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An evaluation of scintillation index in atmospheric turbulent for new super Lorentz vortex Gaussian beam

Hussein Thary Khamees[1], Ahmed Saad Hussein[2], Nadhir Ibrahim Abdulkhaleq[3]
[1]Department of Laser and Optoelectronic Engineering, College of Engineering, Al-Nahrain University, Jadriya, Baghdad, Iraq
[2]Department of Media Technology Engineering, College of Engineering, University of Information Technology and Communications, Baghdad, Iraq
[3]Department of Mobile Communications and Computing Engineering, College of Engineering, University of Information Technology and Communications, Baghdad, Iraq

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ABSTRACT

Super Lorentz vortex Gaussian beam (SLVGB) is propagated via the turbulent atmosphere parameters. The benefit key of the SLVGB wave model is that the unlimited bandwidth wave and a spherical wave are involved. Additionally, Huygens Fresnel integral was used for schoolwork to study the propagation of SLVGB in a slant direction via a moderate turbulent medium. On the other hand, applying the crude international telecommunication union (ITU-R) model possible. Moreover, the Kolmogorov turbulent power spectrum model is applied, and the source field is dispersed by the zenith angle to the receiver plane. Additionally, examine the contour of the source field and the SLVGB intensity. To investigate various parameters such as source size, mode, scintillation index, topological charge, and others that are associated with the beam of super Lorentz vortex Gaussian are entirely understood, the outcomes were examined, and obtained other references to build the beam of slant path propagation in turbulent; the form constants are especially in comparison and matching. Our graphical findings indicate that the parameters happened randomly in the scintillation index and intensity of the SLVGB, resulting in a novel beam technical configuration. To summarize, this article is advantageous for remote sensing and uses an optical communications system and laser applications.

Corresponding Author:

Hussein Thary Khamees
Department of Laser and Optoelectronic Engineering, College of Engineering
Al-Nahrain University, Jadriya, Baghdad, Iraq
Email: husenthary@eng.nahrainuniv.edu.iq

1. INTRODUCTION

The theoretical and everyday interest that the topic studies [1] are laser propagation in atmospheric turbulence for a lengthy period [2]. These studies of aperture laser beam [3] spreading via the perturbation media in space [4]. So as the Gaussian beam propagation with varied angles [5], and related to properties [6], which phase changing [7] besides, the reduction of the signal occurred in the atmosphere layer of the laser beam due to an absorption and scattering process [8]. Until now, the individual limited papers were dedicated to the vortex beams' excellence in the turbulent atmosphere [9], moreover, study the Bessel Gaussian parameters [10]. By intensity, fluctuations have occurred in a turbulent atmosphere strongly via the layer of space [11]. For example, beam kinds, phase, divergence, coherence, variations, and thus [12]. A diagonal pathway propagated has been examined in turbulent environments, a systematic expression of the average intensity for partly coherent annular beams with displacing from the center or a central location of the field [13].

Trendy [13], the vortex beam is concluded the minor to bigger moody turbulent was imitated and examined [14]. Furthermore, the flat-topped vortex hollow beams of the partly scintillation coherent, no evidence propagate of the atmospheric turbulent. In another instance [3], as like slant path [15]. In atmospheric turbulence, the physical appearance of the beam propagation is affected by the turbulent layer. The diffraction optics, computer-synthesized, holograms beams can be simulated and analyzed, like the Hermite-Gaussian methods [16], also investigated in [17], these steps are improved [18]. The beam order of the Lorentzian beam as a foundation is produced and updated depending on their information. The Lorentz-Gauss beam model is the best compared with the original beam for designing a laser of the photodetector [19]. Super Lorentz beam [20], therefore a super Lorentz Gaussian beam is produced solid atmospheric turbulence, and it's evaluated in higher-order mode [21]. Without turbulence, the Lorentz-Gauss beam is propagated in a vacuum [22]. A refractive index of Lorentz Gaussian beam is spread trick particles procedure of more important than that of the ambient [22]. Newly, moderately coherent occasions, Lorentz Gauss beams are prolonged in [23]. Therefore, the super Lorentz beam is one of the best as the beam has occurred enhancements for a study recently [24]. Supper Lorentz gauss vortex beam is created regulated of the spiral point plate. Lorentz gauss beam is a basis for the benefit via super Lorentz vortex Gaussian beam (SLVGB) over the recent has a perplexing phase display, therefore, the intensity in the center area of shape beam [25]. Finally, the article of our work communicated about the new beam for the research paper to examine the bit error rate, and this work agrees with [23], [24] and corresponds with [26]. The remainder of the paper is laid out as: design the source beam for slant beam propagation of SLVGB and analysis in section 2. Section 3 gives a brief account of the mathematical computations and investigates them. Sections 4 present the conclusions.

