Investigation of MQAM and MPSK with EGC in Generalized Flat-Fading Channels

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Abstract – **In this paper, performance investigations have been carried out for Equal Gain combining (EGC) multichannel wireless receiver over generalized flat-fading channels. The Generic Gamma fading model has been used here which is versatile enough to represent most of the short term fading conditions as well as long term Shadowing. The Average Bit Error Rate has been evaluated for M-ary QAM and M-ary PSK modulation formats. With the aid of Moment based approach, computationally efficient rational expressions have been derived. Using these novel expressions, the performance of multichannel wireless receiver with EGC and without diversity combining has been evaluated in variety of generalized flat-fading conditions. The results have been validated through simulations which shows perfect match.**

Index Terms—**Equal Gain Combining, Moment Generating Function, M-ary QAM, M-ary PSK, Flat-Fading Channel, Average Bit Error Rate**

I. INTRODUCTION

Wireless systems suffer from detrimental effects introduced by short term fading and long term shadowing. Considerable efforts have been devoted to statistically model these effects. Various multipath fading models have been used in the literature considering different radio propagation environments and underlying communication scenarios [1]. With the ever-increasing demand of ubiquitous access of personal communication services, wireless systems are required to operate in increasingly hostile environments. Wireless system designers have augmented interest in accurate and flexible models for characterizing the fading channels in order to adequately predict the performance of wireless systems. Fading has long been modeled using Rayleigh and Rician models, but they lack flexibility to fit in these new increasingly diverse fading scenarios. Nakagami-m and Weibull distributions based on single fading parameter are widely accepted because they provide better fit with experimental results. These models cover a range of fading scenarios that include Rayleigh distributions as special case and closely approximate the Rician and Hoyt distributions. More importantly, situations are encountered for which none of these distributions seem to adequately fit experimental data, though one or another may yield a moderate fitting [1].This may be attributed to the fact that the well-known fading distributions are derived assuming homogeneous diffuse scattering field, resulting from randomly distributed point scatterers [2]. The assumption of homogeneous diffuse scattering field is definitely an approximation because the surfaces are spatially correlated, characterizing a heterogeneous environment [3]. More recently, a versatile wireless channel model based on two-parameter Generalized-Gamma distribution has gained renewed interest that can generalize almost all commonly used models for multipath fading [4]. This model includes short term fading models such as Nakagami-m, Weibull as special cases and long term shadowing model as the limiting case. Therefore, Rayleigh, Rician and one sided Gaussian also become special cases indirectly. Moreover, the performance analysis of wireless systems using this flexible small scale fading model is valuable because the literature on performance analysis is relatively sparse in this case. Recently, average bit error rate (ABER) closed form expressions for binary phase shift keying and binary frequency shift keying modulations in terms of MeijerG and Fox's-H special functions were presented in [5]. The Generic-Gamma model has also been used recently in [6] for single channel receivers analysis and generalized switched diversity combining system in [7]. However, the detailed and unified performance analysis for the Multilevel digital modulations with EGC wireless receivers operating over Generic-Gamma fading is not available in the open literature and thus is the topic of our contribution. In this paper, Padé method has been used to obtain computationally efficient rational expressions for the moment generating function (MGF). Using these novel expressions, ABER of important multilevel digital modulation schemes with and without EGC diversity combining has been evaluated. Computer simulations are also generated for the result verifications.

The rest of the paper is organized as follows. In the next section, Multichannel Fading model has been presented. Section III details the performance analysis of the system in terms of moments of output SNR, EGC diversity receiver, and error rate. Moments based rational expressions have also been derived in this section. The numerical and simulation results have been illustrated in Section IV, before the paper is finally concluded in Section V.

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II. MULTICHANNEL FADING MODEL

All transmitted and received signals are real while wireless channel models generally assumed to have complex form [2]. Thus, the transmitted and received signals are represented as complex baseband representation of bandpass signals to facilitate analysis. Given $u(t)$ the complex envelope of the transmitted signal, the complex envelope $v(t)$ of the received signal through a linear time-invariant channel can be obtained. With frequency flat-fading assumption where delay spread is small compared to the duration of a transmitted symbol, received signal will be given by $v(t)=u(t)h(t)$. Here $h(t)$ is the complex low pass channel impulse response for the generalized fading channel. The magnitude of the complex fading envelope through channel can be modeled as wide sense stationary random process $x(t)=|h(t)|$ and all frequency components of the received signal will be subjected to same channel gain. The transmitted signal can be assumed to be received through spatial diversity as multiple copies through diverse multilink L independent fading channels as shown in Figure 1. Because of the flat-fading and stationary environment assumption, each channel amplitude and phase at any given time or space are represented as random variables x_l and ϕ_l, respectively. It is also assumed that the channel amplitude, phase and delay associated with each channel are constant over the signaling interval. Thus, the received signal at the l^{th} branch can be written as

