A Survey on Digital Modulation Techniques for Software Defined Radio Applications

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***Abstract*—This paper analyses different modulation techniques used for Software defined radio. SDR technologies are important from the point of future mobile communication system because of its reconfigurable and multimode operational capabilities. The selection of modulation scheme depends on Bit Error Rate (BER), Signal to Noise Ratio (SNR), Available Bandwidth. The basic criteria for best modulation technique are Power efficiency, better Quality of Service, cost effectiveness, bandwidth efficiency and system complexity.**

Keywords- Software defined radio(SDR), Bit Error Rate(BER), Adaptive Modulation, Signal to Noise Ratio(SNR)

I. INTRODUCTION

Today's wireless networks consist of a large array of mobile equipments. The communication between variety of mobile equipments is regulated by different IEEE Standards. The SDR [1] provides greatest advantage by its reconfigurable front end capability. IEEE Standard 802.11a boasts impressive performance. It is able to transmit at the data rates of up to 54 Mbps. The summary of 802.11a Wi-Fi standard is given in Table 1.

TABLE1. IEEE STANDARD 802.11A [13]

Modu Lation	Cod ing rate (R)	Coded bits per sub carrier (NBP SC)	Coded bits per OFDM symbol (NCB PS)	Data bits per OFDM symbol (ND BPS)	Data rate (Mb/s) (20 MHz channel spacing)
BPSK	1/2	1	48	24	6
BPSK	3/4	1	48	36	9
QPSK	1/2	2	96	48	12
QPSK	3/4	2	96	72	18
16-QAM	1/2	4	192	96	24
16-QAM	3/4	4	192	144	36
64-QAM	2/3	6	288	192	48
64-QAM	3/4	6	288	216	54

Software Defined Radio

SDR Forum [14] has defined SDR as, Radio in which some or all of the physical layer functions are Software Defined. The software is used to determine the specification of the radio and what it does. If the software within the radio is changed, its performance and function may change. SDR has generic hardware platform to implement modulation and demodulation functions. It also involves filtering, changes in bandwidth, frequency selection and in some cases frequency hopping. These devices include field programmable gate array (FPGA), digital signal processors (DSP), general purpose processor (GPP), programmable system on chip (SoC) or other application specific programmable processors.

Q.O.S.:- For a wireless communication Quality of Service is fundamental reference for all network planification. The main Qualities of Service aspects are elaborated by [2].

I) Transmission Quality related with transmitted information fidelity. Information emitted from the sender over communication system must arrive to the receiver without errors, alteration and loss. The Quality global criterion depends on the service types such as legibility in communication, quality and conformity in image transmission, fidelity and purity in musical transmission and rate error probabilities in data transmission.

II) Other technical factors required to be considered are [3], the total attenuation of liaison of propagation, bandwidth, the comportment with distortions, perturbations influences with noise and diaphony.

Today's SDR technology is required to handle multiple waveforms, modulation techniques, pulse shaping techniques and transmit power. The important factors deciding the choice of modulation scheme are a) spectrally efficient modulation which gives least amount of interference for adjacent channel & neighboring channels. b) Robust performance in fading multipath fading channels, Doppler frequency. c)How does the Bit Error Rate varies with the energy per bit available in the system when white noise present. d) The cost efficient modulation scheme. e)Easy to implement circuitry, small size and weight.

The modern wireless communication devices required higher bit rates. Hence to increase the speed of information transmission, bit rate can be increased by sending more number of bits per symbol, with the help of advanced modulation techniques. The bit rate can be increased by providing larger bandwidths, which gives higher symbol rates resulting in higher bit rates. This paper analyses the typical digital modulation techniques used for software defined radio. The IEEE 802.11a standard mainly used digital modulation techniques like BPSK, QPSK and QAM along with OFDM. In section II the Digital modulation techniques are explained in SDR environment. In section III, Literature Survey is presented for SDR communication. The section IV, describes the comparison for representive modulation schemes which are used in variety of wireless communication standards, in SDR environment.

II. DIGITAL MODULATION TECHNIQUES [11]

Binary phase shift keying: - In BPSK, the phase of a constant amplitude carrier is switched between two values according to the two possible signals m_1 and m_2 corresponding to binary 1 and 0 respectively.

