Rigvi

Ch - 3

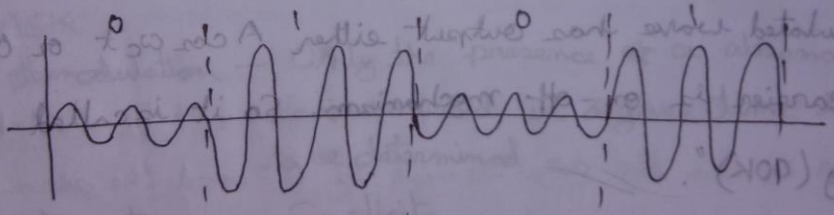
Digital - to - Analog Modulation

*) Why we should choose analog transmission

For digital transmission, low pass channel is required, which is very scarce. On the other hand for analog transmission, band pass channel is required, which is available. So we should choose analog transmission because low pass channel is not available all the time.

*) Amplitude Shift Keying (ASK) (2013, 12, 11

In digital to analog conversion, if the amplitude of the carrier signal is varied to create signal elements and both frequency and phase remains constant, it is called ASK. Amplitude remains constant during bit duration in ASK.

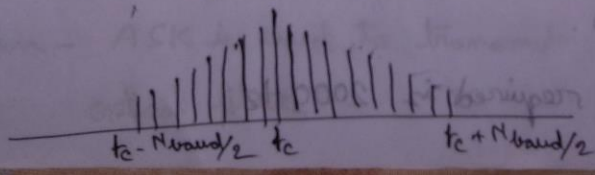


Bit rate = 5, Baud rate = 5

Relation between baud rate & BW in ASK -

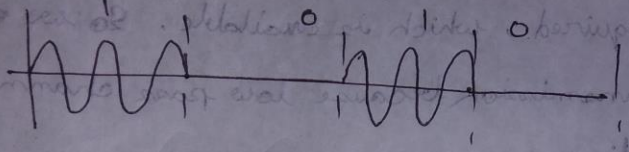
Minimum bandwidth required is equal to baud rate

$BW = (1 + d) \times N_{baud}$



* On-Off Keying (OOK) (2013, 12, 07) / Justify "ASK is sometimes called OOK" (2009, 2)

Although we can have several levels of signal elements, each with a different amplitude, ASK is normally implemented using two levels. This is referred to as Binary amplitude shift keying or On-off keying (OOK).



Mathematically, $V_{ASK}(t) = [1 + V_m(t)][A/2 \cos \omega_c t]$ — ①

For logic 1 = +1 V, equation ① becomes

$$V_{ASK}(t) = (1+1)[A/2 \cos \omega_c t] = A \cos \omega_c t$$

For logic 0 = -1 V, equation ① becomes

$$V_{ASK}(t) = [1-1][A/2 \cos \omega_c t] = 0.$$

So, the modulated wave has output either $A \cos \omega_c t$ or 0. Hence, the carrier is on-off mechanism. So it is called "On-Off keying (OOK)".

* Find the minimum BW for an ASK signal transmitting at 2000 BPS. The transmission mode is half duplex.

In ASK, bit rate and baud rate are the same. So, the baud rate is 2000.

∴ Minimum BW required is 2000 Hz.

* A BW of 100 KHz spans from 200 to 300 KHz. What are carrier freq. and bit rate when d = 1 ?

B = 100000 Hz , d = 1.

Carrier frequency = $\frac{f_{high} + f_{low}}{2} = \frac{300+200}{2} = 250 KHz$.

Now, $S = \frac{B}{1+d} = \frac{100000}{1+1} = 50000$ baud

if r = 1, then = N = S x r = 50000 x 1 = 50 Kbps.

* Multi level ASK

OOK uses only two amplitude levels. We can have multilevel ASK in which there are more than two levels. We can use 4, 8, 16 or more different amplitudes for the signal and modulate the data using 2, 3, 4 or more bits at a time. In these cases, r = 2, 3, 4 and so on.

* ASK

demodulation – Only the presence or absence of a signal of a sinusoid in a given time interval needs to be determined.

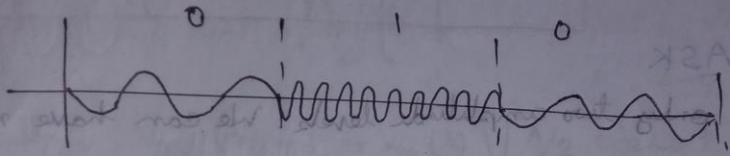
Advantage – Simplicity

Disadv. – ASK is very susceptible to noise interference since noise usually affects the amplitude, therefore ASK is the modulation technique most affected by noise.