$$y_l = x_l e^{-j\phi_l} s(t-\tau_l)+n_l\ ,\ l\in\{1,....,L\} \qquad (1)$$

where $s(t-\tau_l)$ is the delayed transmitted signal, and τ_l is the channel delay and n_l is AWGN with power spectral density $N_l/2$ per dimension. It is assumed that the phase shift introduced by the channel is perfectly tracked at the receiver. Moreover, analysis of systems employing coherent modulations assume that the phase effects due to fading are perfectly corrected at the receiver. While, for non-coherent modulations, phase information is not needed and therefore the phase variation due to fading does not affect the performance in this case. Hence, performance analyses over fading channels require the knowledge of only the fading envelope amplitude statistics. The fading envelope amplitudes $\{x_l\}_{l=1}^{L}$ are assumed to be statistically independent RVs whose mean square values $\{\overline{x_l^2}\}_{l=1}^{L}$ are denoted by $\{\Omega_l\}_{l=1}^{L}$ and whose PDFs are dependent on the variety of wireless channel scenarios. These Generalized fading channels have been modeled here by Generic-Gamma distribution, which can generalize almost all commonly used models for multipath fading [4].

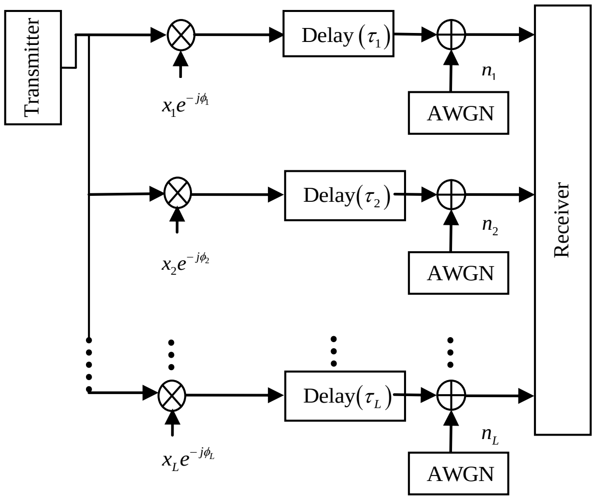

Figure 1 Multichannel Flat-Fading Channel Model.

The PDF of the Generic-Gamma RV is given by

$$p_{x_l}(x_l)=\frac{2v_l x_l^{(2v_l m_l-1)}}{\Gamma(m_l)(\Omega_l/m_l)^{m_l}} exp\left(-\frac{m_l x_l^{2v_l}}{\Omega_l}\right) \qquad x_l\ge 0 \, (2)$$

where v > 0 and m > 0 are fading parameters, Ω_l is the scaling parameter and $\Gamma(.)$ is the Gamma function. The fact that this distribution has one more parameter than the well-known distributions renders it more flexible to better adjust with empirical data. Moreover, this model is based on more realistic heterogeneous scattering environment. For wireless systems, generic gamma model provides a simple way to model all forms of channel fading conditions including shadowing. By varying the two parameters v and m, different fading and shadowing conditions can be described. For instance, v = 1, (2) represent Nakagami-m fading; m = 1, (2) represent Weibull fading; m = v = 1, (2) represent Rayleigh fading. The lognormal distribution used to model shadowing can also be well approximated for limiting case for $m\to\infty$ and $v\to 0$.

III. PERFORMANCE ANALYSIS

It is well known that the performance of wireless communication system, in terms of ABER will depend on the statistics of the output SNR. The received instantaneous signal power in the l^{th} channel is affected by two random processes additive white Gaussian noise (AWGN) and fading power x_l^2. The AWGN is assumed to be statistically independent from the channel fading or complex fading envelope, i.e. $E\left[n_j h_l^*\right]=0$ for j *and* $l\in\{1,....,L\}$ where z^* and $E[z]$ denote the complex conjugate and the average of z. AWGN with identical double-sided power spectral densities is added to each diversity branch signal $(N_l=N_0)$ for any $l\in\{1,....,L\}$.

