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Double-Layer Video Transmission Over D-F Wireless Relay Networks Using Q-QAM and OFDM

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Abstract

Here a wireless relay network with a single source, a single destination, and a multiple relay are considered. The relays are half-duplex and use the decode-and-forward protocol. Here A layered video bitstream, called Double layer video is encoded with a H.264/AVC encoder is transmitted. Unlike voice calls, for which the duration is usually not very long, video streaming applications require continuous transmission for a long time. Thus, the task of optimizing data transmission algorithms has become more important during the last few years. Here to decrease the power consumption due to video transmission applications in Long-Term Evolution(LTE) networks and to improve the energy efficiency of Double layer video, a new modulation technique called quasi-quadrature modulation method, is introduced .For increasing the data rate of double layer video transmission, orthogonal frequency division multiplexing is also suggested.

Keywords:*. *Relay, D-F Protocol, Layered video transmission, Quadracture modulation

1 Introduction

When a communication system transmits data over mobile radio channels, they are subject to errors, because transmission medium typically exhibit time-variant channel quality fluctuations. For two-way communication links, these effects can be minimized using adaptive methods. However, the adaptive schemes require a reliable feedback link from the receiver to the transmitter ad vice versa. Moreover, for a one-way broadcast system, those schemes are not appropriate because of the behaviour of broadcasting. When adaptive schemes cannot be used, the suitable way to ensure communications is to classify the data in to multiple classes with unequal error protection (UEP).

The most important section should be recovered by the receiver even under drastic receiving conditions. Hence, strong error protection is needed for the important data all of the time, even though sometimes there is no need for it. Less important data or less priority is always protected less even though sometimes it cannot be recovered successfully.

Theoretical investigation for efficient communication from a single source to multiple receivers established the fundamental idea that optimize broadcast transmission and reception could be achieved by a superposition or hierarchical transmission scheme.

Hierarchical quadrature amplitude modulation is used as the adaptive constellations for digital video and audio broadcasting. Moreover, the Digital Video Broadcasting standard ,which is now commercially available, incorporated hierarchical 64 QAM for layered video data transmission, since it provides enhanced system-level efficiency and coverage in a wireless environment.

Pursley and Shea proposed communication systems based on hierarchical modulation which support multimedia transmission by simultaneously delivering different types of traffic, each with its own required quality of service.

Another well known and obvious solution to achieve error protection is based on channel coding which is more powerful error-correction coding is applied to a most important data class. The application of rate-compatible punctured convolutional (RCPC) codes to achieve UEP was studied and developed by Cox et al. These UEP methods based on error-correction coding have been extensively used for layered video or image transmission. Sometimes, UEP approaches based on hierarchical modulation and error-correction coding were jointly applied in a system.

Video has been an important media for digital communications and entertainment for many decades. The growth and popularity of the internet network in the mid-1990s motivated video communication over best-effort wireless packet networks. Video over best-effort packet networks is complicated by a number of factors.

However such works has been performed and developed under the RPF project BINTEO and the UCY project ADAVIDEO factors including unknown and time-varying bandwidth, frequency, delay, and losses, as well as many additional issues such as how to efficiently share the network resources amongst many flows and how to fairly perform one-to-many communication broadcasting for popular content.

Video communication over a dynamic or varying environment, such as a cellular and wireless network is much more difficult than over a static channel, since the frequency, delay spread, and loss are not known in advance and are undefined.

There are several schemes are developed to increase the data rate of multimedia transmission. Here to increase the data rate of double layer video OFDM (Orthogonal Frequency Division multiplexing) OFDM is a parallel transmission scheme, where a high-rate serial data stream is split up into a set of low-rate sub streams, each of which is modulated on a separate SC (FDM).

Thereby, the bandwidth of the SCs becomes small compared with the coherence bandwidth of the channel; that is, the individual SCs experience flat fading, which allows for simple equalization. This implies that the symbol period of the up streams is made long compared to the delay spread of the time-dispersive radio channel. By selecting a special set of (orthogonal) carrier frequencies, high spectral efficiency is obtained because the spectra of the SCs overlap, while mutual influence among the SCs can be avoided. The major Contribution of these paper are:

- A state art method of signal modulation which reduce the power consumption of video data transmission while providing the same packet loss probability is suggested.
- Orthogonal frequency division multiplexing is suggested to increase the data rate of double layer video transmission.