2. DESIGN THE SOURCE BEAM FOR SLANT BEAM PROPAGATION OF SLVGB AND ANALYSIS

To begin, a novel mathematical model for SLVGB beams has been developed [27]. The SLVGB's is depicted in (1) as indicated.

$$U_{a,b}(\mathrm{s}, z=0) = \frac{\omega_{1x}\omega_{1y}\left(\chi_1^a + jy_1^b\right)^M}{(\omega_{1x}^2+\chi_1^2)(\omega_{1y}^2+y_1^2)} exp\left(-\frac{\chi_1^2+y_1^2}{\omega_1^2}\right) \quad (1)$$

Where $U_{a,b}(\mathrm{s}, z=0)$ means the initial domain in the source plane, for that's $z=0$ denotes the distance spread, is defined as: ω_{1x}, ω_{1y} are denoted to the Lorentz part of beam source size, s the vector of position is denoted by $\chi_1 + y_1$which its oriented in χ, y the route cartesian coordinate, ω_1 is indicated to the waist Gaussian part, a, b refer to the supper Lorentz part of beam order, M is means to the charge of topological refer to the vortex function, firstly, assume the value of M to be a positive integer greater than or equal to one. Super Lorentz could be used to define a linear superposition function, which is helpful in many situations [25], as illustrated in (2).

$$\frac{1}{(\omega_{1x}^2+\chi_1^2)(\omega_{1y}^2+y_1^2)} = \frac{\pi}{2\omega_{1x}^2\omega_{1y}^2}\sum_{m=0}^{N}\sum_{n=0}^{N} a_{2m}a_{2n}H_{2m}\left(\frac{\chi_1^a}{\omega_{1x}}\right)H_{2n}\left(\frac{y_1^b}{\omega_{1y}}\right) exp\left(-\frac{\chi_1^2}{2\omega_{1x}^2}-\frac{y_1^2}{2\omega_{1y}^2}\right) \quad (2)$$

Wherever, N is the numeral of expressions, H_{2m} (.), H_{2n} (.) signifies a factor of 2 mth and 2 nth order of Hermit polynomials, correspondingly, a_{2m}, a_{2n} are expressed the expansion coefficients by [25] as:

$$a_{2m} = \frac{(-1)^m\sqrt{2}}{2^{2m}}\left\{\frac{1}{m!}erc\sqrt{2}2^{-1}\,exp(\,0.5) + \sum_{n_1=1}^{m}\frac{2^{n_1}}{(2n_1)!(m=n_1)!}\left[\begin{matrix} erc\sqrt{2}2^{-1}\,exp(\,0.5) + \\ \frac{\sqrt{2}}{\pi}\sum_{n_2=1}^{n_1}(-1)^{n_2}(2n_2-3)!! \end{matrix}\right]\right\} \quad (3)$$

Which prepared the (2), (3) into (1), the source field of SLVGB is become as in (4). Where $erfc$ (.) is the balancing fault function, the SLVGB can be selected $M=1$ and beam $order\ a=b=1$ in the source plane, which rearranged the (2), (3) replacing into (1), the source field of SLVGB is become as in (4) and then using (4).

$$U_{a,b}(\mathrm{s}, z=0) = \frac{\pi}{2\omega_{1x}^2\omega_{1y}^2}\sum_{m=0}^{N}\sum_{n=0}^{N}(\chi_1 + jy_1)a_{2m}a_{2n}H_{2m}\left(\frac{\chi_1}{\omega_{1x}}\right)H_{2n}\left(\frac{y_1}{\omega_{1y}}\right) exp\left(-\frac{\chi_1^2}{u_x^2}-\frac{y_1^2}{u_y^2}\right) \quad (4)$$

