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[Mani Deep Karumanchi](#) , [J.I. Sheeba](#) & [S. Pradeep Devaneyan](#)

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# Triple-Hop Hybrid FSO/mmW Based Backhaul Communication System for Wireless Networks Applications of 5G and beyond

*Mogadala Vinod Kumar, Yenneti Laxmi Lavanya,  
Bharati Bidikar and Gottapu Sasibhushana Rao*

## Abstract

Wireless networks applications of 5G and beyond require high throughput and high capacity. To achieve this, a macro cell is split into several small cells. When using Free Space Optics (FSO) some of the small cell base stations (BSs) which are located at the edges of a macro cell may not directly communicate with the base station of that macro cell, resulting in high outage probability (OP) and average bit error rate (ABER). Therefore, there is a need to develop a new system model to improve the OP and ABER performance. For such scenarios, triple-hop (TH) hybrid free space optics/millimeter wave (FSO/mmW) system has been proposed by considering neighboring small cell BSs as intermediate relays to forward the backhaul data. The OP and ABER of the proposed TH hybrid FSO/mmW system are derived for various channel conditions and are further verified by performing Monte-Carlo simulations. In this work, FSO link is modeled by Gamma-Gamma distribution over weak and strong turbulence channel conditions. Further the mmW link is modeled by using Nakagami-m distribution which perfectly models various fading scenarios.

**Keywords:** free space optics, millimeter waves, triple-hop, outage probability, average bit error rate, gamma-gamma, Nakagami-m

## 1. Introduction

Mobile cellular traffic has astoundingly increased during the last decade mainly due to the stunning expansion of smart wireless devices and bandwidth demanding applications (i.e., high-definition videos, gaming, social networking, etc.). The overall mobile data traffic is expected to grow up to 77 Exabyte's per month by 2022 which is about a seven-fold increase over 2017 data traffic [1]. In addition, the number of devices and connections will continue to grow exponentially. The fifth generation (5G) networks are aimed at meeting the requirements of mobile communications even beyond 2025. Current backhaul communication of cellular networks uses licensed microwave spectrum and wired copper/fiber based links. These two systems have several limitations (e.g., low data rates, security issues, and high cost of installation in urban canyons). Choosing a suitable technology in the design of the backhaul

# A dual-band U-shaped microstrip antenna for 5G mmWave applications

Chandrasekhar Rao J<sup>1\*</sup>, Srinivasa Rao U<sup>1</sup>, Vinod Kumar M<sup>1</sup> and Sreenivasa Rao D<sup>2</sup>

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**Abstract.** This research proposes a compact dual-band patch antenna for 5G mmWave wireless communication applications. The  $5 \times 4.8 \times 0.508$  mm<sup>3</sup> sized antenna is made of Rogers RT/duroid 5880(tm) dielectric material and is fed via a 50-Ω microstrip feedline. A rectangular slot was used on the radiating patch to create resonance at the 30GHz band from 29.2GHz to 31GHz. Another slot was etched from the ground to obtain another resonance at 49GHz from 48GHz to 50.1GHz. The S<sub>11</sub> of -10dB and VSWR of less than 2 indicates that the designed bands have strong impedance matching capabilities. Peak gain of 4.99 dBi at 30GHz and 7.39 dBi at 49GHz are attained, as well as maximum radiation efficiency of more than 90% and sustained omnidirectional radiation characteristics are achieved. The results demonstrate that the suggested antenna is appropriate for next-generation wireless applications.

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Smartphone use, IoT devices, and speed of network are all expected to significantly rise data traffic as the number of mobile users rises. The current mobile communication spectrum at low frequency bands has several issues with communication speed, such as having a low bit rate, and it won't be able to keep up with the rapid growth in the communication industry soon. Due to rapid development of wireless communication technology, the 2G/3G/4G standard has become widely used. Such bandwidth, however, is insufficient to meet the recently proposed 5G NR standards such as n77 from 3.3GHz to 4.2GHz, n78 at 3.3GHz to 3.8GHz, n79 from 4.4GHz to 5.0GHz, and Millimeter wave (mmWave) bands (>24GHz). Therefore, it is highly desired to develop a 5G terminal antenna with wideband performance to completely cover all 2G to 5G frequencies. In order to support 5G, the FCC separated the frequency range into three bands: below-1 GHz, sub-6GHz band, and Millimeter wave band. The mmWave frequency bands above 24 GHz have an abundance of spectrum that can provide extremely high capacity, extremely high throughput, and extremely low latency [1].