Moreover, the AWGN is assumed to be uncorrelated between different branches, i.e., $E\left[n_j n_l^*\right] = N_0 \delta_{jl}$, where δ_{jl} is the Kronecker delta function defined as $\delta_{jj} = 1$, and $\delta_{jl} = 0$ for $j \neq l$. Thus, with all aforesaid considerations the instantaneous SNR per bit can be expressed as $\gamma_l = x_l^2 E_s / N_0$. Further, all channel gains are assumed to have same average power, i.e., $E\left[|h_j|^2\right] = E\left[|h_l|^2\right] = \Omega_0$ for any $j, l \in \{1,....,L\}$ and the average SNR per bit will be written as $E[\gamma] = \bar{\gamma} = \Omega_0 E_s / N_0$.

A. Moments of output SNR

The computation of statistical moments of output SNR is required in this analysis. Using (2), and the random variable transformation given in [11] as $p_{\gamma_l}(\gamma_l) = p_{x_l}\left(\sqrt{\Omega_l \gamma_l / \bar{\gamma}_l}\right) / 2\sqrt{\gamma_l \bar{\gamma}_l / \Omega_l}$, the PDF of instantaneous output SNR through l^{th} branch can be obtained as

$$p_{\gamma_l}(\gamma_l) = \left(\frac{\Gamma\left(m_l + \frac{1}{v_l}\right)}{\Gamma(m_l)\bar{\gamma}_l}\right) \frac{v_l \gamma_l^{v_l m_l - 1}}{\Gamma(m_l)} \times exp\left\{-\left(\frac{\Gamma\left(m_l + \frac{1}{v_l}\right)\gamma}{\Gamma(m_l)\bar{\gamma}_l}\right)^{v_l}\right\} \quad \gamma_l \geq 0 \tag{3}$$

To find n^{th} order moment using (3), an integral of the form I, given below

$$I = \int_0^\infty \gamma_l^{n + v_l m_l - 1} exp\left\{-\left(\Gamma\left(m_l + \frac{1}{v_l}\right)\gamma_l / \Gamma(m_l)\bar{\gamma}_l\right)^{v_l}\right\} d\gamma_l$$

need to be solved. By applying transformation $\gamma_l^{v_l} = t$ and using [9, Eq. 3.381.4], in I the closed form expression of n^{th} moment of output SNR through the l^{th} channel can be obtained as

$$E\left[\gamma_l^n\right] = \bar{\gamma}_l^n \frac{\Gamma\left(m_l + \frac{n}{v_l}\right)\Gamma^{n-1}(m_l)}{\Gamma^n\left(m_l + \frac{1}{v_l}\right)} \tag{4}$$

B. EGC Diversity Receiver Analysis

Among the different diversity combining techniques EGC provides intermediate solution in terms of performance and the implementation complexity. In EGC receivers, each signal branch is multiplied by a complex weight and then added up. Each complex weight can be considered as consisting of a phase correction that causes the signal amplitudes to add up coherently, while noise is added incoherently. Further, each branch is real amplitude weighted with same factor, irrespective of the signal amplitude. Thus the decision statistics at the combiner output for equally likely transmitted symbols over generalized gamma faded channels can be given in terms of output SNR as

$$\gamma_{egc} = \frac{E_s}{LN_0}\left(x_1 + x_2 + \cdots + x_L\right)^2 \tag{5}$$

Using the instantaneous SNR in each of the L branches (5) can be rewritten as

$$\gamma_{egc} = \frac{1}{L}\left(\sum_{l=1}^{L}\sqrt{\gamma_l}\right)^2 \tag{6}$$

Using the n^{th} order moment of the EGC output SNR is given as

$$E\left[\gamma_{egc}^n\right] = \frac{1}{L^n} E\left[\left(\sum_{l=1}^{L}\sqrt{\gamma_l}\right)^{2n}\right] \tag{7}$$

Expanding the term $\left(\sqrt{\gamma_1} + \cdots + \sqrt{\gamma_L}\right)^{2n}$ and using multinomial theorem [10, eq. 24.1.2], results in

$$E\left[\gamma_{egc}^n\right] = \frac{(2n)!}{L^n} \sum_{\substack{h_1, h_2, \ldots h_L = 0 \\ h_1 + h_2 + \ldots + h_L = 2n}}^{2n} E\left[\prod_{l=1}^{L}\frac{\gamma_l^{h_l/2}}{h_l!}\right] \tag{8}$$