Definitions: - E_b= Energy-per-bit
E_s = Energy-per-symbol
T_b = Bit duration
T_s = Symbol duration
N0/2 =Noise Power Density (W/Hz)
P_b= Probability of bit-error
P_s = Probability of symbol-error, If the sinusoidal carrier has amplitude A_c and energy per bit E_b =1/2 $(A_c)^2$ T_b, then the transmitted BPSK signal is given by

$$s_{BPSK} = \sqrt{\frac{2E_b}{T_b}}\cos(2\pi f_c t + \pi + \theta c) \quad (1)$$

$$s_{BPSK} = -\sqrt{\frac{2E_b}{T_b}}\cos(2\pi f_c t + \theta c) \quad 0\leq t \leq T_b \text{ (binary 0)} \quad (2)$$

This modulation is the most robust of all the PSKs since it takes the highest level of noise or distortion to make the demodulator reach an incorrect decision. It is, however, only able to modulate at 1 bit/symbol and so is unsuitable for high data-rate applications. BPSK is functionally equivalent to 2-QAM modulation. The BPSK signal is equivalent to a double sideband suppressed carrier amplitude modulated waveform. Hence a BPSK signal can be generated using a balanced modulator. Demodulation in BPSK Receiver requires reference of transmitter signal in order to properly determine phase, hence it is necessary to transmit carrier along with signal. It requires complex and costly receiver circuitry. It gives good BER for low SNR giving power efficiency.

QPSK - Quadrature Phase Shift Keying

Quadrature Phase Shift Keying has twice the bandwidth efficiency of BPSK. For every single modulation symbol two bits are transmitted. The phase of carrier takes on four equally spaced values like 0, π/2, π , 3 π/2 .The two modulated signals, each of which can be considered to be a BPSK signal, are summed to produce a QPSK signal. QPSK transmitters and receivers are more complicated than the ones for BPSK. However, with modern electronics technology, the penalty in cost is very moderate. As with BPSK, there are phase ambiguity problems at the receiving end, and differentially encoded QPSK is often used in practice. The QPSK signal is given by

$$S_{QPSK}(t)=\sqrt{\frac{2E_s}{T_s}}\cos\left[2\pi f_c t + \frac{(i-1)\pi}{2}\right] \quad 0\leq t \leq T_s \text{ for } i=1,2,3,4 \quad (3)$$

Where T_s is symbol duration and is equal to twice the bit period.

If basis function $\varphi 1(t) = \sqrt{\frac{2}{T_s}}\cos(2\pi f_c t)$, $\varphi 2(t) = \sqrt{\frac{2}{T_s}}\sin(2\pi f_c t)$ are defined for $0\leq t \leq T_s$ (4)

For QPSK signal set, then $S_{QPSK}(t)= \sqrt{E_s}\cos\left[\frac{(i-1)\pi}{2}\right]\varphi 1(t) - \sqrt{E_s}\sin\left[\frac{(i-1)\pi}{2}\right]\varphi 2(t)$ for i=1,2,3,4 (5)

QPSK has two dimensional constellation diagram with four points. The distance between adjacent points in constellation is $\sqrt{2E_s}$. Each symbol consists of two bits, hence Es = $2E_b$, then the distance between two neighbouring points in QPSK constellation is given by $2\sqrt{E_b}$.

Offset QPSK

Offset quadrature phase-shift keying (OQPSK) is a variant of phase-shift keying modulation using 4 different values of the phase to transmit. It is sometimes called staggered quadrature phase-shift keying (SQPSK).Taking four values of the phase (two bits) at a time to construct a QPSK symbol can allow the phase of the signal to jump by maximum of 180° at a time. When the signal is low-pass filtered (as is typical in a transmitter), these phase-shifts result in large amplitude fluctuations. This is an undesirable quality in communication systems. By offsetting the timing of the odd and even bits by one bit-period, or half a symbol-period, the in-phase and quadrature components will never change at the same time. From the constellation of OQPSK, it can be seen that this will limit the phase-shift to no more than 90° at a time. This results in much lower amplitude fluctuations than non-offset QPSK and is sometimes preferred in practice. OQPSK ensures that there exist less baseband signal transitions applied to the RF amplifier, which helps to remove spectrum regrowth after amplification. In OQPSK the maximum phase shift of the transmitted signal at any time instant is limited to ±90°. Hence hardlimiting or nonlinear amplification OQPSK signal does not regenerate the high frequency sidelobs as that of in QPSK. It results in reduced spectral occupancy and allowing more efficient RF amplification. OQPSK is very attractive for mobile communication systems where bandwidth efficiency and efficient nonlinear amplifiers are critical for low power drain.