Application – ASK is used to transmit digital data over optical fiber.

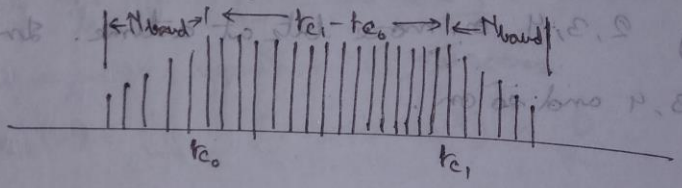
Frequency Shift keying (FSK) (2013, 12

In frequency shift keying, the frequency of the carrier signal is varied to represent data. The freq. of the modulated signal is constant for the duration of one signal element, but changes for the next signal element if the data element changes. Both Peak ~~and~~ amplitude and phase remain constant.



Relation between baud rate & BW in FSK —

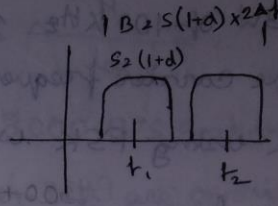
$$BW = f_{c_1} - f_{c_0} + N_{baud}$$



Binary FSK (BFSK)

In BFSK, we consider two carrier frequencies, f_1 & f_2. ~~First~~ First carrier is used if the the data element is 0 and the second ~~ab~~ carrier is used if data element is 1. Normally the carrier frequencies are very high and the difference between them is small. The difference between two frequencies will be $2\Delta f$.

Diagram - previous.



So, Bandwidth for BFSK will be = $S(1+d) + 2\Delta f$. — (2009, 07)

Multilevel FSK

We can use more than two frequencies in multilevel FSK. However, we need to remember that the frequencies need to be $2\Delta f$ apart. For the proper operation of modulator & demodulator, it can be shown that the minimum value of $2\Delta f$ needs to be S.

So, Bandwidth for MFSK $B = (1+d) \times S + (L-1) 2\Delta f$

if $d = 0$, then $B = L \times S$.

Find the minimum BW for an FSK signal transmitting at 2000 BPS. Transmission is in half duplex mode and the carrier are seperated by 3000 Hz.

$BW = f_{c_1} - f_{c_0} + N_{baud} = f_{c_1} - f_{c_0} + \text{bit rate} = 3000 + 2000 = 5000\ Hz$

Find the maximum bit rates for an FSK signal if the BW of the medium is 12000 Hz and the difference between the two carriers is 2000 Hz. Transmission is in full duplex mode.

$BW = 12000\ Hz$ ∴ Allocated BW = 12000/2 = 6000.

Now, Baud rate = $BW - (f_{c_1} - f_{c_0}) = 6000 - 2000 = 4000$

∴ Bit rate is 4000 BPS.

* A BW of 100 KHz spans from 200 to 300 KHz. What should be the carrier frequency and the bit rate if we modulated the data using FSK with d = 1. (2014, 12

Carrier freq. = $\frac{300+200}{2}$ = 250 KHz.

Now, $B = (1+d) \times S + 2\Delta f = 100$ [∵ choosing $2\Delta f$ to be 50 KHz]

$\Rightarrow 2S = 50 KHz \quad \therefore S = 25 K baud$

if $r = 1$, then $S = N = 25 K bps$.

* We need to send 3 bits at a time at a bit rate of 3 MBPS. The carrier freq. is 10 MHz. Calculate the number of the levels, the baud rate and the BW.

Level, $L = 2^3 = 8$ [∵ $r = 3$]

Baud rate, $S = \frac{N}{r} = \frac{3 MBPS}{3} = 1 M baud$

This means, carrier freq. must be 1 MHz apart ($2\Delta f = 1 MHz$).

∴ Bandwidth = $1 \times S$ [let $d = 0$]

$= 8 \times 1 = 8 MHz$.

* FSK -

Demod. — Demodulator must be able to determine which two possible frequencies is present at a given time.

Adv. — FSK is less susceptible to noise & errors than ASK. Receiver looks for specific frequency changes over a number of intervals so voltage spike can be ignored

Disadv. — FSK spectrum is 2X ASK spectrum.

Appl. — Voice line, High freq. radio transmission.

* Baud rate, $S = \frac{N \text{ (data rate)}}{r \text{ (bit in one signal)}} = \frac{N}{\log_2 L}$.

