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Comparison of Bit Error Rate Performance of Multi Tone Channel Utilising De-OQPSK and De-Off Set 16 QAM with Guard Interval

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Abstract: Digital communications systems use Multi tone Channel (MC) transmission techniques with differentially encoded and differentially coherent demodulation. Today there are two principle MC application, one is for the high speed digital subscriber loop and the other is for the broadcasting of digital audio and video signals. In this study the comparison of multi carriers with OQPSK and Offset 16 QAM for high-bit rate wireless applications are considered. The comparison of Bit Error Rate (BER) performance of Multi tone Channel (MC) with offset quadrature amplitude modulation (Offset 16 QAM) and offset quadrature phase shift keying modulation (OQPSK) with guard interval in a fading environment is considered via the use of Monte Carlo simulation methods. BER results are presented for Offset 16 QAM using guard interval to immune the multi path delay for frequency Rayleigh fading channels and for two-path fading channels in the presence of Additive White Gaussian Noise (AWGN). The BER results are presented for Multi tone Channel (MC) with differentially Encoded offset 16 Quadrature Amplitude Modulation (offset 16 QAM) and MC with differentially Encoded offset quadrature phase shift keying modulation (OQPSK) using guard interval for frequency flat Rician channel in the presence of Additive White Gaussian Noise (AWGN). The performance of multitone systems is also compared with equivalent differentially Encoded offset quadrature amplitude modulation (Offset 16 QAM) and differentially Encoded offset quadrature phase shift keying modulation (OQPSK)with and without guard interval in the same fading environment

Keywords: Multi Tone, Fading Channels, Offset16 QAM, Differentially Encoded, Offset QPSK, Wireless and Mobile Communication, Star QAM

INTRODUCTION

The development of multi-tone techniques [2, 4] has allowed the transmission of high quality audio and digital television pictures to be demonstrated from both terrestrial and satellite based systems [5, 6]. The aim of this study is to investigate the comparison of multi tone with OQPSK and with Offset 16 QAM modulation for high-bit rate wireless applications [7, 11]. In order to improve spectral efficiency the use of Differentially Encoded (DE) 16 star Quadrature Amplitude Modulation (QAM) is employed to modulate the parallel carriers [12, 13]. The Multi tone Channel (MC) with OQPSK and Offset 16 QAM is a wideband modulation scheme which is specifically designed to cope with the problems of multi path reception. It achieves this by transmitting a large number of narrowband digital signals over a wide bandwidth. The consequently longer symbol duration renders the system less susceptible to the effects of Inter Symbol Interference (ISI) induced by a frequency selective channel.

Multi Tone System Overview and Signal Generation: In this work the use of multi tone system with OQPSK and Offset 16 QAM modulation (MC) techniques is considered to achieve high bit rate wireless communications [12] The Fast Fourier Transform (FFT) enables the efficient generation and demodulation of multi tone system [9]. Figure 1 shows the block diagram of multi tone with OQPSK and Offset 16 QAM modulation system. The binary input sequence is applied to the offset 16 QAM or OQPSK base band modulator, the output of the modulator is a complex base band In phase (I) and Quadrature (Q) symbol sequence. For the simulations where coherent demodulation is being investigated, In either case, the complex symbol sequence is formed into parallel blocks by the Serial to Parallel (S/P) converter before applying it to the Inverse Fast Fourier Transform (IFFT) [9] which generates the multi tone signal. The resulting out put of the IFFT are consisting of blocks of N complex samples which is then converted into a serial format by the Parallel to Serial converter (P/S) which is applied to guard add circuit before quadrature up conversion to Radio Frequency (RF), then the signal is ready for transmission.
At the receiver, the incoming signal is quadrature down converted before applying it to guard remove circuit. The output of the guard remove circuit is a complex base band received signal. This complex signal is formed into blocks of length N samples by the Serial to