M-Ary Quadrature Amplitude Modulation (QAM)

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. As both amplitude and phase variations are present it is also considered as a mixture of amplitude and phase modulation. Digital formats of QAM are often referred to as "Quantized QAM" and they are being increasingly used for data communications in radio communications systems. When using QAM, the constellation points are normally arranged in a square grid with equal vertical and horizontal spacing. The most common forms of QAM use a constellation with the number of points equal to a power of 2 i.e. 2, 4, 8, 16 . . By using higher order modulation formats, it is possible to transmit more bits per symbol. As the points are closer together they are therefore more susceptible to noise and data errors. When the states are closer together, a lower level of noise can move the signal to a different decision point. QAM contains an amplitude component hence linearity is necessary. The linear amplifiers are less efficient and consume more power, and this makes them less attractive for mobile applications. QAM is widely used in many digital data radio communications and data communications applications. Some of the more popular forms are 16QAM, 32 QAM, 64QAM, 128QAM, and 256QAM. Here the figures indicate the number of points on the constellation. QAM is a higher order form of modulation and therefore it is able to carry more bits of information per symbol. A higher order format of QAM gives the higher data rate for the link. The general form of an M-Ary QAM signal can be defined as#

$$S_i(t) = \sqrt{\frac{2E_{min}}{T_s}}\, a_i \cos(2\pi f_c t) + \sqrt{\frac{2E_{min}}{T_s}}\, b_i \sin(2\pi f_c t)$$

$0 \leq t \leq T \quad i = 1,2\ldots..M$ (6)

Where E_{min} = Energy of signal with lowest amplitude and a_i and b_i are pair of independent integers chosen as per the location of particular signal point.

OFDM: - Orthogonal Frequency Division Multiplex, OFDM is a special case of multicarrier transmission, where a single data stream is transmitted over a number of lower-rate subcarriers (SCs). It consists of number of closely spaced modulated carriers. The modulation produces number of overlapping sidebands spreading out either side. The sidebands can be received without interference since they are orthogonal to each other. The carrier spacing is made equal to symbol period. The lower data rate reduces the interference from reflections. This is achieved with the help of guard interval. OFDM increases robustness against frequency-selective fading or narrowband interference. The OFDM transmission scheme has the following key advantages:

- OFDM is an efficient way to deal with multipath; for a given delay spread, the implementation complexity is significantly lower than that of a single-carrier system with an equalizer. In relatively slow time-varying channels, it is possible to enhance capacity significantly by adapting the data rate per subcarrier according to the signal-to-noise ratio (SNR) of that particular SC.
- It is robust against narrowband interference because such interference affects only a small percentage of the SCs.
- OFDM makes single-frequency networks possible, useful for broadcasting applications. It is more sensitive to frequency offset and phase noise. OFDM has a relatively large peak-to-average-power ratio, which tends to reduce the power efficiency of the radio frequency (RF) amplifier.

The different applications for variety of digital modulation techniques are described in Table 2

TABLE2. THE APPLICATIONS FOR DIFFERENT MODULATION FORMATS[12]

Modulation format	Application
MSK, GMSK	GSM, CDPD
BPSK	Deep space telemetry, cable modems
QPSK, π/4 DQPSK	Satellite, CDMA, NADC, TETRA, PHS, PDC, LMDS, DVB-S, cable (return path), cable modems, TFTS
OQPSK	CDMA, satellite
FSK	GFSK DECT, paging, RAM mobile data, AMPS, CT2, ERMES, land mobile, public safety
8, 16 VSB	North American digital TV (ATV), broadcast, cable
8PSK	Satellite, aircraft, telemetry pilots for monitoring broadband video systems
16 QAM	Microwave digital radio, modems, DVB-C, DVB-T
32 QAM	Terrestrial microwave, DVB-T
64 QAM	DVB-C, modems, broadband set top boxes, MMDS
256 QAM	Modems, DVB-C (Europe), Digital Video (US)