Therefore, several antenna were presented at 5G sub-6GHz and 5G mmWaves [2-10]. In [2], a small, wideband, partially slotted ground, rectangular-patch antenna working at sub-6GHz is presented. For fifth-generation (5G) and long-term evolution applications, a compact multi-slotted patch antenna is suggested in [3]. In [4], a 5G broadband printed dipole antenna operates at 26.5-38.2 GHz with gain around 5dBi is presented. A wideband, low-profile antenna-in-package (AiP) design is presented for 5G mmWave n257 (26.5–29.5 GHz) band mobile applications in [5]. [6] presents an antenna-in-package (AiP) with endfire and dual polarisation operating at 28 GHz. A new miniaturized dual-band quarter-wave half-slot antenna for quasi-millimeter wave applications that operates at 24



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# A Fork Shaped UWB Antenna with WLAN/Wi-MAX/ X Band Rejection Characteristics

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- III. Results and Discussion
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##### Abstract:

A novel fork shaped patch antenna for UWB (Ultra-wide Band) products is devised on 27 X 27 X 1.6 mm<sup>3</sup> FR4 epoxy substrate. Slots are inserted in the partial ground plane to improve the bandwidth of the antenna. Three band stop functions are accomplished by carving slits in the ground plane, feed line, and radiating element at 5.15–5.85 GHz (WLAN), 3900–4200 MHz (C-band satellite communication), 3.3–3.75 GHz (Wi-MAX), and 7900–8400 MHz (X-band satellite communication frequency). All slots are optimized by parametric analysis. The proposed antenna showing good impedance bandwidth stretching from 3100 to 10600 MHz. The prototype shows good radiation characteristics and observed good match between simulated and experimental results.

**Published in:** 2023 International Conference on Computer Communication and Informatics (ICCCI)

**Date of Conference:** 23-25 January 2023

**INSPEC Accession Number:** 23162929

**Date Added to IEEE Xplore:** 24 May 2023

**DOI:** 10.1109/ICCCI56745.2023.10128314

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# Dual-band Micro-Strip Antenna using Split Ring Resonators for ISM Bands

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- II. Related Works
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- IV. Results and Discussion
- V. Conclusion and Future Scope

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**Abstract:** The new generation of communication devices integrated more than one standard into a single system. When the frequency band of the antenna increases, it leads to an incre... [View more](#)

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#### Abstract:

The new generation of communication devices integrated more than one standard into a single system. When the frequency band of the antenna increases, it leads to an increase in antenna complexity. The primary purpose of this dual-band antenna is to achieve a smaller size, enhanced bandwidth and good gain. Initially, the general design equations and parameters are used to design the conventional patch antenna for 2.4 GHz; further, simple modifications (i.e. using slots and split rings) are included in the patch as well as ground to operate the antenna in dual-band mode. ANSYS High-Frequency Structure Simulator software (HFSS) is used to design and assess the proposed antenna for performance evaluation. The Return Loss of the suggested pattern at 2.45 GHz is  $-22.0729$  dB and at 5.8 GHz is  $-27.4999$  dB, whereas VSWR values are 1.17 and 1.08. The maximum gain at the 5.8 GHz band and 2.45 GHz band is found to be 6.511 dB and 3.219 dB, which is good for superior WLAN coverage and other IS M band applications.

**Published in:** 2022 International Conference on Augmented Intelligence and Sustainable Systems (ICAISS)

**Date of Conference:** 24-26 November 2022

**INSPEC Accession Number:** 22540403

**Date Added to IEEE Xplore:** 16 January 2023

**DOI:** 10.1109/ICAISS55157.2022.10010915

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This is to Certify that **Dr. J. CHANDRASEKHAR RAO** of **Bapatla Engineering College, Bapatla** Presented a paper entitled "**Design of Microstrip Patch Antenna for 5G mm-wave Applications**" in the **International Conference on Communications, Signal Processing and Computing (ICCSPC-2023)**, organized by Department of Electronics and Communication Engineering, Bapatla Engineering College, Bapatla, Bapatla (Dt), Andhra Pradesh, INDIA, during 17<sup>th</sup> & 18<sup>th</sup> April 2023.

**Dr. Nazeer Shaik**  
Principal

**Dr. N. Venkateswara Rao**  
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This is to Certify that **Mr. G.MAHESH** of **Bapatla Engineering College, Bapatla** Presented a paper entitled "**Miniaturized Novel Patch Antenna using DGS for Wi-Fi and S-band Applications**" in the **International Conference on Communications, Signal Processing and Computing (ICCSPC-2023)**, organized by Department of Electronics and Communication Engineering, Bapatla Engineering College, Bapatla, Bapatla (Dt), Andhra Pradesh, INDIA, during 17<sup>th</sup> & 18<sup>th</sup> April 2023.