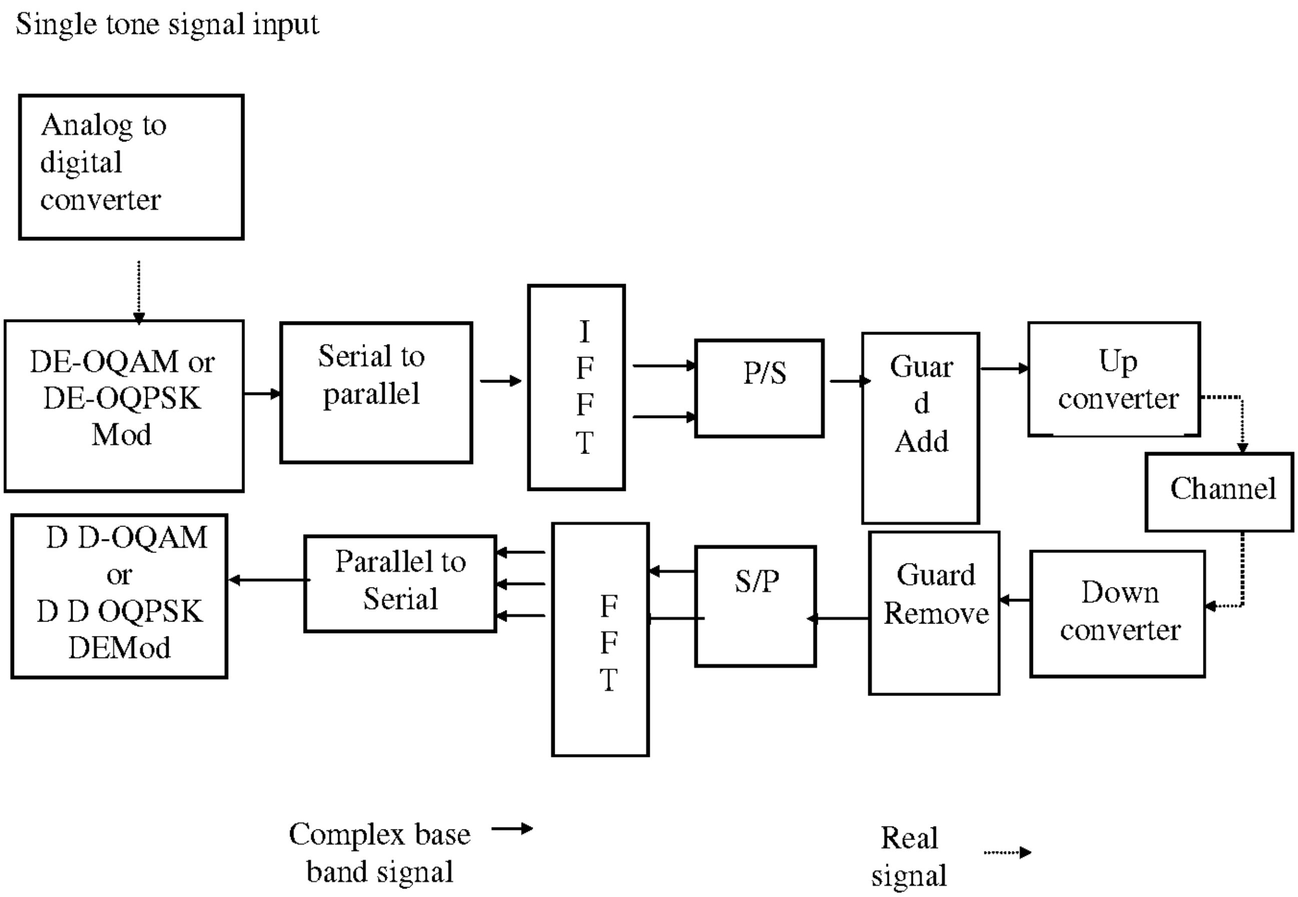

Fig. 1. Multi Tone System Simulation

Parallel converter (S/P) before being Fast Fourier Transformed (FFT) to yield a block of N received complex symbols [9]. These symbols are then converted back in to a serial binary format by the Differentially Decoded (DD) Offset 16 QAM or Differentially Decoded (DD) OQPSK demodulator. When coherent demodulation is being performed, the complex symbols at the output of the P/S converter are then converted back in to the binary serial format by the demodulator. For simulation purposes a Pseudo Random Binary Sequence (PRBS) is applied to the differentially encoded Offset 16 QAM or Differentially Encoded (DE) OQPSK modulator and an error counter is connected to the serial data output and also to the PRBS source, which acts as a reference. In a channel with delay spread, it is often necessary to add a guard period to the transmitted symbols. By preceding each symbol by a guard period to absorb the inter-symbol interference. The guard period must be of limited duration [10], because although a longer guard period gives a more rugged system, it imposes a penalty because of the power required for its transmission.