This paper is organized as follows. Section 2 covers the system model. Section 3 deals with the Principles of signal modulation. Section 4 the theoretical description and mathematical proof of the proposed quasi-quadrature modulation method. Section 5 covers with OFDM. Section 6 gives the simulation results and section 7concludes this paper.

2. System model

We consider a single source, a single destination, and N relays, all of which are equipped with a single antenna, as shown in Fig. 1. The relays are half-duplex, i.e., the relays cannot transmit and receive at the same time, and use the decode-and-forward protocol. Due to the half-duplex relay, each transmission requires two time slots. In the first timeslot, the source broadcasts a message to all the relays and the destination.

Assume the relays are not able to communicate with each other; hence, they do not know if any other relay successfully decodes the message. Rather, if the relays decode the message (or a portion of it) successfully, they forward it to the destination in the second time slot. We assume the relays communicate with the destination using orthogonal channels.

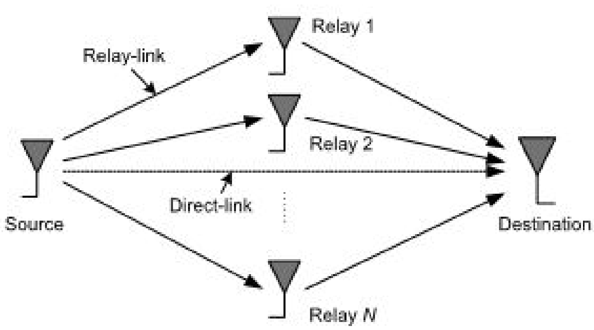

Fig 1. System Model

And assume the channels from the source to the relays and from the relays to the destination experience flat Rayleigh fading, and we use the modified Jakes model to simulate different fading rates. Due to the spatial separation, we also assume that all the channels from the source to the relays and from the relays to the destination are independent. We assume that the channel gain is constant for each symbol, and that it can be accurately estimated at the receiver. However, the channel gain is assumed to be unknown at the transmitter.

To provide high data rate, allowable Bit Error Rate (BER), and maximum delay for the bit stream transmission this single data stream is single transmitted over a number of lower rate sub carrier. The idea of OFDM is to split the total transmission bandwidth into a number of orthogonal sub carriers in order to transmit the symbols using these sub carriers in parallel.

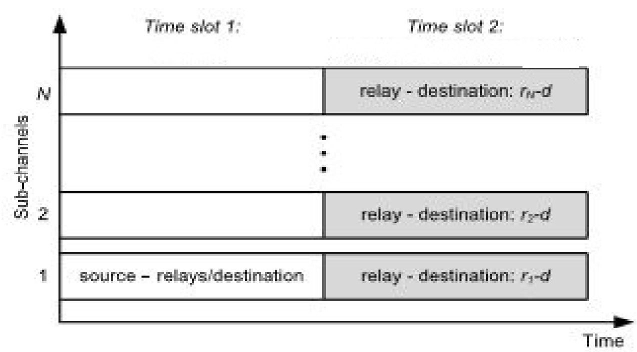

Fig 2. Relay protocol

The number of carriers in an OFDM system is not only limited by the available spectral bandwidth, but also by the IFFT size which is determined by the complexity of the system[1].

3. Principles of Signal Modulation

Quadrature Amplitude Modulation or QAM is a form of modulation which is widely used for modulating data signals onto a carrier used for radio communications. It is widely used because it offers advantages over other forms of data modulation such as PSK, although many forms of data modulation operate alongside each other Quadrature Amplitude Modulation.

QAM is a signal in which two carriers shifted in phase by 90 degrees are modulated and the resultant output consists of both amplitude and phase variations. In view of the fact that both amplitude and phase variations are present it may also be considered as a mixture of amplitude and phase modulation.

Quadrature amplitude modulation, (QAM) may exist in what may be termed either analog digital formats. The analog versions of QAM are typically used to allow multiple analog signals to be carried on a single carrier.

For example it is used in PAL and NTSC television systems, where the different channels provided by QAM enable it to carry the components of chroma or colour information. In radio applications a system known as C-QUAM is used for AM stereo radio. Here the different channels enable the two channels required for stereo to be carried on the single carrier.