Moreover, the factor j is equal to either x or y, depending on the case (henceforth). In an atmospheric turbulent environment, it is possible to control the receiver field of a Lorentz vortex Gauss beam using the modified Huygens-Fresnel integral technique, as seen in (5).

$$U_{a,b}(\mathrm{r},\, z=0) = -\frac{jk}{2\pi z}\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} U_{a,b}(\mathrm{s}, z=0)\, exp\left[-\frac{jk}{2z}(r_1-r)^2 + \psi(r_1\text{-r})\right] d_{x1}d_{y1} \tag{5}$$

Where $U_{a,b}(r, z=0)$ called the domain in the receiver plane the $z=L$ indicates the pathway of propagation, r the vector represents the encapsulated location in a receiving plane, and the $k=\frac{2\pi}{\lambda}$ is the wavenumber, λ the wavelength the appearance is $\psi(r_1-r)$ shown the phase position in the random complex. Lastly, the $\langle I(r,L)\rangle$ average intensity of the SLVGB can be calculated using (6).

$$\langle I_{a,b}(r,z\ =\ L)\rangle = \frac{k^2}{4\pi^2 z^2}\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} U_{a,b}(r,z\ =\ L)U^*{}_{a,b}(r,z\ =\ L)\, exp\begin{bmatrix}-\frac{jk}{2z}(r_{11}-r)^2 + \\ \frac{jk}{2z}(r_{12}-r)^2\end{bmatrix} \tag{6}$$

Consequently, as the angle ⟨ ⟩ brackets, over a randomized substrate, the aggregate average identifies patterns and is well-described as complicated stage turbulence $\psi(.)$ in the receiving plane. When (8) and are used together, the spatial power spectrum of refraction's deflective index variations may be described [27], and [7].

$$\Phi_n(\kappa) = 0.33 C_n^2 \kappa^{\frac{-11}{3}} \tag{7}$$

Where $k = k_x^2 + k_y^2$ is the spatial rate, in addition to the scintillation index, is the guess of super Lorentz Gaussian beam in diagonal starting, then we translate the ITU-IR sample of structural invariant into a sense of height h incarnate as [7] and which clarified in (8) as exhibited.

$$C_n^2(h) = 8.148\times 10^{-56} V^2 h^{10} e^{-0.00h} + 2.7\times 10^{-16} e^{-h(1500)^{-1}} + C_0 e^{-0.0h} \tag{8}$$

The framework constant parameter $C_n^2(h)$ is proportional to the grade of the earth-space and estimated in $m^{-\frac{2}{3}}$, then C_0 its expected value ($17\times 10^{-13} m^{-\frac{2}{3}}$), the meter per second is denoted V of rms wind velocity. To end, to estimate the scintillation index, that correlation on the commute (6), (7) into (8), and revised the integration with (3.478.1) from [25]. The most straightforward way to describe the scintillation phenomena is to look at the standardized conflict of the area periods it consolidates, which shows its intensity $I_{a,b}(r,L)$ changes, also named scintillation index ($b_{a,b}^2$) (9) in [7], [20], [21] explains how to describe the on-axis of the SLVGB scintillation index in a gradient route explosive environment.

$$b_{a,b}^2 = \frac{\langle I_{a,b}^2\rangle}{\langle I_{a,b}\rangle^2} - 1 \tag{9}$$

During studying the structural harms caused by wrinkles, one direct effect is that wrinkles fabricate many pseudo minutiae. The minutiae number in the same standard ranges is much higher than that in the smaller standard ranges. As a result, we offer a unique approach for detecting and reconstructing wrinkles in fingerprint images based on the minutia density distribution (MDD). The results show that the method can witness the pairing of minutia and rebuild the next point of ridges effectively.