Fading Channel Models: The comparison of of multi carriers with OQPSK and Offset 16 QAM modulation which is considered the mobile and wireless applications, for this reason, the appropriate radio channel models are chosen to support the simulation process for this work. A typical channel model in land mobile radio is known as frequency flat Raleigh fading. This model is suitable for modeling urban areas that are characterized by many obstructions, e.g., buildings, or any objects surrounding the mobile station where a line of sight path does not exist. In suburban areas, a line of sight path may exist between transmitter and receiver and this will give rise to Rician fading. Rician fading may be characterized by a factor which is defined as the power ratio of the specular a (line of sight or direct path) component to the diffuse components d [8, 15]. This ratio a, defines how near to Rayleigh statistics the channel is. In fact, when the power ratio of the specular $a = 0$ there is a Rayleigh fading and there is no fading at all when $a = \propto$. The rate of change of the fading is defined by the Doppler rate. The Doppler rate is proportional to the velocity of the mobile station and the frequency of operation. The normalized Doppler rate is given by $f_d T_s$ where f_d is the maximum Doppler rate and T_s is symbol duration for Multi tone with OQPSK or Offset 16 QAM modulation. For these work simulations, the symbol duration is equal to one second so that the normalized Doppler rate is equal to the Doppler rate [17]. In general, normalized Doppler rates less than 0.01 are applicable to most systems.

A more complex propagation model includes many discrete scatters, where each propagation path may have a different amplitude, propagation delay and Doppler shift. When the components of a signal are received with different delays, the phase difference between them is a function of the frequency of the components. Thus the transmitted signal will experience a channel with a non-flat frequency response, which also varies with time. This type of channel is said to be frequency selective and is usually modeled as a tapped delay line, where the number of taps is equal to the number of discrete delayed paths. Clearly, the effect of the tapped delay line is to introduce overlap between the transmitted symbols. This form of degradation is known as Inter Symbol Interference (ISI). One simple frequency selective channel model is known as the two path-fading channel. In this model the first arriving path

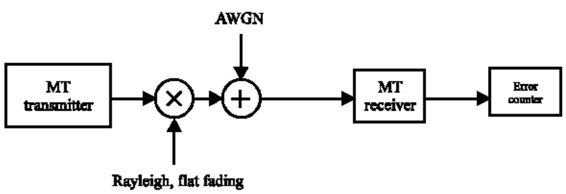

Fig. 2: Simulation Model

experiences Rician fading and the second arriving path (which has a delay set by the delay parameter, z) experiences Rayleigh fading. In addition, we define a ratio (d) between the power in the first path and the power in the second path. In this study, d =15 and the ratio a for the Rician fading path is equal to 15 for all the simulations. Figure 2 shows the simulation model,

Transmitted Signal with Guard Period: In the presence of inter symbol interference caused by the transmission channel, the properties of MC between the signals are no longer maintained. One can approach asymptotically towards a solution to the problem of channel selectivity by increasing indefinitely the number of carriers. However, this method is limited by the temporal coherence of the channel (Doppler effect) or simply by the technological limitation of the phase noise of the oscillators. The second solution sacrifices some of the emitted energy by preceding each symbol by a guard period to absorb the inter-symbol interference. This is achieved using the guard period add block the guard period must be of limited duration [3, 10], because although a longer guard period gives a more rugged system, it imposes a penalty because of the power required to transmit this guard period. Let Δ be the guard period. Therefore the duration of transmitted signal is given by $t_s = \Delta + T_s$. The guard period is added by taking the last four samples of the 16 time domain samples at the output of the IFFT and then inserting them in front of the 16 original samples. Consequently, the total number of transmitted samples is now 20 samples per symbol block. The complementary block in the receiver is the guard period remove block. The resulting ouput of the guard remove is 16 samples per symbol which is the16 original samples.