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# Design of Dual Band mm Wave Multiple Input Multiple Output (MIMO) Antenna for Future Wireless Applications

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### Abstract



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- II. Proposed Dual Band mm wave Antenna Design
- III. Result Analysis
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**Abstract:**In this paper, a novel compact dual-band multiple input multiple output (MIMO) antenna is suggested for use in 5G mmWave wireless communication applications. The antenna ... **View more**

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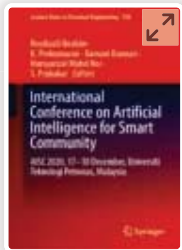
In this paper, a novel compact dual-band multiple input multiple output (MIMO) antenna is suggested for use in 5G mmWave wireless communication applications. The antenna of size  $12 \times 4.8 \times 0.508$  mm<sup>3</sup> which is fed by a 50-microstrip feedline and is designed on Rogers RT/duroid 5880(tm) dielectric material. The proposed antenna comprises of a pair of orthogonally placed elements on top of substrate and a slotted ground on bottom of substrate. On each radiating element, a rectangular slot was employed to produce resonance at the 28GHz band, which spans 27.5GHz to 28.6GHz. In order to obtain a second resonance at 48GHz between 46.6GHz and 49.1GHz, a couple of square slot were cut into the ground. The antenna offers good impedance matching at the working bands with  $S_{11} < -10$ dB. The antenna elements arranged orthogonally to achieve isolation between the ports. To improve the isolation further, a narrow rectangular slot is used on the ground. The antenna provides high isolation of  $>32$ dB, peak gains of 7.8dBi at 28GHz and 5.3dBi at 48GHz, radiation efficiencies of  $>90\%$  at operating bands, omnidirectional radiation patterns, envelop correlation coefficient (ECC) of 0.0016, diversity gain (DG) of 10dB, total active reflection coefficient (TARC) of  $<-6$ dB, mean effective gain (MEG) of -3dB. The results manifests that the proposed design is good choice for 5G mmWave wireless communication applications.

**Published in:** 2023 IEEE Wireless Antenna and Microwave Symposium (WAMS)

**Date of Conference:** 07-10 June 2023

**INSPEC Accession Number:** 23706974






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# Intelligent Control Techniques for Parameter Tuning of PID Controller for LFC with Emphasis on Genetic Algorithm

[B. Venkata Prasanth](#), [Raja Sathish Kumar](#), [Vijaya Krishna  
Boyina](#)  & [K. Ramash Kumar](#)

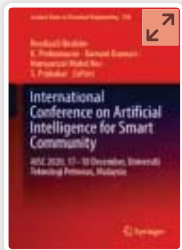
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## Abstract


The theme of this work is carried out to reduce the deviations involved in LFC of a developed system by via GA technique (intelligent controller) deployed PID controller. In MATLAB environment, the system is



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## Environmental Feasibility Survey of Solar Photovoltaic Cells

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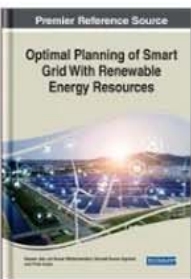
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### Abstract

Sustainable power source advancements presents an  
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the current power energy situation requesting  
practical necessities. Be that as it may, the creation  
cycle of RETs particularly sunlight based photovoltaic  
(SPV) is material what's more, energy costly cycle. In



# Real-Time Monitoring of Smart Meters Based on Blockchain Technology

K. Ramesh, Satya Dinesh Madasu, Idamakanti Kasireddy  
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DOI: 10.4018/978-1-6684-4012-4.ch007

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## Abstract

In this chapter, the authors primarily discuss how blockchain is being utilized in smarter grids across the globe and how some use cases can be a good fit as a technology. They ensure the reliability and uninterrupted power supply to end users by using smart metering in micro and macro grids, which is possible with novel technology that is transparent and without any cyberattacks/hackers: blockchain technology (BCT). In this chapter, BCT is implemented significantly at micro/macro smart grid network. Such a network would give efficient improvement and be interesting.