* An analog signal has a bit rate of 8000 BPS and baud rate of 1000 baud. How many data elements are carried by each signal element

$N = 8000$ BPS, $S = 1000$ baud $\therefore r = \frac{N}{S} = 8$

$\therefore \log_2 L = 8 \quad \therefore L = 2^8 = 256.$

* Phase Shift Keying (PSK) (2013, 12)

In phase shift keying, the phase of the carrier is varied to represent two or more different signal elements. Both peak amplitude and freq. remain constant.

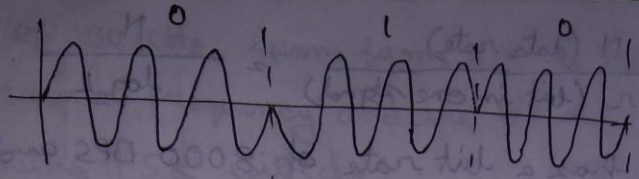
Relation between Baud rate & BW in PSK

$$BW = (1+d) \times N_{baud}$$

Diagram — same as ASK.

* Binary PSK (BPSK) / 2-PSK

The simplest PSK is binary PSK, in which we have only two signal elements, one with a phase of 0° and the other with a phase of 180°. BPSK is as simple as ASK with one big advantage, it is less susceptible to noise. BPSK is also superior to FSK because we do not need two carrier signal.

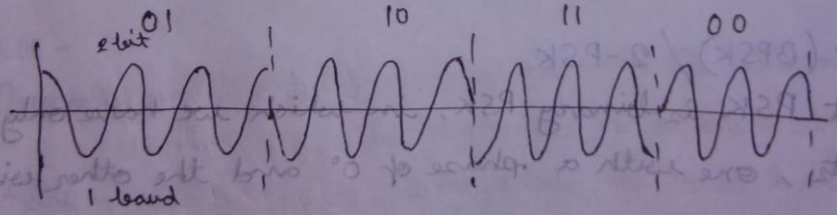


Bandwidth of BPSK is the same as that for ASK but less than that for BFSK. No BW is wasted for separating carrier signals.

*) Quadrature PSK (QPSK) / 4-PSK

QPSK uses two separate BPSK modulations; one is in-phase, the other quadrature (out-of-phase). The bit to each BPSK signal has one-half the frequency of the original signal. The two composite signals created by each multiplier are sine waves with same frequency but different phases.

QPSK utilizes four variations of phase shift by 90°. There are four kind of signal elements in the output signal (L=4), so we can send 2 bits per signal element (r=2). It allows data transmission two times as fast as 2-PSK.



Dibit	Phase
00	0
01	90
10	180
11	270

*) 8-PSK

8-PSK utilizes eight variations of phase shift by 45°. There are eight kind of signal elements in the output signal (L=8), so we can send 3 bits per signal element (r=3).

It allows data transmission three times as fast as 2-PSK.

* Find the BW for a 4-PSK signal transmitting at 2000 BPS. Transmission is in half duplex mode.

For 4-PSK baud rate is one half of the bit rate (∵ 1 baud = 2 bit)

∴ Baud rate, $S = N \times \frac{1}{r} = \frac{2000}{2} = 1000$ baud.

∴ BW = 1000 Hz.

* Find the BW for a signal transmitting at 12 MBPS for QPSK. value of d = 0.

$S = N \times \frac{1}{r} = \frac{12M}{2} = 6$ Mbaud. ∴ BW = 6 MHz.

* Given a BW of 5000 Hz for an 8-PSK signal, what are the baud rate and bit rate.

Baud rate is same as BW ∴ Baud rate = 5000 baud.

But bit rate is 3 times of baud rate ∴ Bit rate = 15000 BPS.

* Why I and Q channels are required in QPSK. (2014,

In QPSK, two bits are clocked into bit splitter. One bit is directed towards I channel & another to Q channel. The I bit modulates the carrier that is in phase and Q bit modulates the carrier that is 90° out of phase. QPSK is combination of two BPSK.

I & Q channel enables two BPSK modulator, to be combined in parallel. I channel enables $\pm \sin \omega_c t$ phases. Q channel enables $\pm \cos \omega_c t$ phases. Thus for four phases I & Q are required QPSK.