Results of comparison with two path-fading channels

Comparison of the Performance of Multi Tone Channels (MC) with DE-offset 16QAM and mMulti Tone Channels (MC) with DE- OQPSK with Magnitude two Path Fading Channels: In mobile communication systems, the errors are introduced not only by noise, but also by intersymbol interference. These later errors cannot be eliminated by simply increasing the transmitter power. The error rate due to ISI can be appreciable even if the delay spread is much

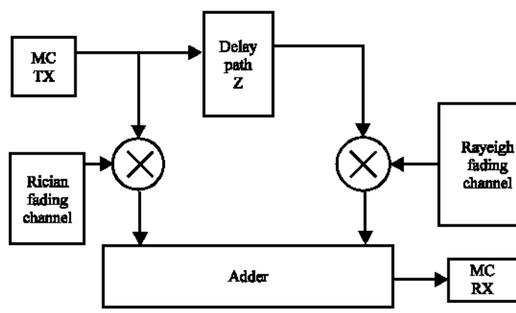

Fig. 3: Two Path Fading Channel Model

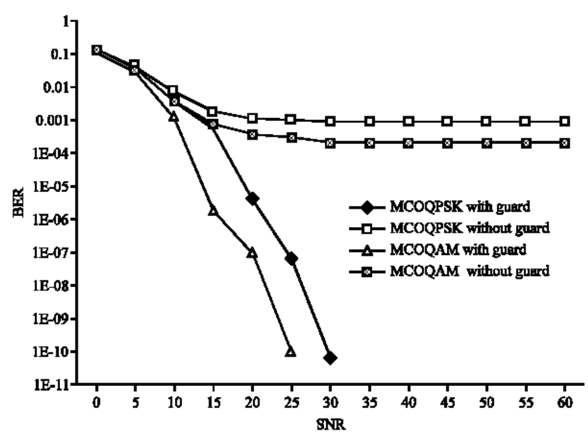

Fig. 4: Comparison of BER Performance for Multi Tone Channels (MC) with DE-OQPSK and mMulti Tone Channels (MC) with DE- OQAM with and without a Guard Period in Presence of AWGN for Magnitude two Path Fading, Doppler Frequency fd = 0.1 Hz, a = 15, d = 15 and a Second Path Delay z = -1 Samples

smaller than the bit duration [2, 10] In this study a two-path fading channel model is being implemented Using the SPW simulator. Figure 3 shows a frequency selective fading channel model for two path fading channel [14, 18].

Figure 4 compares the BER performance for Multi tone Channels (MC) with DE-offset 16QAM and MC with DE-OQPSK [19, 20] with and without a guard period in the presence of AWGN for the magnitude only two-path fading model, Doppler rate 0.1 Hz, for various signal delays in the second path. The result of comparison shows that the performance of Multi tone Channel (MC) with DE-offset 16QAM with guard period is better than the performance of MC with DE-OQPSK with guard. Also the comparison results shows that the performance of MC DE-OQPSK with out guard worse than the results for MC with DE-offset 16 QAM with out guard For example z=-1 (means a delay of one sample period), for this work, 16 tones channels simulations and the delay corresponds with 1/16 of the transmitted symbol period..

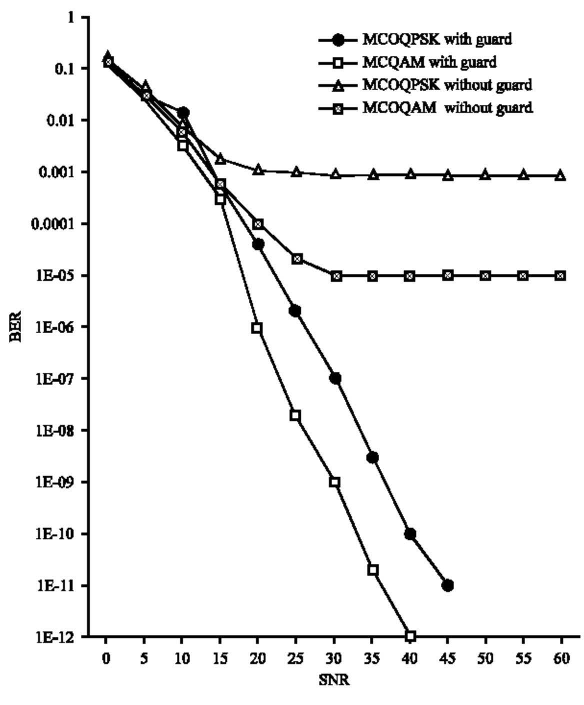

Fig. 5: Comparison of BER Performance for Multi Tone Channels (MC) with DE-OQPSK and MC with Offset 16 QAM with and without a Guard Period in Presence of AWGN for Magnitude only two Path Fading, Doppler Frequency fd =0.1 Hz, *a*=15, *d* = 15 and a Second Path Delay z = -3 Samples

