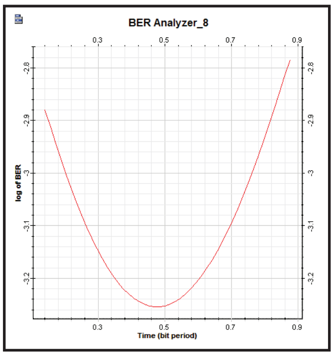

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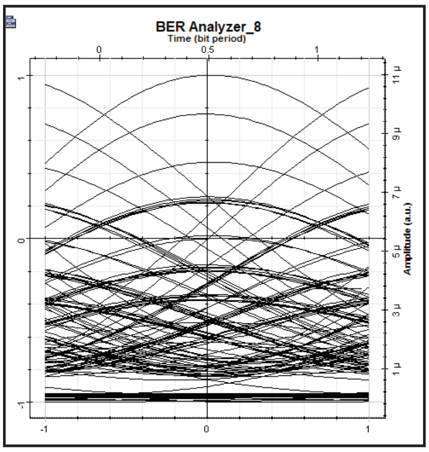

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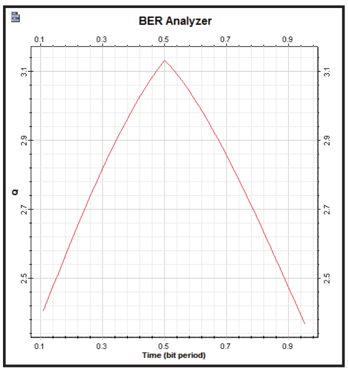
Fig. 4: Q-Factor And BER Value and Eye Diagram At 50 Km, 2.5 Gbps



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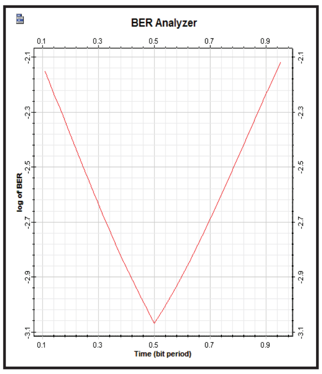

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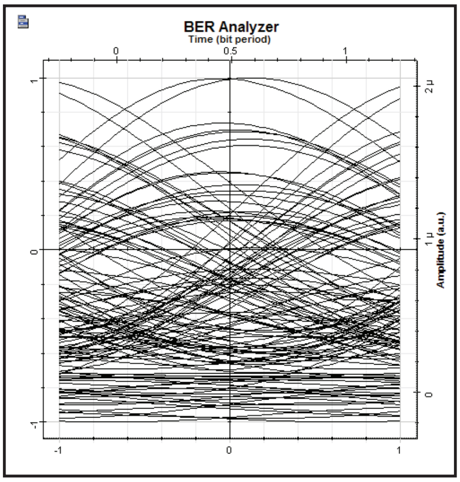

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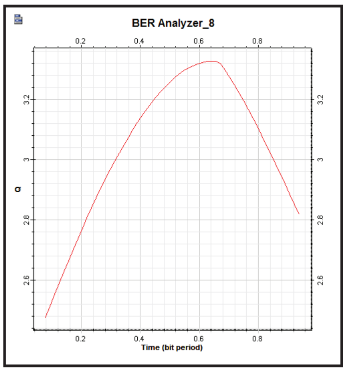
Fig. 5: Q-Factor and BER Value and Eye Diagram at 80km, 2.5 Gbps

B. Data Rate = 5 Gbps

Table 3: Analysis of TDM PON At 5 Gbps

Parameters↓ Length →	50km	80km
Time Delay	0.1s	0.0875s
Max Q factor	3.32787	3.47103
Min BER value	0.000434056	0.000257054
Eye height	4.17752e-007	1.41508e-007
Threshold	6.82629e-006	1.7141e-006



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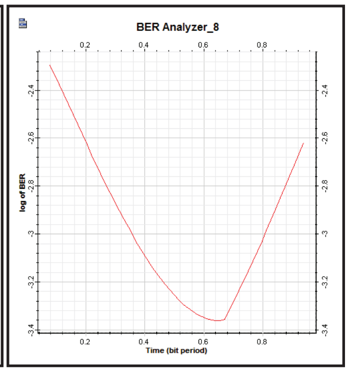

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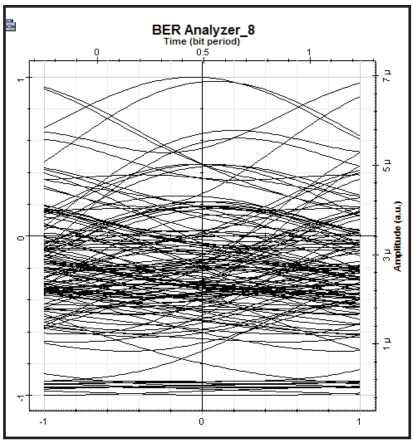

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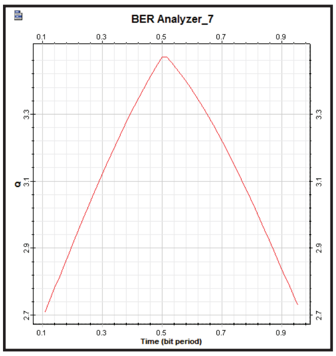
Fig. 6: Q-Factor and BER Value and Eye Diagram at 50km, 5 Gbps