III LITERATURE SURVEY

A. BER in presence of Additive white Gaussian noise

In [4] Adrian Tarniceriu et al. have presented the characteristics of modulation techniques and determined the figure of merit for each particular modulation in context of SDR. The wireless standard IEEE 802.16, WI-MAX is used for analysis which uses modulation techniques like QPSK, QAM-16 and QAM-64 on OFDMA carrier support. The transmitter and receiver are considered ideal and Additive white Gaussian noise is introduced by channel. The maximum transmitted power is constant, regardless of the used modulation. It shows that higher SNR are required to demodulate the signal within the same BER as the modulation number of bits per symbol increases. In Fig.1 the Bit Error rates verses Signal-to-Noise Ratios for different modulation techniques are presented [4].

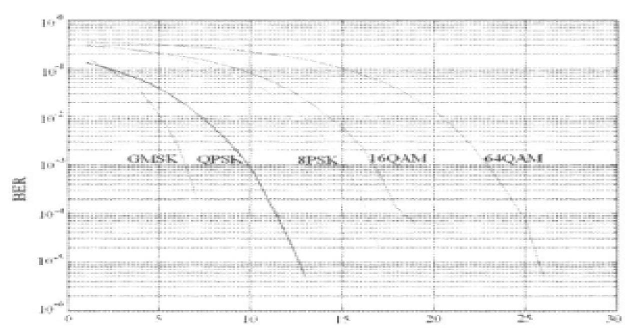

Figure 1. BER vs. SNR [4]

The following table shows the maximum Bit Error Rates that can be accepted for usual services. Table 3.0

TABLE3. MAXIMUM ACCEPTED BIT ERROR RATES [4]

Service	Maximum BER
Audio	10e-4
Video	10e-5
Data	10e-6
Mobile Video	10e-8

In [5] Muhamad Islam et al. have modelled the transceiver in Matlab and BPSK transmitter is used along with Additive white Gaussian noise (AWGN) channel and BPSK receiver. The PSK modulation scheme for SDR is proposed to pick the constellation size that offers the best reconstructed signal quality for each average SNR. The audio signal transmission quality is evaluated and the performance of the linear modulation is compared. It shows for a given SNR, simpler modulation schemes tend to have higher quality, giving lower bit rates. BPSK has better quality for given SNR as compared to other modulation schemes. Therefore, it is used as the basic mode for each physical layer. It has the maximum coverage range among all transmission modes.

B. Adaptive Modulation and Coding

In [6] Sami H.O.Salih et al. have shown implementation of adaptive modulation and coding technique using Matlab. The different order modulations are combined with different coding schemes. It gives higher throughput and better spectral efficiency by sending more bits per symbol. Here the various modulation types are implemented using single Matlab function that can be called with the appropriate coefficients. The Fig. 2 shows the simulation plot of BER vs. SNR for different modulation techniques for Broadband Wireless Access System using WiMAX.

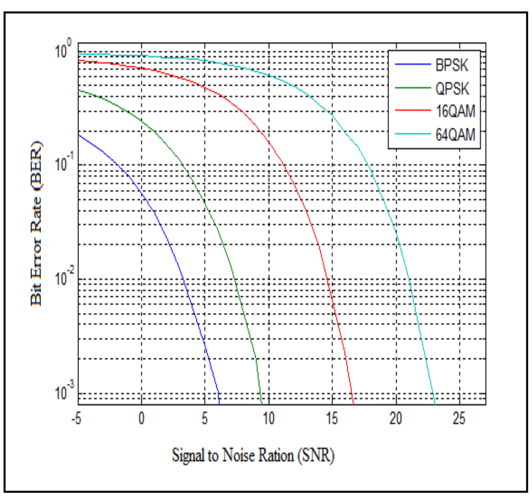

Figure 2. Simulation BER vs. SNR [6]

In traditional communication systems, the transmission is designed for “worst case” channel scenario, giving an error rate below fixed limit. The adaptive transmission has advantage of changing transmitted power level, symbol rate, coding scheme, constellation size or any combination of these parameters in order to deliver better link average spectral efficiency given by bits/sec/Hz.