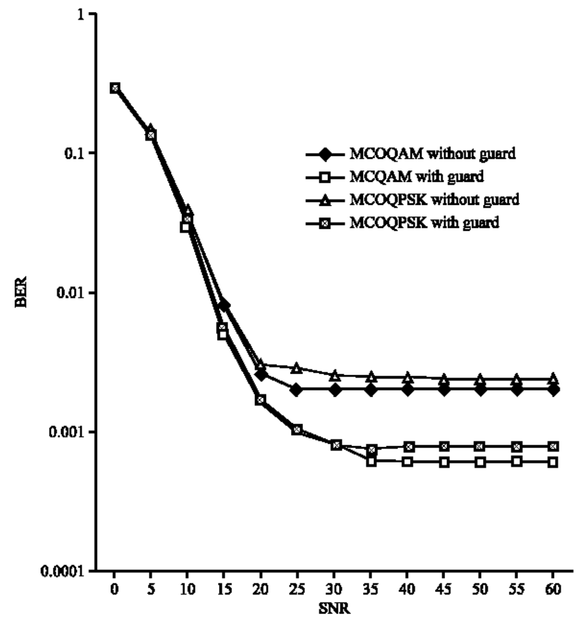

Fig. 6: Comparison of BER Performance for Multi Tone Channel (MC) DE-OQPSK and MC with DE- OQAM with and without a Guard Period for a Second Path of Delay z = -1, *a* =15, *d* = 15, fd = 0.1 Hz

The first path is Rician with a = 15 and the ratio of power in the first path to the power in the second path (d) is 15. For this relatively being channel it can be observed that the BER is independent of the second path delay. For both values of path delay, it can be seen that the removal of the guard period has given rise to irreducible BERs

The result of comparison in Fig. 5. shows that the signal to noise ratio is 25 dB, the bit error rate for Multi tone (MC) OQPSK is $3x10^{-6}$ but the BER for the Multi tone (MC) with offset 16 QAM is $2x10^{-8}$ when the delay Z =-1

Figure 6 Shows the BER performance for Multi tone Channel (MC) with Offset 16 QAM with and without a guard period as compared with MC with 16 QAM in presence of AWGN with and without magnitude two path fading, Doppler frequency, fd = 0.1 Hz, a=15, d=15 and a second path delay z=-3 samples. The results for MC/Offset 16 QAM with a guard period in magnitude only for two path fading is similar to Guassain, but the results for Multi tone Channels (MC) with Offset 16 QAM without a guard period and with magnitude two paths fading becomes worse, but the worst result is for the case MC with DE-OQPSK without a guard period and without magnitude two paths fading. This may be explained due to the increasing multi path delay (z =-3) in the channel, also when dealing magnitude two path fading, this means that dealing with magnitude changes in the channel, a not dealing with phase changes in the channel

Comparison of the Performance of Multi Tone Channel (MC) with DE-Offset 16 QAM and Multi Tone Channel (MC) with DE- OQPSK with a Guard Period in AWGN and two-path Channel Fading: To overcome the problem of the multi path delay, in this work a guard period was inserted between successive transmitted symbols. To reduce the problem of multi path delay a guard period is inserted into the transmitted symbols, which is in this work simulation is equal to 1/4 of the symbol period. Thus each transmitted symbol has its duration increased from 16 to 20 sample periods. This guard period is used to absorb the signal delay induced by the two path-fading channel. The simulation results shown in Fig 6, 7 shows an improvement in performance of the MC with DE-Offset 16 QAM and MC with DE-OQPSK system due to the addition of the guard period for various values of second path delay.