## Chapter Preview

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## Introduction

In this chapter primarily discuss how blockchain is being utilized in smarter grids across the globe and how some use cases can be good fit as a technology. Currently from a blockchain point of view the energy market is somewhere around USD 180 million dollars and it is expected in next five years it will grow to something like 5000 USD. Different businesses are actually using blockchain for various things but then particularly for financial transactions and interactions because it offers a secure way of secure channel for doing business, managing data and all that now it has really made a significant impact on the operational cost in reducing the operational costs and maintaining the data integrity one can reduce the capital expenditure for that matter in terms of adoption (Gao, 2018). That's the reason why globally the energy markets are looking to blockchain as a long-term solution to most of the problems at the current. As we know, energy segment is facing a couple of key players which are doing some really fantastic work in terms of blockchains in energy segment particularly power ledger. A network of computers now as they are distributed network computers they do not provide any scope for hackers to try and play with the system for two reasons. One is the blockchain is basically a string of blocks connected to each other until acted to each other which are more like in cryptographically hashed right (Berk et al., 2016). So the hash of block 0 will be used to encrypt the block 1 and the hash of block 1 is used to encrypt block 2 and so on. So the point is the

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**"MAJOR ISSUES AND CHALLENGES IN ENGLISH AND ORIENTAL LANGUAGES AND LITERATURES"**

(ఇంగ్లీష్ ప్రాచ్య భాషలు, సాహిత్యాలు - సమస్యలు, సవాళ్లు)

conducted by the Departments of English and Oriental Languages, at Andhra Loyola College

16-18 February 2023.

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# **TEACHING OF ENGLISH**

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# Competency Base Language Teaching: An Outcome Based English Language Pedagogy

Shabreen Sultana Shaik

## Abstract

Competency Based Language Teaching (CBLT) is based on a functional perspective on the nature of language. Language is learnt as a medium of interaction and communication. CBLT is built around the notion of communicative competence and seeks to develop functional communication skills in learners. Competency based pedagogy provides students a choice in what or how they learn, and to demonstrate learning. Prabhu argues that the development of competence in a second language requires not systematization of language inputs or maximization of planned practice but rather the creation of conditions in which learners engage in an effort to cope with communication. 'Outcome' is the central dimension of the process of teaching-learning in CBLT. This chapter explores the outcome based pedagogy to meet the student centered language teaching.

## Introduction

English is a global language and it plays a significant role as the second and official language in many countries. Untrained teachers, rote learning, grammar translation method and overcrowded classrooms are the factors which affect the process of language learning. Competency Based Language Teaching (CBLT) is based on a functional perspective on the nature of language. It seeks to teach language in relation to the social contexts in which it is used. Language always occurs as a medium of instruction and communication between people for the achievement of specific goals and purposes. CBLT is built around the notion of communicative competence and seeks to

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# CHAPTER 27

## NARRATIVE TECHNIQUE OF V. S. NAIPAUL'S SELECT NON-FICTION: AN ANALYSIS

Mr. Suresh Chimata <sup>1</sup>, Dr PVN Malleswara Rao <sup>2</sup>

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### **Abstract:**

This chapter aims to examine the narrative technique employed by V. S. Naipaul in his non-fiction works. Naipaul's unique style of writing has attracted much attention from literary critics and scholars. In his non-fiction works, Naipaul uses various narrative techniques such as self-reflection, historical and cultural analysis, and vivid description to explore complex social and cultural issues. In fact, it is through this genre that V. S. Naipaul has been able to adopt an entirely new style and present his views in a striking and stunning manner. Through an analysis of his non-fiction works, this paper will examine how Naipaul's narrative technique shapes his writing and how it contributes to his unique voice as a writer.

*Key Words: Narrative technique, style of writing, vivid descriptions, self portrait*

### **Introduction:**

V. S. Naipaul is considered one of the most prominent and controversial writers of the 20th century. Born in Trinidad, Naipaul moved to England in the 1950s and became a prolific writer of both fiction and non-fiction works. Naipaul's non-fiction works, in particular, have attracted much attention from literary critics and scholars due to his unique style of writing. In his non-fiction works, Naipaul explores complex social and cultural issues using various narrative techniques. This chapter aims to explore the narrative technique used by Naipaul in three of his major non-fiction works: "An Area of Darkness," "The Wounded Civilization," and "A Million Mutinies Now" and "Turn in the South." Through this analysis, the chapter seeks to demonstrate how Naipaul's narrative technique contributes to the depth, complexity, and intellectual rigour of his non-fiction works.

### **Literature Review:**

Naipaul's non-fiction works have been the subject of much critical analysis. One of the most notable aspects of Naipaul's non-fiction is his use of self-reflection as a narrative technique. According to Bhabha (1995), Naipaul's writing is characterized by "an intense self-consciousness, a self-interrogation that often takes the form of autobiography or self-portrait." Naipaul's use of self-reflection allows him to explore complex social and cultural issues through his own experiences and observations.

Another important narrative technique used by Naipaul in his non-fiction works is historical and cultural analysis. Naipaul often explores the history and culture of the societies he writes about, using his analysis to shed light on contemporary issues. According to Gunesekera (1993), Naipaul's non-fiction works are "an act of investigation and discovery, a search for the root causes of the present in the past."

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