Digital formats of QAM are often referred to as "Quantised QAM" and they are being increasingly used for data communications often within radio communications systems. Radio communications systems ranging from cellular technology through wireless systems including WiMAX, and Wi-Fi 802.11 use a variety of forms of QAM, and the use of QAM will only increase within the field of radio communications.

QAM is more susceptible to noise because the states are closer together so that a lower level of noise is needed to move the signal to a different decision point. Receivers for use with phase or frequency modulation are both able to use limiting amplifiers that are able to remove any amplitude noise and thereby improve the noise reliance. This is not the case with QAM.

The second limitation is also associated with the amplitude component of the signal. When a phase or frequency modulated signal is amplified in a radio transmitter, there is no need to use linear amplifiers, whereas when using QAM that contains an amplitude component, linearity must be maintained. Unfortunately linear amplifiers are less efficient and consume more power, and this makes them less attractive for mobile applications.

Considering the classic QAM, the input bit stream is divided into two parallel streams. Both streams are modulated by two carrier waves, usually sinusoids, which are out of phase with each other by 90 degree. Thus, the two obtained components form a 2-D constellation diagram. Each point in the constellation presents a symbol of the I-Q grid, i.e.,

$$M= [I ,Q]= \{ m_0,\ldots\ldots , m_{N-1} \} \quad (1)$$

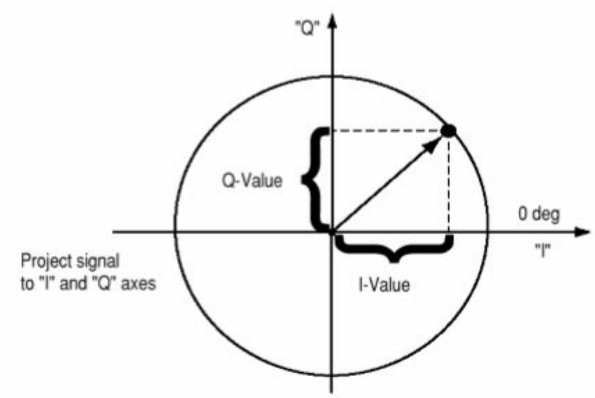

Fig 3. " I & Q" Component

Where I and Q are in-phase and quadrature components of the signal, respectively, and a denotes a digital bit (0 either 1). The number of bits per symbol for multilevel QAM (M-QAM) modulation is calculated as

$$L= \log_2 N \quad (2)$$

The mathematical representation of the QAM signal is defined as ,

$$S_{QAM}(t) = C(t)M_I(t)\cos(wt) - C(t)M_Q(t)\sin(wt) \quad (3)$$

Since the downlink channel of LTE uses orthogonal frequency-division multiplexing (OFDM), the transmitted signal is defined as follows. Then, the signal energy for a QAM signal is calculated as

$$E_{QAM} = C^2(t) \int_0^{66.7} (M_I(t)\cos(wt) \; M_Q(t)\sin(wt))^2 dt \quad (4)$$

Where C(t) be the pulse shape in time domain $M_I(t)$ and $M_Q(t)$ are in-phase and quadrature symbol amplitudes respectively, and ω = 2πf, with f being the frequency of the signal. To further simplify calculation, and assume that c(t) is rectangular pulse shape, and its value is constant during 66.7 ųs of modulated symbol transmission time[2].

4. Qusi-Quadracture Modultion Scheme For Energy-saving Transmission

Here a new method of quasi-QAM (Q-QAM) to improve energy efficiency. As mentioned in ordinary QAM suggests two (in-phase and quadrature) signal components. Here modulate signal only by in-phase component of the QAM signal. However the receiver is able to represent the input signal as a two component signal, providing special mapping associations. Mathematical representation of a Q-QAM signal is defined as

$$S_{Q-QAM} = C(t)M_I(t)\cos(wt) \quad (5)$$

The signal energy of the Q-QAM signal is

$$E_{QAM} = C^2(t) \int_0^{66.7} (cos^2(wt)) \quad (6)$$

Thus the total energy of the Q-QAM signal is

$$E_{Q-QAM} = \frac{C^2(t)}{4} M_I^2(t)(wt + \cos(wt)\sin(wt)) \quad (7)$$

Only half of the energy is needed for transmitting in-phase components with the proposed Q-QAM. The transmitter sends only the in-phase component, consuming half the energy. However, the receiver uses the association table for reconstructing the quadrature component of the signal. Thus, both in-phase and quadrature components of the QAM symbol at the receiver side by ordinary quadrature modulation is provided.