For statistically independent branches the term $E\left[\prod_{l=1}^{L}\gamma_l^{h_l/2}/h_l!\right]$ can be written as

$$E\left[\prod_{l=1}^{L}\frac{\gamma_l^{h_l/2}}{h_l!}\right] = \prod_{l=1}^{L}\frac{E\left[\gamma_l^{h_l/2}\right]}{h_l!} \tag{9}$$

Using (9), (8) can be reduced to simple expression for the n^{th} order moment of the EGC output SNR as

$$E\left[\gamma_{egc}^n\right] = \frac{(2n)!}{L^n} \sum_{\substack{h_1, h_2, \ldots h_L = 0 \\ h_1 + h_2 + \ldots + h_L = 2n}}^{2n} \prod_{l=1}^{L}\frac{E\left[\gamma_l^{h_l/2}\right]}{h_l!} \tag{10}$$

Thus, the statistical moment of EGC receiver as derived in (10) is dependent only on the statistical moments of the output SNR $E\left[\gamma_l^n\right]$ per branch through the generic gamma faded paths.

C. Average Error Rate Analysis

The statistical moments based error rate analysis has been carried out here for generalized fading channels as described in [6].

$$R^{GG}_{\langle A-1/A\rangle} = \frac{1}{1+s\bar{\gamma}+(2/5)s^2\bar{\gamma}^2+(2/25)s^3\bar{\gamma}^3+(1/125)s^4\bar{\gamma}^4+(1/3125)s^5\bar{\gamma}^5} = \frac{1}{(1+0.2s\bar{\gamma})^5} \quad (12)$$

$$R^{GG}_{\langle A-1/A\rangle} = \frac{1+.04t-.03t^2-0.1t^3-.09t^4-.05t^5-.01t^6-.001t^7-0.5\mathrm{e}^{-4}t^8-1.2\mathrm{e}^{-7}t^9}{1+t+.3t^2-.14t^3-.22t^4-.17t^5-.08t^6-.02t^7-.4\mathrm{e}^{-2}t^8-.3\mathrm{e}^{-3}t^9-.4\mathrm{e}^{-5}t^{10}}$$
$$where\ t=(\bar{\gamma}\mathrm{s}),\ e^{(.)}=10^{(.)} \quad (13)$$

$$R^{GG}_{\langle A-1/A\rangle} = \frac{1+13.7t+88.6t^2+402.6t^3+1382.9t^4+3201.1t^5+4391.6t^6+3163.5t^7+987.6t^8+83.1t^9}{1+14.7t+101.8t^2+486t^3+1755.1t^4+4453.7t^5+7174.4t^6+6714.8t^7+3258.7t^8+658.4t^9+29.9t^{10}} \quad (14)$$
$$where\ t=(\bar{\gamma}\mathrm{s})$$

$$R^{GG}_{\langle A-1/A\rangle} = \frac{1+3.8t+3.4t^2-3.8t^3-8.8t^4-5.6t^5-1.2t^6-0.01t^7+0.64\mathrm{e}^{-3}t^8-0.15\mathrm{e}^{-4}t^9}{1+4.8t+7.5t^2+0.75t^3-11.5t^4-15.4t^5-9.5t^6-3.1t^7-0.5t^8-0.05t^9-0.13\mathrm{e}^{-2}\ t^{10}} \quad (15)$$
$$where\ t=(\bar{\gamma}\mathrm{s}),\ e^{(.)}=10^{(.)}$$

Using this Padé method, tractable rational functions (RAF) are derived for different channel scenarios represented by generic-gamma fading model that represent variety of channel fading conditions such as Rayleigh, Weibull, Nakagami-m and shadowing (in limiting sense) for particular values of parameters *m* and *v*. Moreover, for of *m* = *v* = 1, the RAF found to be in simple closed form given by