3. MATHEMATICAL COMPUTATIONS AND INVESTIGATES

From the beginning to analysis, the propagation belongings of an SLVGB in the atmospheric blustery are arithmetically measured via the designs investigated directly in the equations above. Figure 1 denotes the optical system communication diagram that concludes the turbulence and slant path propagation of an SLVGB beam over propagation distances L and zenith angle = 50°. The factors selected in computations are $\lambda = 0.85$ μm and the charge of topological M is equal to one to five numbers, the source size of waist Gaussian is and the source size of Lorentzian, respectively, the structure constant parameter is used for the type ($C_0 = 17\times 10^{-13} m^{-\frac{2}{3}}$). The elevation plane h = 5 km. Moreover, the SLVGB is used to characterize the elements that influence beam order (00, 10, 21, 22, 33). While the factors of SLVGB are divided into two parts, the middle of the part Gaussian is more diverse than the source sizes of the super Lorentz part. The middle of the Gaussian fragment is less diverse than the source sizes of the super Lorentz part, and the middle of the Gaussian fragment is less diverse than the source sizes of the super Lorentz part. To explain the isotropic beam influence of intensity fluctuations, the average measured intensity increases quickly. It reached its maximum value when a certain amount reduced L spread distance. A compressed package will be fashioned afterward the propagation distance L is set to an appropriate value, resulting in the formation of a super Lorentz vortex Gauss in the turbulent atmosphere. Once the elevation distance h is sufficiently great, the Lorentz vortex Gauss meal beam tends to have a Gaussian distribution comparable to that of the Gaussian distribution.

The lowest of the three situations is a super Gauss beam with a Lorentz spiral spread of one, and the most influential is the dispersion of the supper Lorentz vortex Gauss beam with the source size, which is the most influential among the three cases. Furthermore, Figure 2 to Figure 7 are represented the source contour in the transmitter plane of an SLVGB per different beam orders, despite the fact of intensity is collected to the curves of an edge in a contour. While the number of rings is increased the values depend on the beam order of SLVGB. Additionally, these Figure 8 is embodied the scintillation index of an SLVGB by changed beam orders, also, for example, orders (00, 10, 21, 22, 33) are a similar response which means the same profile, but the form of SLVGB that's carried beam order 21 in vertical axis profile and the beam orders of (22, 33) that the manner of the profile same and it is similar, but the power focused in the canter of lopes and its numbered four, we observed that performances all beam orders are lesser. Therefore, in Figure 8 to Figure 9, the curves of the SLVGB beam order that the manners are similar. Additionally, the numbers of topological charges (1–5) are supporting to increase in the performance of the beam, so as the intensity of SLVGB is increased linearly with the rise in the numbers of topological charges (M).