C. M-QAM for Digital radio and television broadcasting (DVB-T, DVB-T2)

In [8] Mohamed Al Wohaishi et al. have shown the analysis of digitally modulated signals in communication systems which use software defined radio concept and modern synthetic instruments. M-QAM is used for transmission of information in DVB-T, DVB-T2. Simple picture is transmitted through simulated radio channel to show the result of signal impairments. Experiments were done using software defined radio concept of communication system. Modular PXI HW platform was used in connection with graphically oriented development environment. Terrestrial DVB-T broadcasting uses QPSK, 16-QAM and 64-QAM modulation schemes, while terrestrial DVB-T2 broadcasting, which allows transmission of high definition picture format, uses 256-QAM modulation scheme. The simulation of different M-QAM modulation shows that increasing of the state number, leads to an increase of transfer rate (transfer more bits per symbol).The downside however is that with the growing number of states BER increases at the same transmission power as a result of worse distribution of symbols in constellation diagram.

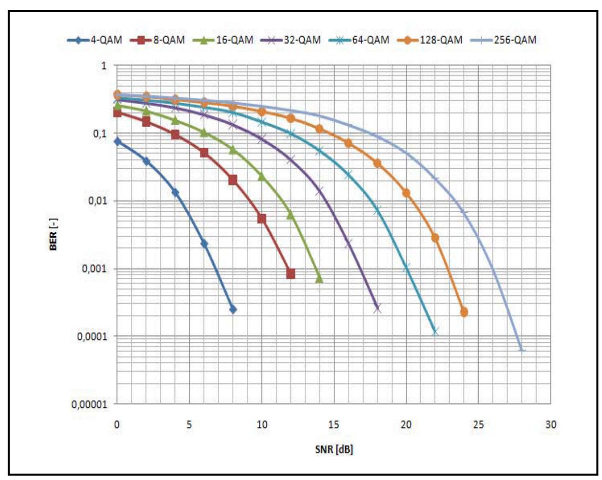

Figure 3. Measured BER dependency on SNR [8]

QAM: - The commonly used Quadrature Amplitude Modulation (QAM) techniques are 16 QAM and 64 QAM. It represents the best trade off between theoretical performance and implementation complexity. In [9] Michel Borgne presented a comparative study of four 2^n state QAM techniques. The effects of filtering, interference, amplifier nonlinearities and selective fading are analysed. The spectral efficiency of QAM is attractive but it is difficult to implement.

These schemes are sensitive to nonlinearities and selective fading. In such systems it is necessary to include compensative devices such as nonlinearity cancellers and adaptive equalizers. QAM is very bandwidth efficient, but require strong signal strength for good BER. This is particularly so for the more dense bandwidth schemes such as 64 QAM.

D. Configurable architecture of modulation technique for SDR

In [7] Jignesh Oza et al. have elaborated the configurable architecture of modulation technique for SDR application. The configurable architecture removes the need for hardware changes when the technology is upgraded. Modulation techniques are implemented on FPGA and Matlab in order to optimize the SDR architecture. It is shown that, modulation technique FSK and QPSK when configured together gives maximum optimization with good performance. This combination chosen has maximum common hardware as well along with quite few other features over other combinations like ASK+MSK, MSK+FSK, QAM+FSK. Table 4.0 elaborates the different features shown by QPSK+FSK combination.

TABLE4. CONFIGURABLE MODULATION TECHNIQUES FEATURES [7]

FEATURES	Modulation Technique(QPSK+FSK)
Bandwidth	Only highest bandwidth is that of the FSK signal which is very less compared to other techniques used.
SNR	Higher Signal to Noise ratio
Data Rate	Higher Data rate
Applications	Can be used in Wide Applications
PB v/s Eb/No	As QPSK is Combined Requires Lesser Eb/No for a given value of PB
Reliability	Higher
Hardware Complexity	Less Complex
Hardware Cost	Costly
Implementation on FPGA	Less Complex Compared to MSK+FSK and QAM+FSK

SDR Systems are required to support multiple air interfaces and signal processing functions at the same time. Byeong-Gwon Kang [13] discussed the modulation schemes of OCQPSK (Orthogonal Complex QPSK) and HPSK (Hybrid PSK) used for IMT-2000 Services of Synchronous Systems and asynchronous systems, respectively. With growing multimedia applications including data services in cellular networks, wireless internet access and wireless LANs, system flexibility is required for high speed mobile radio system. As different modulation schemes and frequency bands are required for different services, SDR can replace hardware device by upgradable software programmable devices. Therefore SDR can offer good choice for adaptive modulation or multiple access schemes. OCQPSK and HPSK modulation schemes are adopted in IMT-2000 Services of CDMA 2000 and WCDMA, respectively. Each modulation method can be chosen by external selection in the implemented Modem with SDR applications.