$$R^{GG}_{\langle A-1/A\rangle} = \frac{1}{1+s\bar{\gamma}_l} \quad (11)$$

The above closed form expression corroborate exactly with the expression of MGF of output SNR given in [11] for Rayleigh fading channel. Further, in the case of (*m* = 5, *v* = 1) Hankel matrix is rank deficient except for *D* = 5 and the RAF found in this case is given by (12). The closed form expression (12) matches exactly with the MGF of output SNR given in [13] for Nakagami-m fading channel with *m* = 5. Moreover, computationally simple rational expression for other fading scenarios has also been derived. Weibull Fading conditions has been created by using parameter values $m=1$ *and* $v=1.5$ and the corresponding RAF is obtained as (13). In addition to these, even worse than Rayleigh fading condition can also be created with generic gamma model using $m=1$ *and* $v=0.75$, and the expression for such severe fading is computed as (14). In the other extreme, long term fading (shadowing) has also been created with $m=10$, $v=0.5$ and the corresponding RAF has been obtained as (15). Average Error rate analysis of multichannel receiver, over generalized fading channels employing EGC has also been carried out. The expressions for EGC receiver output SNR, $R^{GG_e}_{\langle A-1/A\rangle}$ can be obtained in tractable form using (10) and Padé approach described in [6] as

$$R^{GG_e}_{\langle A-1/A\rangle} = \sum_{n=0}^{2A-1}\frac{(-1)^n}{n!}E\left[\gamma^n_{egc}\right]s^n+O\left(s^{2A}\right) \quad (16)$$

where $E\left[\gamma^n_{egc}\right]$, moment statistics of EGC diversity receiver can be easily evaluated in terms of moments of output SNR $E\left[\gamma^n_l\right]$, that is available as (4) in simple closed function form. The ABER expressions are given below in terms of RAF for the single channel receiver. The conditional BER of MQAM based on signal space approach that are quite accurate at both low and high SNR is given in [12] as

$$P_e(E/\gamma_l) = \frac{4\left(\sqrt{M}-1\right)}{\pi\sqrt{M}\,log_2(M)}\times \sum_{i=0}^{\sqrt{M}/2-1}\int_0^{\pi/2} exp\left(-\frac{(2i+1)^2}{2\,sin^2\varphi}\frac{3log_2(M)}{(M-1)}\gamma_l\right)d\varphi \quad (17)$$

The ABER for square constellation MQAM can be given as

$$P_e(E) = \frac{4\left(\sqrt{M}-1\right)}{\pi\sqrt{M}\,log_2(M)}\sum_{i=0}^{\sqrt{M}/2-1}\int_0^{\pi/2} R^{GG_e}_{\langle A-1/A\rangle}d\varphi \quad (18)$$
$$where\ \ s=(2i+1)^2\,3log_2(M)/2\,sin^2\varphi(M-1)$$

The conditional BER for MPSK suitable for both low and high SNR is given in [12] as

$$P_e(E/\gamma_l) \cong \frac{2}{\pi\,max\left(log_2(M),2\right)}\times \sum_{i=1}^{max(M/4,1)}\int_0^{\pi/2} exp\left(-sin^2\left(\frac{(2i-1)\pi}{M}\right)\frac{log_2(M)}{sin^2\varphi}\gamma_l\right)d\varphi \quad (19)$$

Unconditional BER for MPSK is given by

$$P_e(E) \cong \frac{2}{\pi\, max\left(log_2(M),2\right)} \times \sum_{i=1}^{max(M/4,1)} \int_0^{\pi/2} R^{GG_e}_{\langle A-1/A\rangle}\, d\varphi \qquad (20)$$

$$where\ \ s = sin^2\left((2i-1)\pi/M\right) log_2(M) \big/ sin^2\varphi$$

IV. NUMERICAL AND SIMULATION RESULTS

Numerical evaluation of analytical work done here is required to estimate or quantify the performance characteristics of the wireless receivers with and without diversity over the generalized flat-fading channels. ABER of important Multilevel digital modulations through Generalized fading channel have been numerically evaluated using simple rational functions derived in previous section and compared for accuracy with simulation results. The simulation model used here to generate different channel conditions considers a received signal composed of clusters of multipath components propagating in a non-homogeneous environment. In each cluster of multipath components, the phases of the scattered waves are random and have similar delay times (frequency flat-fading). The number of multipath components can be given at a point by parameter *m* and non-linearity (representative of non-homogeneous scatter field) by the parameter v of the generic gamma model, i.e.