Moreover, this approach also allows for the increase of the SNR for input at the receiver by transmitting the in-phase component with the same energy as both in-phase and quadrature components in QAM. In this case, the quality of packet data transmission doubles.

To achieve better scalability of resource allocation, alternate MIMO transmission schemes for QPSK modulation and concerted MIMO transmission is also suggested for 64-ary QAM. For 16 QAM, both cases are allowed.

5. Orthogonal Frequency Division Multiplexing

Orthogonal frequency division multiplexing (OFDM) is a widely used modulation and multiplexing technology, which has become the basis of many telecommunications standards including wireless local area networks (LANs), digital terrestrial television (DTT) and digital radio broadcasting in much of the world.

In the past, as well as in the present, the OFDM is referred in the literature as Multi-carrier, Multitone and Fourier Transform. The OFDM concept is based on spreading the data to be transmitted over a large number of carriers, each being modulated at a low rate. The carriers are made orthogonal to each other by appropriately choosing the frequency spacing between them.

Division Multiplexing, divides the total available bandwidth in the spectrum into sub-bands for multiple carriers to transmit in parallel. It combines a large number of low data rate carriers to construct a composite high data rate communication system. Orthogonality gives the carriers a valid reason to be closely spaced with overlapping without ICI.

In contrast to conventional Frequency Division Multiplexing, the spectral overlapping among subcarriers are allowed in OFDM since orthogonality will ensure the subcarrier separation at the receiver, providing better spectral efficiency and the use of steep band pass filter was eliminated.

OFDM transmission system offers possibilities for alleviating many of the problems encountered with single carrier systems. It has the advantage of spreading out a frequency selective fade over many symbols. This effectively randomizes burst errors caused by fading or impulse interference so that instead of several adjacent symbols being Completely destroyed, many symbols are only slightly distorted. This allows successful reconstruction of majority of them even without forward error correction.

Because of dividing an entire signal bandwidth into many narrow subbands, the frequency response over individual subbands is relatively flat due to subband are smaller than coherence bandwidth of the channel. Thus, equalization is potentially simpler than in a single carrier system and even equalization may be avoided altogether if Differential encoding is implemented.

In digital communications, information is expressed in the form of bits. The term symbol refers to a collection, in various sizes, of bits . OFDM data are generated by taking symbols in the spectral space using M-PSK, QAM, etc, and convert the spectra to time domain by taking the Inverse Discrete Fourier Transform (IDFT). Since Inverse Fast Fourier Transform (IFFT) is more cost effective to implement, it is usually used instead. The main features of a practical OFDM system are as follows:

- The bit stream is convolutionaly encoded for correcting errors, interleaved and mapping of bits onto symbols, by using quadrature modulation technique.
- By using inverse fast Fourier transform the symbols are modulated onto orthogonal sub-carriers.
- Channel equalization: the channel can be estimated either by using a training sequence or sending known so-called pilot symbols at predefined sub-carriers.
- A cyclic prefix is appended to maintain the orthogonality through the transmission medium.. The cyclic prefix consists of the N last samples of the bit stream, which are copied and placed in the beginning of bit stream.
- After the transmission through the channel cyclic extension of the received signal is removed, FFT is used to convert the signal in to frequency domain.
- Demodulation and de-interleaving.

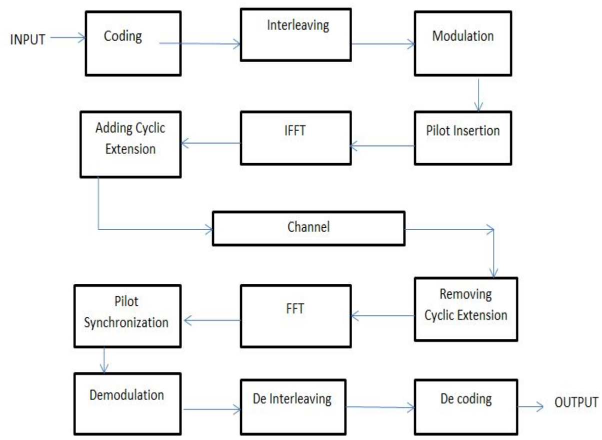

Fig.4 Orthogonal frequency division multiplexing

The block diagram showing a simplified configuration for an OFDM transmitter and receiver is given in Figure. The more complex (also more costly) the OFDM system is, the higher IFFT size it has; thus a higher number of carriers can be used, and higher data transmission rate achieved. The choice of MPSK modulation varies the data rate and Bit Error Rate (BER).