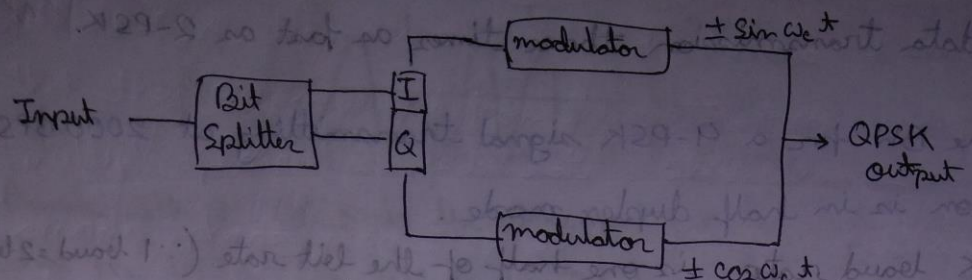
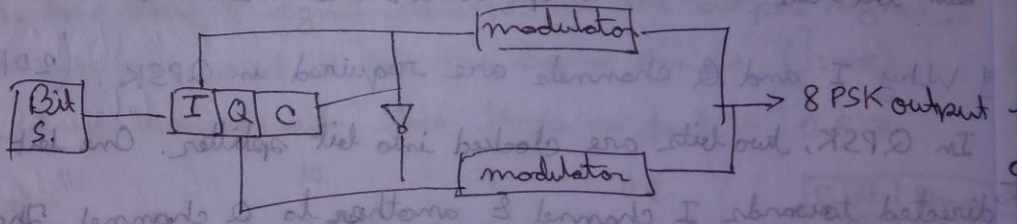


Fig. Block diagram of modulator — (2014

* Significance of I, Q and C channels in 8-PSK modulator. (2007, 09

The incoming serial bit stream is converted to a parallel three channel output, I, Q & C. With two input bits, four voltages are possible.

The I & Q bit determines the polarity of the output signal whereas C bit determines magnitude. Consequently, with two magnitudes and two polarities, four different output are possible for each I & Q.



* PSK

Demod. — Demodulator must determine the phase of received sinusoid with respect to some reference phase.

Adv. — ① PSK is less susceptible to errors than ASK, while it requires the same bandwidth as ASK.

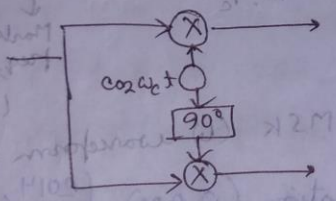
② More efficient use of BW compared to FSK.

Disadv. — more complex signal detection / recovery process.

** Differentiate among ASK, FSK, PSK.

Contents	ASK	FSK	PSK
1. Variable	Amplitude	Frequency	Phase
2. Noise immunity	Poor	High	High
3. Error probability	High	Low	Low
4. Complexity	Simple	Moderate	Very complex
5. Detection method	Envelope	Envelope	Coherent

** Block diagram of QPSK demodulator (2007



** What is M-ary encoding (2009, 07. ? Advantages (2015

An M-ary transmission is a type of digital modulation where instead of transmitting one bit at a time, two or more bits are transmitted simultaneously

Adv. – (i) Higher information transfer rate (bit rate) for a given symbol rate

(ii) Reduced bandwidth requirement for a given bit rate.

** Explain MSK (2015

Minimum Shift Keying (MSK) is continuous-phase FSK with a minimum modulation index (h = 0.5) that will produce orthogonal signaling.

With CP-FSK, the mark and space frequencies are selected such that they are seperated from the center frequency by an exact multiple of one-half of bit rate. This ensures a ~~smooth~~ smooth phase transition in the analog output signal when it changes from mark to space freq. or vice versa.

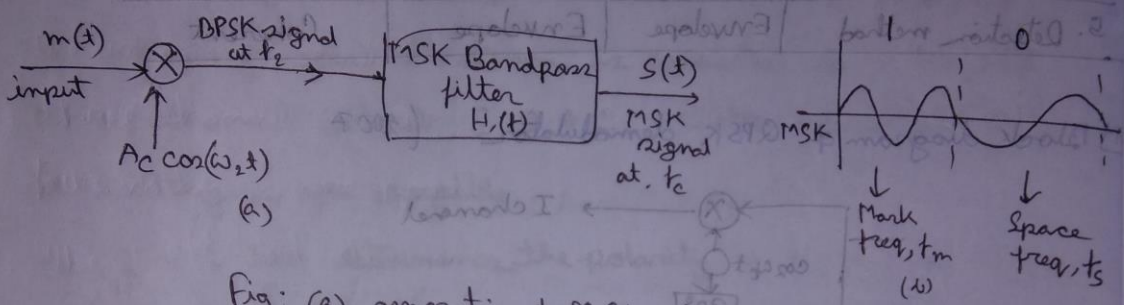
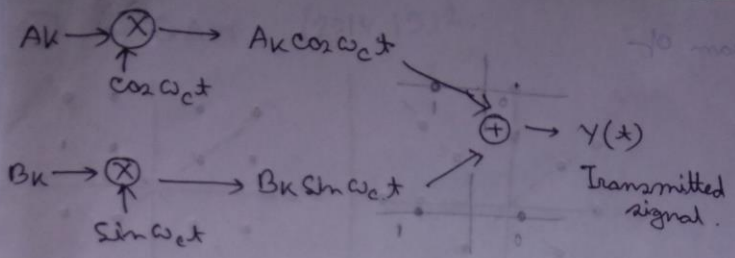


Fig: (a) generation of MSK (b) waveform.