E. GMSK Modulation

GMSK Modulation: - GMSK has been widely used in mobile wireless communication due to its constant envelope signal feature which eases the requirement for power amplifier linearity. In this case the phase of the carrier is instantaneously varied by 'Modulating' signal. It is used as modulation standard of GSM System. It can be regarded as 2-level FSK modulation with modulation index of 0.5. In [12] Jagadeesh Gurugubelli et al. have used the linear approximated GMSK in SDR environment because it gives a common I/Q modulator that can be used for all second generation systems. The generalized Parametrizable modulator for a reconfigurable radio can perform GMSK and QPSK modulation. GMSK is underlying modulation scheme for Global System for Mobile (GSM) Standard, while QPSK technique is the basic scheme for Code Division Multiple Access (CDMA) Standard. Harada and Masayki [10] presented SDR that can realize global positioning service (GPS) navigation system, Vehicle information and communication system (VICS), Electronic toll collection system (ETC), AM/FM radio broadcasting services, FM multiplex broadcasting system. It also served modulation schemes such as BPSK, QPSK, GMSK, ASK and π/4 QPSK. The SDR realizes simultaneous multiple services when user would like to use several communication services in driving situations.

F. OFDM(Orthogonal Frequency Division Multiplexing)

The next generation wireless communication systems require higher data rates transmission for better quality of service. Multiple antennas and orthogonal frequency division multiplexing (OFDM) are mostly favored technologies for 3G and 4G. IEEE and ETSI have selected OFDM as their physical layer techniques for next generation of wireless systems [15]. High data rate communication systems are restricted by problem of intersymbol interference (ISI) due to multiple paths. OFDM is considered as most promising technique to combat this problem [16]. OFDM is very efficient in spectrum usage and is very effective in a frequency selective channel. OFDM is already used in Digital Audio and Video Broadcasting and wireless LAN's (802.11 Family) and is emerging as technology for future broadband access. In [17] Haitham J. Taha et al. have presented combination of OFDM and CDMA technique. It offers great advantage which can lower the symbol rate in each subcarrier. The longer symbol duration makes it easier to synchronize the transmission. The main advantages of multicarrier modulation are, it solves multipath propagation problem using simple equalization at the receiver. The system is more efficient than single carrier transmission. The system supports multiple access systems such as (TDMA, FDMA, MC-CDMA) and various modulation techniques. Weinstein and Elbert [18] proposed a complete OFDM system which includes generation of signals with an FFT and adding generated intervals in case of multipath channels. M.A lard and Lassalle [19] discussed OFDM for broadcast application and mobile reception.

III. COMPARISON OF REPRESENTATIVE MODULATION SCHEMES

In this section, the modulation schemes that are used for SDR communication are compared with respect to their performance under a variety of digital radio channels conditions. A performance measure used is the baseband equivalent E_B/No (defined as the ratio of average signal energy per bit to noise power spectral density, as measured at the input to the receiver) required to achieve a bit error rate of 10e-4. This error rate is adequate for most general purpose digital radio applications.

A. Ideal Performance

In order to establish a baseline for comparison, Table 5 presents the ideal performance of the representative modulation techniques in the presence of Additive White Gaussian Noise. The performance shown by QAM, MSK, and QPSK is almost identical. The MSK and OQPSK differ only in the weighting functions applied to the I and Q channels.