$$x_l = \left(\sqrt{\sum\nolimits_{i=1}^{m} p_i^2 + \sum\nolimits_{i=1}^{m} q_i^2}\right)^{1/v} \qquad (21)$$

where p_i and q_i are independently distributed Gaussian variables with zero mean and unit variance. The expressions for ABER of MQAM and MPSK given in previous section are computed numerically for different channel fading conditions. These numerical results along with simulation results without diversity combining are shown graphically in Figure 2 and Figure 4 for range of fading scenarios, i.e. *m*=1, *v*=0.75 (severe fading); *m* = 1, *v* = 1 (Rayleigh fading); *m* = 1, *v* = 1.5 (Weibull fading); *m* = 1, *v* = 2 (Weibull fading); *m* = 2, *v* = 1 (Nakagami-m fading); *m* = 5, *v* = 1(Nakagami-m fading); *m* = 10, *v* = 0.5 (lognormal shadowing). It can be seen from nearly linear ABER curves contrary to that of exponential decay found in non-fading channels, severe penalty in terms SNR has to be paid due to small scale fading. A simple increase in transmitted signal power to combat this loss may not be practically feasible in many cases due to power constraints. Thus, dual EGC as alternative power efficient diversity technique has been tried here to assess the performance gain. The generic forms of ABER expressions for EGC are evaluated numerically. Computer simulations of ABER with dual EGC for the representative channel fading conditions have been obtained from a sample set of 10,000 values for each SNR. The comparison of these results with no diversity system has also been made in terms of diversity gains at different target ABER values as tabulated in Table I. The ABER results of 16-QAM and 16-PSK with dual EGC used in this diversity gain comparison are depicted in Figure 3 and 5, respectively. It is also apparent from the figures that in general the ABER improves as average SNR per bit ($\overline{\gamma}$) increases and for a fixed value of $\overline{\gamma}$ also, ABER improves with an increase of *v* and/or *m*. Amount of Fading (*AoF*) a statistical moment based fading severity index has been computed here using $AoF = \left(E\left[\gamma_l^2\right]/\overline{\gamma}_l^2\right) - 1$.