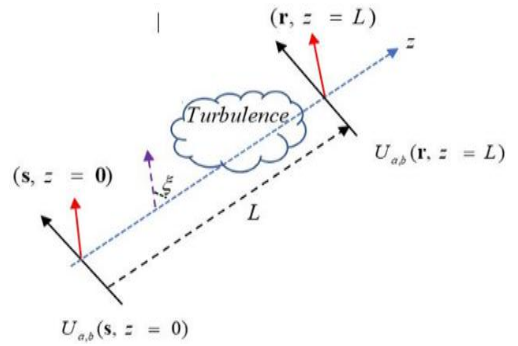

Figure 1. Drawing illustration, the SLVGB spread concluded

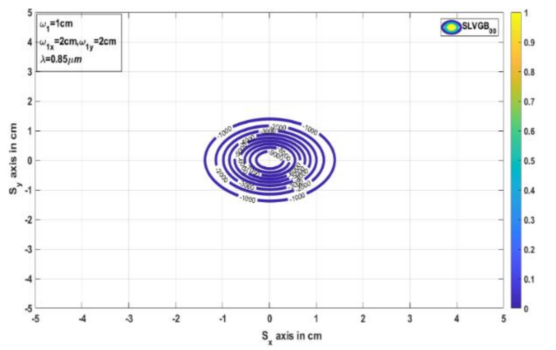

Figure 2. The contour of the source arena of SLVGB creates in spring plane

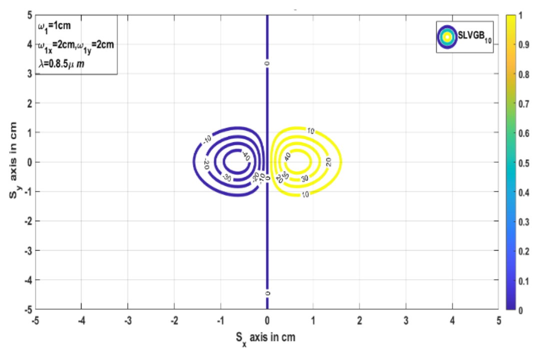

Figure 3. The contour of source intensity propagates an SLVGB in basis level

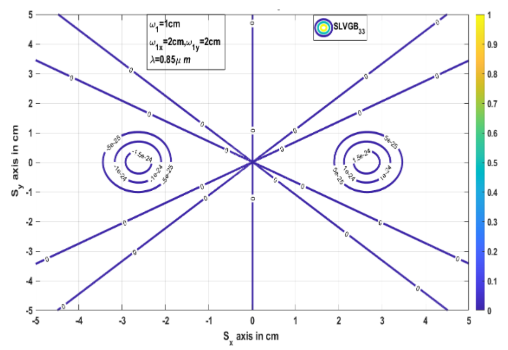

Figure 4. Dual contour of a super Lorentz vortex Gaussian source beam in spring horizontal

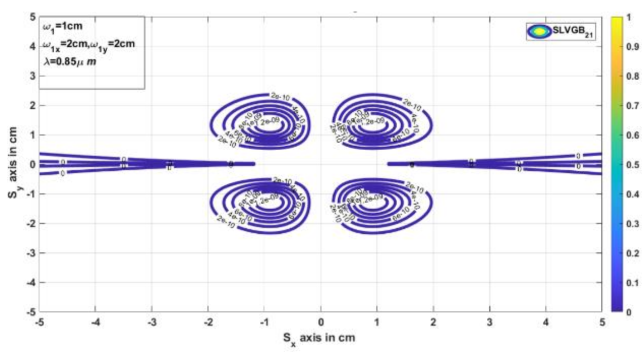

Figure 5. The contour of source intensity propagates an SLVGB at groundwork level

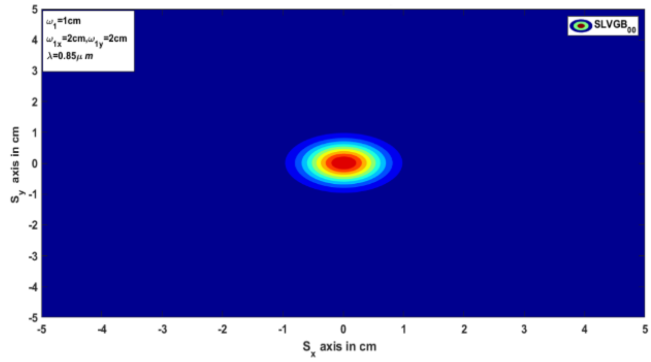

Figure 6. The contour of a super Lorentz vortex Gaussian source beam in spring horizontal

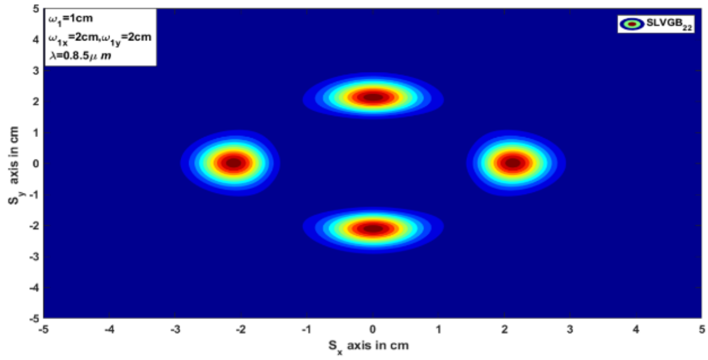

Figure 7. Fourth contour rings of source intensity circulation of an SLVGB spiral plane

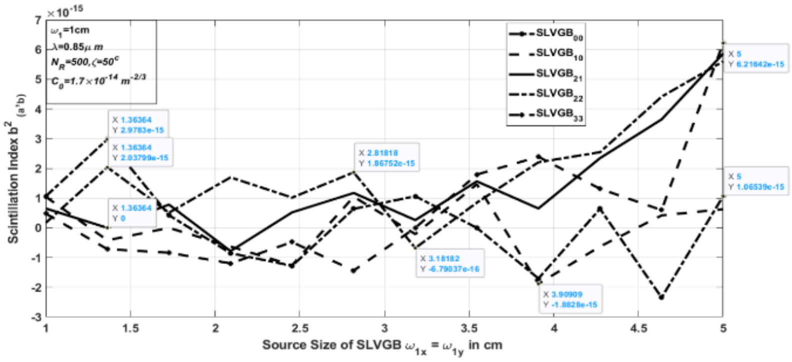

Figure 8. Scintillation index against source size at chosen values of different beam orders for h = 5 km, λ = 0.85 µm, ζ = 50°, and M = 1–5