*) Quadrature Amplitude Modulation (QAM) (2014, 12, 11

QAM is the combination of ASK & PSK. QAM sends two different signals simultaneously on same frequency. Original info. stream is split into two sequences that consists of odd & even symbols. A_K sequence (in phase) is modulated by $\cos 2\pi f_c t$ *) B_K sequence (quadrature-phase) is modulated by $\sin \omega_c t$. Composite signal $A_K \cos \omega_c t + B_K \sin \omega_c t$ is sent through the channel. At the receiver two signals are demodulated and combined to produce the original binary signal.



1 0 1 1 0 1
1 -1 1 1 -1 1
B1 A1 B2 A2 B3 A3

What are the advantages of QAM over ASK & PSK. (2011, 10

PSK is limited as it cant distinguish small differences in phase. Again, we cant change all three properties of a signal. But in QAM both PSK & ASK are combined. We can use two carrier - one in phase and the other with different amplitude levels. Again, QAM is not susceptible to noise.

QAM is suitable for high bit rates as noise immunity of QAM is very high. So, Low error probability. Utilization of BW is possible because baud rate is half the bit rate in QAM.

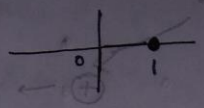
Constellation Diagram (2011,

Constellation diagram is a graphical representation of the phases and amplitude of different bit combinations in digital - to - analog modulation. In this, a signal element type is represented as a dot.

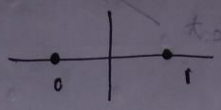
Date

Constellation diagram of

① ASK (OOK) (2013

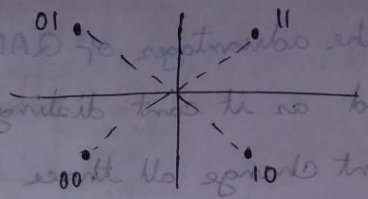


② BPSK (2014,



③ QPSK/4-PSK ; 4QAM

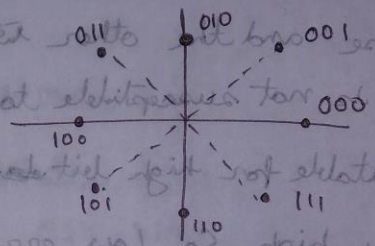
Dibit	Phase
00	225
01	135
10	315
11	45



1 Amp,
4 Phase.

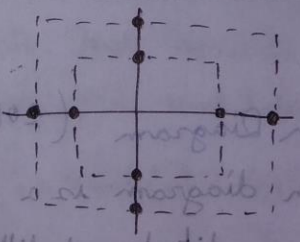
④ 8-PSK (2013,

Tribit	Phase
000	0
001	45
010	90
011	135
100	180
101	225
110	270
111	315



⑤ 8-QAM (2012,

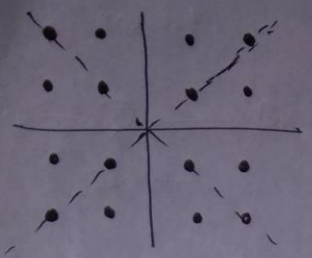
000	0°
001	0°
010	90°
011	90
100	180
101	180
110	270
111	270



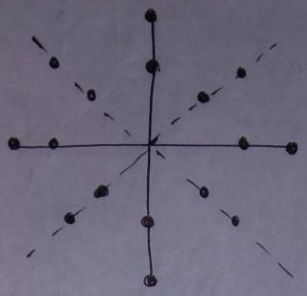
2 Amp,
4 phase.

(For choosing best, number of phase shift > number of amplitude shift.
if match, then check amplitude level. Lower amplitude → better)

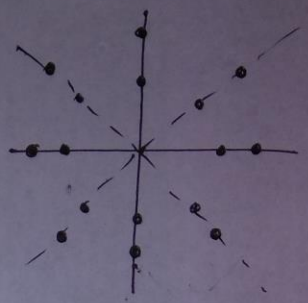
(VI) 16-QAM (2014, 13, 12, 2



3 amp., 12 phase



4 amp., 8 phase



2 amp., 8 phases.