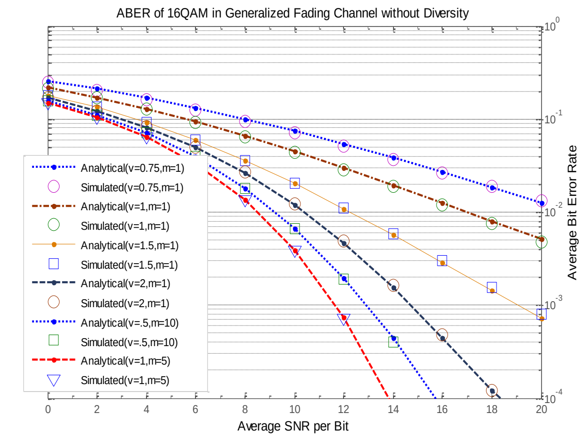

Fig. 2 ABER vs average SNR of 16QAM without diversity

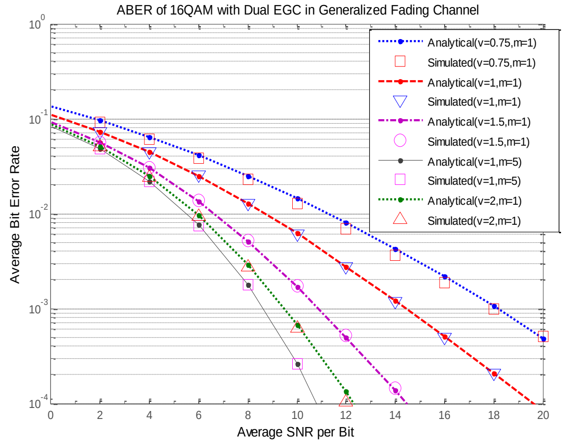

Fig. 3 ABER vs average SNR of 16-QAM with EGC

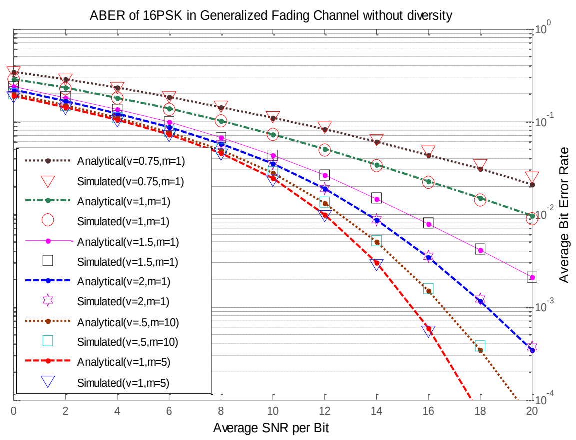

Fig. 4 ABER vs average SNR of 16-PSK without diversity

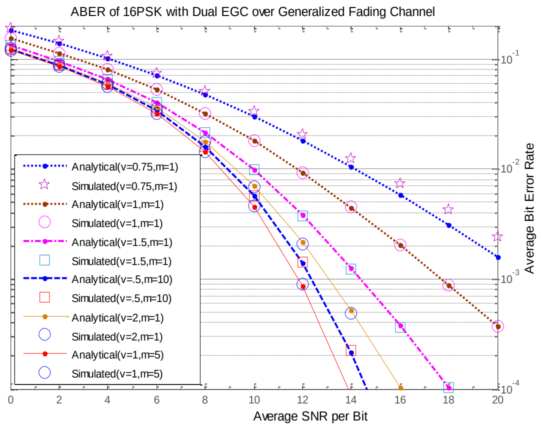

Fig. 5 ABER vs average SNR of 16-PSK with EGC

The comparison of no diversity systems and dual EGC system ABER curves show that the diversity gain is more in case of severe fading (m = v = 1 with *AoF*=1) as compared to the case of less severe fading (m = 5, v = 1 with *AoF* = 0.2). For example, in the case of 16QAM the diversity gain due to dual EGC at target ABER of 10^{-3} , the diversity gain is 9.7dB for severe fading channel that reduces to only 3.2dB for less severe fading conditions. This further verifies that the degradation in performance due to severe fading can be compensated more effectively by using diversity techniques.

Table I Diversity gains (in dB) of with Dual EGC

AoF (Representative Fading model)	***16PSK*** (Target ABERs)		***16QAM*** (Target ABERs)	
	10^{-2}	10^{-3}	10^{-2}	10^{-3}
1(Rayleigh) (m = 1,v = 1)	8.2	9.2	8.2	9.7
0.46(Weibull) (m = 1, v = 1.5)	5.5	7.7	5.4	7.5
0.2(Nakagami) (m = 5,v = 1)	3.0	3.2	1.5	3.1

As evident from depicted results that the numerical results obtained for variety of channel fading conditions obtained using moment based approach used here and computer simulation results show perfect agreement. On the other side, the performance results obtained in [5] for were based on complicated expressions involving Meijer'sG and Fox'sH special functions. Numerical evaluation of the integrals involving such special functions is tricky [11, sec. 2.2.1.5], especially the higher values of fading parameter m and v leads to numerical instabilities and erroneous results. Moreover, the Fox's H special function can't be evaluated using these software packages. Hence, the moments based Padé approach used here not only leads to exact expressions for the special cases but also provide with simple-to-evaluate expressions that resulted in unified performance analysis over generalized flat-fading channels with and without diversity combining. Note that if the accuracy is not satisfactory for some cases, it is always possible to choose a higher value of A to enhance accuracy as long as the Hankel matrix is not rank deficient.

V. CONCLUSIONS

The performance analysis of generalized fading channels with and without diversity combining has been done. The novel Generic-Gamma model used here embodies almost all forms of multipath fading and shadowing. The ABER performance of multilevel digital modulations in variety of fading channel conditions with EGC diversity combining has been investigated. Using moment based Padé method; simple-to-evaluate rational expressions for the MGF have been derived. Numerical and simulation results are presented using Matlab™ to complement the theoretical content of the paper. The results obtained from numerical evaluation of rational expressions and computer simulations shows perfect match. The existence of two fading parameters m and v make it possible to describe different levels of fading individually or collectively. Thus, the Generic-Gamma model and unified analyses presented here provide a significant enhancement in the ability to evaluate the multi-channel wireless system performance over all existing models, including the Rayleigh, Nakagami-m, Weibull and lognormal.

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Call for Papers and Special Issues

Aims and Scope

JAIT is intended to reflect new directions of research and report latest advances. It is a platform for rapid dissemination of high quality research / application / work-in-progress articles on IT solutions for managing challenges and problems within the highlighted scope. JAIT encourages a multidisciplinary approach towards solving problems by harnessing the power of IT in the following areas:

- **Healthcare and Biomedicine** - advances in healthcare and biomedicine e.g. for fighting impending dangerous diseases - using IT to model transmission patterns and effective management of patients' records; expert systems to help diagnosis, etc.
- **Environmental Management** - climate change management, environmental impacts of events such as rapid urbanization and mass migration, air and water pollution (e.g. flow patterns of water or airborne pollutants), deforestation (e.g. processing and management of satellite imagery), depletion of natural resources, exploration of resources (e.g. using geographic information system analysis).
- **Popularization of Ubiquitous Computing** - foraging for computing / communication resources on the move (e.g. vehicular technology), smart / 'aware' environments, security and privacy in these contexts; human-centric computing; possible legal and social implications.
- **Commercial, Industrial and Governmental Applications** - how to use knowledge discovery to help improve productivity, resource management, day-to-day operations, decision support, deployment of human expertise, etc. Best practices in e-commerce, e-commerce, e-government, IT in construction/large project management, IT in agriculture (to improve crop yields and supply chain management), IT in business administration and enterprise computing, etc. with potential for cross-fertilization.
- **Social and Demographic Changes** - provide IT solutions that can help policy makers plan and manage issues such as rapid urbanization, mass internal migration (from rural to urban environments), graying populations, etc.
- **IT in Education and Entertainment** - complete end-to-end IT solutions for students of different abilities to learn better; best practices in e-learning; personalized tutoring systems. IT solutions for storage, indexing, retrieval and distribution of multimedia data for the film and music industry; virtual / augmented reality for entertainment purposes; restoration and management of old film/music archives.
- **Law and Order** - using IT to coordinate different law enforcement agencies' efforts so as to give them an edge over criminals and terrorists; effective and secure sharing of intelligence across national and international agencies; using IT to combat corrupt practices and commercial crimes such as frauds, rogue/unauthorized trading activities and accounting irregularities; traffic flow management and crowd control.

The main focus of the journal is on technical aspects (e.g. data mining, parallel computing, artificial intelligence, image processing (e.g. satellite imagery), video sequence analysis (e.g. surveillance video), predictive models, etc.), although a small element of social implications/issues could be allowed to put the technical aspects into perspective. In particular, we encourage a multidisciplinary / convergent approach based on the following broadly based branches of computer science for the application areas highlighted above:

Special Issue Guidelines

Special issues feature specifically aimed and targeted topics of interest contributed by authors responding to a particular Call for Papers or by invitation, edited by guest editor(s). We encourage you to submit proposals for creating special issues in areas that are of interest to the Journal. Preference will be given to proposals that cover some unique aspect of the technology and ones that include subjects that are timely and useful to the readers of the Journal. A Special Issue is typically made of 10 to 15 papers, with each paper 8 to 12 pages of length.

The following information should be included as part of the proposal:

- Proposed title for the Special Issue
- Description of the topic area to be focused upon and justification
- Review process for the selection and rejection of papers.
- Name, contact, position, affiliation, and biography of the Guest Editor(s)
- List of potential reviewers
- Potential authors to the issue
- Tentative time-table for the call for papers and reviews

If a proposal is accepted, the guest editor will be responsible for:

- Preparing the "Call for Papers" to be included on the Journal's Web site.
- Distribution of the Call for Papers broadly to various mailing lists and sites.
- Getting submissions, arranging review process, making decisions, and carrying out all correspondence with the authors. Authors should be informed the Instructions for Authors.
- Providing us the completed and approved final versions of the papers formatted in the Journal's style, together with all authors' contact information.
- Writing a one- or two-page introductory editorial to be published in the Special Issue.

Special Issue for a Conference/Workshop

A special issue for a Conference/Workshop is usually released in association with the committee members of the Conference/Workshop like general chairs and/or program chairs who are appointed as the Guest Editors of the Special Issue. Special Issue for a Conference/Workshop is typically made of 10 to 15 papers, with each paper 8 to 12 pages of length.

Guest Editors are involved in the following steps in guest-editing a Special Issue based on a Conference/Workshop:

- Selecting a Title for the Special Issue, e.g. "Special Issue: Selected Best Papers of XYZ Conference".
- Sending us a formal "Letter of Intent" for the Special Issue.
- Creating a "Call for Papers" for the Special Issue, posting it on the conference web site, and publicizing it to the conference attendees. Information about the Journal and Academy Publisher can be included in the Call for Papers.
- Establishing criteria for paper selection/rejections. The papers can be nominated based on multiple criteria, e.g. rank in review process plus the evaluation from the Session Chairs and the feedback from the Conference attendees.
- Selecting and inviting submissions, arranging review process, making decisions, and carrying out all correspondence with the authors. Authors should be informed the Author Instructions. Usually, the Proceedings manuscripts should be expanded and enhanced.
- Providing us the completed and approved final versions of the papers formatted in the Journal's style, together with all authors' contact information.
- Writing a one- or two-page introductory editorial to be published in the Special Issue.

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