From the comparison results it can be seen that the performance improvement in terms of values of irreducible BER decrease as the delay between first and second paths rise towards that corresponding with the guard period. It is Clear that the modest BER performance levels achieved when the second path delay exceeds one sample period are unacceptable without further measures being applied e.g., forward

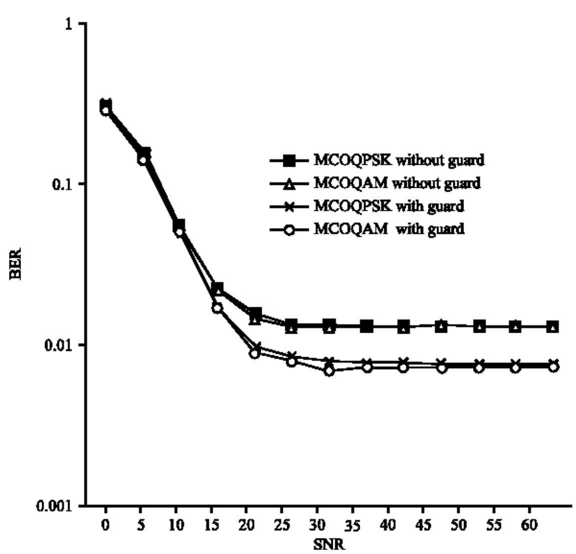

Fig. 7: Comparison of BER Performance for Multi Tone Channel (MC) with DE-OQPSK and MC with DE- OQAM System with and without a Guard Period for a Second Path of Delay of z =- 3, a =15, d = 15, fd = 0.1 Hz

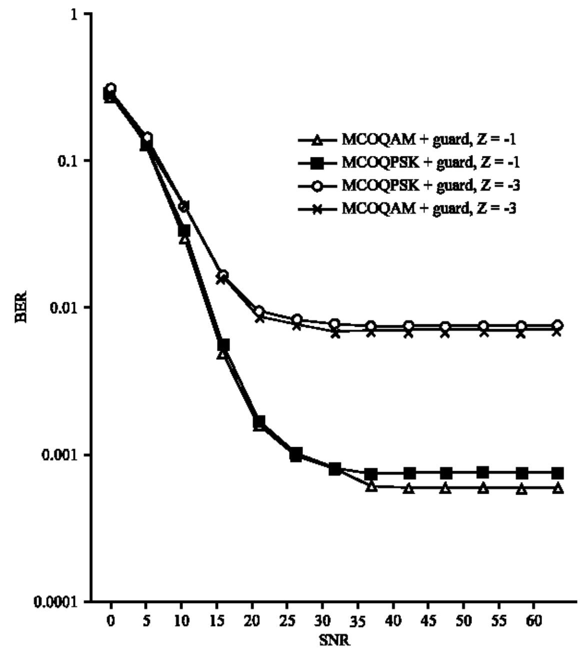

Fig. 8: Comparison of BER Performance for Multi Tone Channel (MC) with DE-OQPSK and MC with DE- OQAM System with a Guard Period in the Presence of AWGN and Two-path Fading Channel for Various Second Path Delays z, a = 15, d = 15, fd = 0.1 Hz

error correction, It should be also noted that the Doppler rate of 0.1 Hz used in these simulations is much more severe than is likely to be experienced in most indoor channels.

Figure 8 summarizes the comparison of BER results for Multi tone Channel (MC) with DE- Offset 16 QAM and MC with DE-OQPSK with a guard period in the presence of AWGN and two-path fading for various second path delays. All these results have a Rician fading power ratio of a =15 for the first path and a power ratio d =15 between first and second paths and a Doppler rate f_d =0.1 Hz. These simulation results show that, the irreducible BER increases when the delay between the first and second arriving paths was increased. When the delay is equal to three samples periods, the BER performance is very poor because the channel delay is now in excess of the guard period.

CONCLUSION

In this study, the result of comparison of the performance of Multi tone Channel (MC) with DE-OQPSK and Multi tone Channel(MC) with DE-OQAM with a guard period has been investigated in AWGN, flat Rayleigh/ Rician fading and two-path fading channels. With a specular power component (a = 15) for a Rician channel at a normalized Doppler rate of

0.1, the degradation from Rayleigh channel (a = 0) gives rise to an unacceptable irreducible BER of about 0.01, for the delay spread z =-3. but the BER is about 0.001, for the delay spread z =-1. However, for the indoor or microcellular environment a direct path is likely to lead to less hostile channels than flat Rayleigh fading. With two-path fading and a normalized Doppler rate of 0.1, the BER performance is not acceptable, even at low values of second path delay. The BER performance for coherent demodulation of multi tone with DE-OQPSK and MC DE- OQAM is poor at a Doppler rate of 0.1 Hz, though the use of a guard period does improve things for low values of second path delay. Finally the BER performance for coherent demodulation of multi tone with DE- OQAM is better than multi tone with DE-OQPSK.

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