The higher order of PSK leads to larger symbol size, thus less number of symbols needed to be transmitted, and higher data rate is achieved. But this results in a higher BER since the range of 0-360 degrees of phases will be divided into more sub regions, and the smaller size of sub-regions is required, thereby received phases have higher chances to be decoded incorrectly. OFDM signals have high peak-to-average ratio, therefore it has a relatively high tolerance of peak power clipping due to transmission limitations.

The main aspect in OFDM is maintaining orthogonality of the carriers. If the integral of the product of two signals is zero over a time period, then these two signals are said to be orthogonal to each other. Two sinusoids with frequencies that are integer multiples of a common frequency can satisfy this criterion Therefore, orthogonality is defined by:

$$\int_0^T \cos(2\pi f_0 lt)\cos(2\pi f_0 kt) \qquad (8)$$

where $l \neq k$

Where l and k are two unequal integers; f_0 is the fundamental frequency; T is the period over which the integration is taken[4].

6. Simulation results

A layered video bit stream, called Double layer video is transmitted. which is a combination of a High resolution and Low resolution version of the same video. For simulation here using Matlab 2014a ,and select an in build video ‘xylophone.mpg’ for making Double layer video. These video sequences have CIF resolution (352 x 288) and frame rate of 25fps. Out of 141, here first 10 frames are selected and encoded with a H.264/AVC encoder

.

6.1 Quasi-Quadrature Modulation Method

This encoded bit stream is then modulated by using either the in phase component nor the quadrature component. Which is transmitted thorough a Rayleigh fading channel. The D-F relays are decode the data in the first time slot and if it decode successfully forward to the destination in the second time slot.

However, the receiver is able to represent the input signal as a two-component signal, providing special mapping associations. The Energy performance comparison graph of Q-QAM and Conventional quadrature modulation (QAM) is at the receiver section after maximal ratio combining method is given in fig 5.

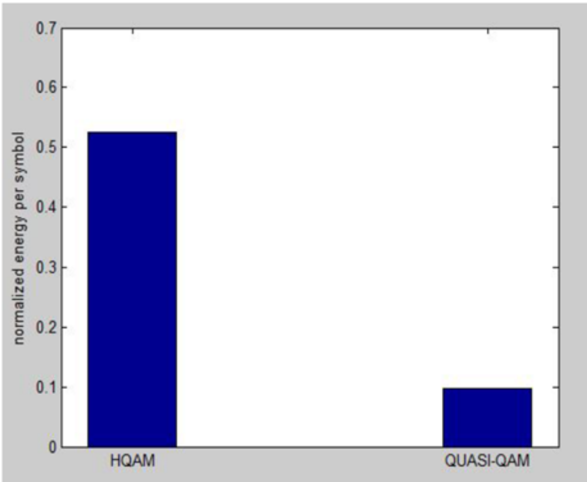

Fig.5 Normalized energy Needed for QAM and Q-QAM

As shown in fig.5, only less than half of the energy is needed for transmitting in-phase or quadrature components of the double layer video with the proposed Q-QAM. The transmitter sends only the one component, consuming less than half the energy. However, the receiver uses the association table for reconstructing the quadrature component or in-phase of the signal. Thus, provide both in-phase and quadrature components of the QAM symbol at the receiver side by ordinary quadrature modulation .

Here the Normalised energy for QAM modulation is 0.5 and that of prosed scheme is 0.1. Moreover, this approach also allows for the increase of the SNR for the double layer video at the receiver by transmitting the in-phase component with the same energy as both in-phase and quadrature components in QAM. In this case, the quality of packet data transmission doubles.

6.2 Orthogonal Frequency division Multiplexing Method

Here from the total encoded bitstream of double layer video, 9600 bits are transmitted via over a number of lower rate sub carriers, each being modulated at lower rate. The carriers are made orthogonal to each other by appropriately choosing the frequency spacing between them.