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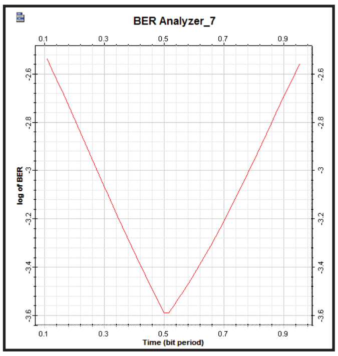

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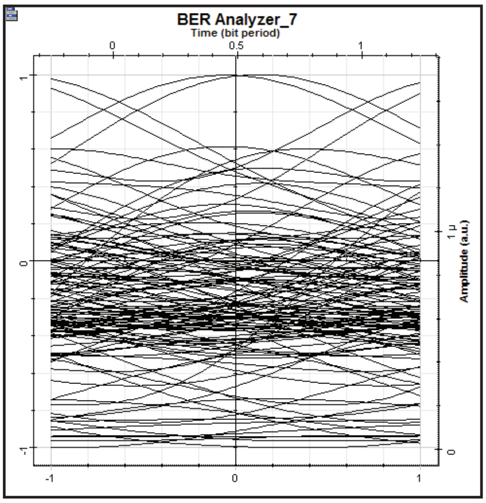

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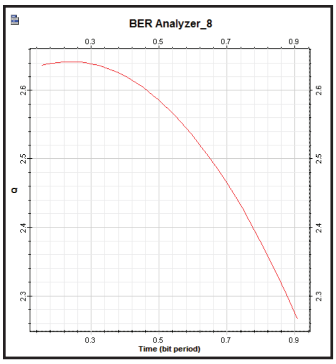
Fig. 7: Q-Factor and BER Value and Eye Diagram at 80km, 5 Gbps

C. Data Rate = 10 Gbps

Table 4: Analysis of TDM PON At 10 Gbps

Parameters↓ Length →	50km	80km
Time Delay	0.05s	0.05s
Max Q factor	2.6418	2.58836
Min BER value	0.00363294	0.00319441
Eye height	-3.27453e-007	-1.07791e-007
Threshold	4.99084e-006	2.04361e-007



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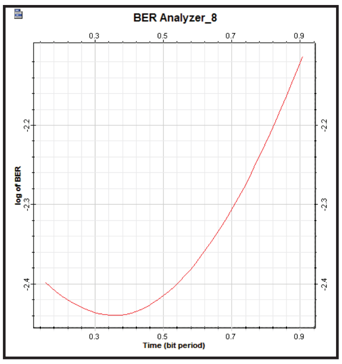

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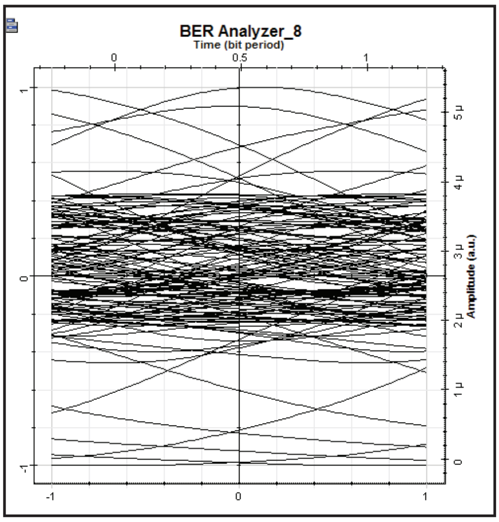

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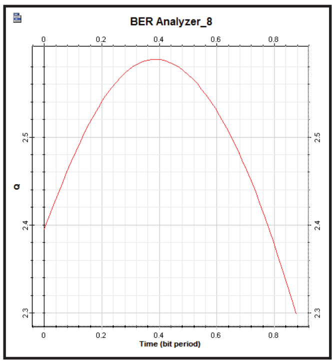
Fig. 8: Q-Factor and BER Value and Eye Diagram at 50km, 10 Gbps



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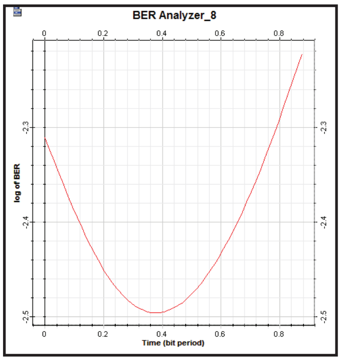

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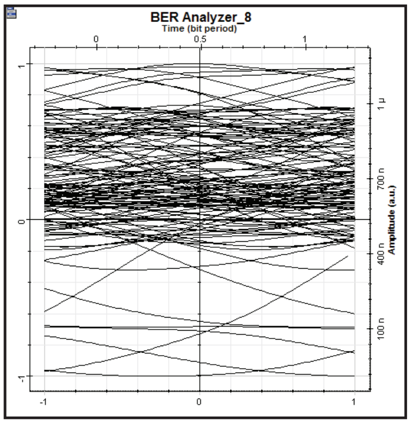

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Fig. 9: Q-Factor and BER Value and Eye Diagram at 80km, 10 Gbps

VI. Conclusion

From the results simulated using OptiSystem.13, we deduced that the best performance of the system is achieved at 5 Gbps in case of 50 kms reach as well as 80kms reach. The data rates have been compared using 2.5, 5, 10 Gbps. If distance is given higher priority in terms of comparison, we can say that longer reach gave better results for Q-factor and BER value.

The system can be extended to WDM PON and OFDM PON architectures using different coding schemes so as to achieve better bandwidth capacity and high data rate capabilities.

References

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