TABLE 5. IDEAL PERFORMANCE OF REPRESENTATIVE MODULATION SCHEMES [20]

Modulation Scheme	E_B/N_0 Required*
QAM	8.4
FSK Noncoherent detection d=1	12.5
MSK d=5	8.4
MSK d=5 Differential encoding	9.4
BPSK - Coherent detection	8.4
DPSK	9.3
QPSK	8.4
DQPSK	10.7
OQPSK	8.4
8-ary PSK - Coherent detection	11.8
l6ary PSK - Coherent detection	16.2

* For bit error rate of 10e-4

d= FM Modulation Index

TABLE6. RELATIVE SIGNALING SPEEDS OF REPRESENTATIVE MODULATION SCHEMES [20]

Modulation Scheme	Speed (b/s per Hz)	E_B/N_0 Required*
QAM	1.7	9.5
FSK - Noncoherent detection d=1	0.8	11.8
MSK d=5	1.9	9.4
MSK d=5 Differential encoding	1.9	10.4
BPSK - Coherent detection	0.8	9.4
DPSK	0.8	10.6
QPSK	1.9	9.9
DQPSK	1.8	11.8
8-ary PSK - Coherent detection	2.6	12.8
l6ary PSK - Coherent detection	2.9	17.2

*For Bit Error Rate of 10e-4
d = FM Modulation Index

TABLE 7. PERFORMANCE OF REPRESENTATIVE MODULATION SCHEMES IN THE PRESENCE OF CW INTERFERENCE [20]

Modulation Scheme	E_B/N_0 Required*	
	S/I 10 dB	***S/I 15dB***
FSK Noncoherent detection d=1	14.7	13.3
BPSK - coherent detection	10.5	9.2
DPSK	12.0	10.3
OPSK	12.2	9.8
DOPSK	>20	14.0
8-ary PSK - Coherent detection	~20	15.8
l6ary PSK - Coherent detection		>24

*For bit error rate of 10e-4
d = FM Modulation Index

B. Spectral Characteristics

The spectral characteristics of the modulation schemes can be compared according to the extent to which a signal will interfere with signals in adjacent channels. This can be measured by the attenuation of a signal's power spectrum a specified distance from the center frequency. In case of Phase Modulation systems if phase transitions can be made to occur more smoothly, improved spectral characteristics can be achieved. The sidelobes can always be reduced by suitable, post modulation filtering, which results in degradation in performance. Thus, the spectral merits of the various schemes can only be judged after doing a detailed study of the tradeoffs between cost and performance. Another important spectral property is the bandwidth required to transmit at a specified information rate. The so called "speed" of a modulation technique (equal to *R/W,* where *R* is the data rate and *W* is the IF bandwidth) is an important figure of merit. In Table 6, the speeds for each technique are listed together with the E_B/N_o required for a BER when the signal is filtered at the indicated bandwidth (i.e., the degrading effects of finite bandwidth are included).

C. Effects of Interference

The effect of co-channel and adjacent channel interference is important factor in evaluating potential modulation schemes for digital radio. It can be observed that MSK scheme has large advantage over the AM and PM schemes, when no post-modulation filtering is employed. Noncoherent FSK and BPSK show the minimum degradation from ideal performance, while the 8-ary and 16-ary schemes show the maximum degradation.

D. Effects of Fading

Fading is another problem often encountered on digital radio links. If the fading is caused by two resolvable multipath components, then the results of Table 7 can be utilized (the CW interferer can represent the signal from the secondary path). If the fading is caused by a large, number of equal amplitude components, the Rayleigh fading model is more useful.

E. Effects of Delay Distortion

Most of the delay distortion observed on line-of-sight radio links is introduced by the radios and not the channel. For quadratic and linear delay distortion for the case in which the maximum differential delays (relative to the mid-band delay) is equal to the symbol duration. DQPSK suffers severe degradation from quadratic delay distortion, while the coherent biorthogonal schemes (QAM, MSK, and the variations of QPSK) are degraded significantly by linear delay distortion. Thus, delay distortion can be an important criterion in the selection of a modulation scheme for digital radio. [20]

IV. CONCLUSIONS

This paper presented an analysis of the modem modulation techniques that are used in the latest wireless standards, such as IEEE - 802.11, IEEE - 802.16 also known as WiMAX. It also gives an insight on selecting proper modulation techniques for SDR as per existing channel quality. Software Defined Radio (SDR) system is a useful and adaptable future-proof solution to cover both existing and emerging standards. It provides the designs with reconfigurability, intelligence and software programmable hardware. SDR has given promising solution in building multi-mode, multiband and multifunctional wireless communication devices. The Quality of service provided by wireless communication services can be greately improved with the help of correct selection of modulation technique. It will sreve to increase radio coverage, reduce power consumption . The better return on investment will be provided for next generation wireless communication Systems along with good quality.

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