The data is encoded, interleaved and appropriate cyclic prefix is added at the transmission section, after transmitting through a Rayleigh fading channel via D-F relays the received data is then demodulated, de-interleaved and decoded by computing maximal ratio combing method at the destination ,the performance comparison graph of Orthogonal Frequency division Multiplexing(OFDM) and SISO (Single input Single output) schemes are given in fig.6.

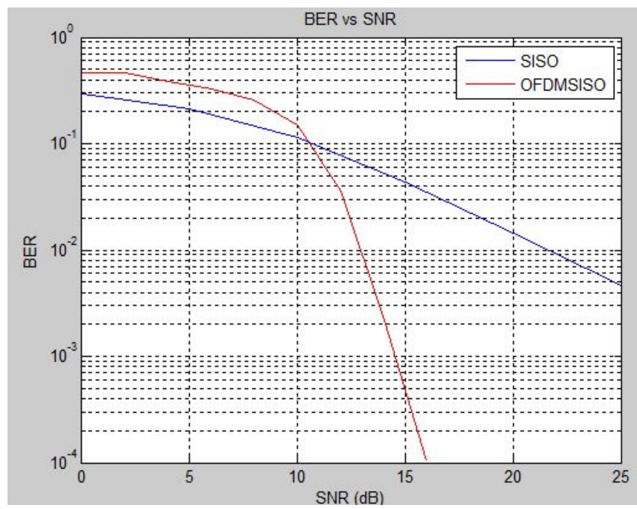

Fig. 6. Performance Comparison of MIMO and OFDM

As shown in fig.6 OFDM(Orthogonal Frequency division Multiplexing) is scheme drastically reduce the BER(Bit Error Rate) at 16dB SNR. Where for conventional scheme more than 25dB is .Thus OFDM provides high data rate, lower multipath distortion and Resilience to RF interference than MIMO.

6.3 Performance Comparison of Q-QAM and OFDM

Q-QAM is an energy efficient method for double layer video transmission. While

OFDM provides high data rate. The BER Vs SNR Performance of Q-QAM and OFDM is given in Fig.7

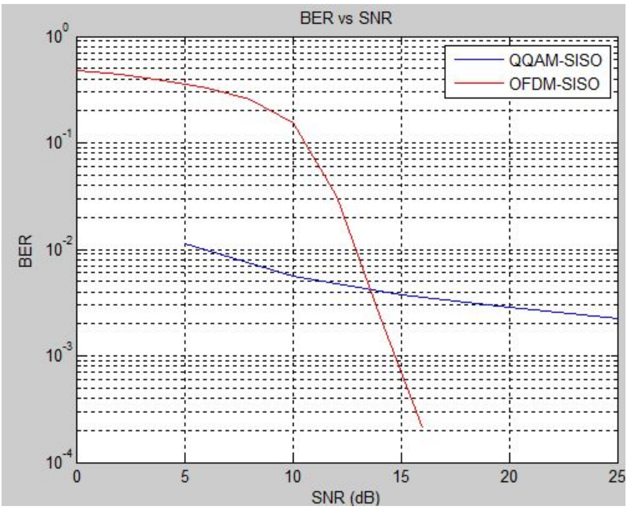

Fig .7 Performance Comparison of Q-QAM and OFDM

As shown in Fig.7 OFDM (Orthogonal Frequency division Multiplexing) scheme drastically reduce the BER(Bit Error Rate) at 16dB SNR.But Q-QAM method shows worst BER Vs SNR performance compared with OFDM .

7. Conclusions

In these Paper, double layer video transmission over decode and forward (D-F) relay network using Q-QAM and OFDM are considerd. A double layer video hich is a combination of a high resolution and low resolution version of the same video. A new method of quasi-quadrature modulation that transmits only a quadrature or in-phase component of symbols instead of both quadrature and in-phase components of the Double layer video is proposed.

This method is compatible with existing quadrature modulation schemes, which are well known and have been used for a long time in LTE mobile networks. This approach can decrease power consumption per symbol transmission with the same bit error probability. And OFDM is suggested to ensure good and stable video quality with high data rate for double layer video transmission.

Q-QAM Provides an energy efficient method for Double layer video transmission. OFDM scheme drastically reduce the BER (Bit Error Rate) at 16dB SNR. Where for conventional scheme more than 25dB is needed. But Q-QAM method shows worst BER Vs SNR performance compared with OFDM

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