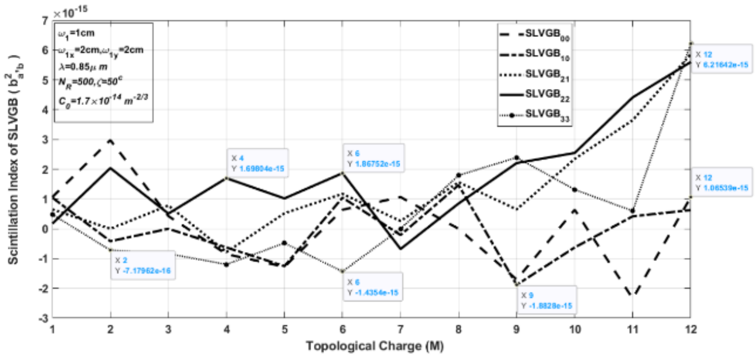

Figure 9. Scintillation index against source size related elected values of different beam orders for h = 5 km, λ = 0.85 µm, and ζ = 50°

4. CONCLUSION

In presumption, we should accessible the propagation characteristics of the slant path focused SLVGB beam mathematically are constructed, and the technique of comprehensive Huygens-Fresnel integral is utilized. Moreover, the scintillation index is measured with various parameters and analyzed using the random phase screen method. Depend on the simulation analysis of an SLVGB. On the other hand, the influenced value of propagation distance L, altitude h, zenith angle, source size, and the topological charge of the beam as researched. Furthermore, static speediness, altitude, grounded structure constant, a topological charge of these values is reverse to propagation wave related to a source sizes of Gaussian fragment and Lorentzian portion. Using the equivalent, the SLVGB with the smaller propagates extra quickly. Per the similar besides, beam, as remembered and set a minor, propagates extra quickly of the specified value. Finally, the article as the study is valuable for applied to remote sensing and the system of optical communications furthermore to laser applications. Additionally, outcomes are obtained and very beneficial for designing and using links to optic wireless communication.

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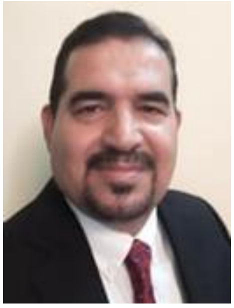
BIOGRAPHIES OF AUTHORS

Hussein Thary Khamees obtained his B.Sc. Electrical Engineering from Al-Mustansiriya University, Baghdad, Iraq (1999). He earned an M. Sc. Bachelor of Laser Engineering from the University of Technology, Baghdad, Iraq (2006). He received his Ph.D. in the Department of Electronics and optical Communications Engineering, Çankaya University, Ankara, Turkey (2018). Finally, he obtained the degree of Associate Professor in January 2022. He can be contacted at email: husenthary@eng.nahrainuniv.edu.iq and husseinthary@gmail.com.

Ahmed Saad Hussein currently works at the Faculty of Engineering, University of Information Technology and Communications. He is a PhD candidate at the School of Computing and Artificial Intelligence, Southwest Jiaotong University, Chengdu, China. He received his MSc. degree in Fundamental Informatics and Information Technology from Southern Ural State University, Russia, in 2014. His BSc. degree in Computer Communication Engineering from Al-Mansour University College, Iraq, in 2009. He can be contacted at email: husseinsaad187@yahoo.com.



Nadhir Ibrahim Abdulkhaleq had his BSC in Electrical Engineering from Cairo-Egypt in 1990 and MSc. in Radar and Communication from the Technology University in Baghdad-Iraq in 1995, and a Ph.D. in Electronics and Communication Engineering from Çankaya University in Turkey in 2017. He currently works as an Asst. Prof. in Department of Mobile Computing and Communications Engineering-College of Engineering University of Information technology & Communications (UTC). He had published several papers in coding theory and wireless sensor networks. He can be contacted at email: nadhir.abdulkhaleq@uoitc.edu.iq.