6.14.4 QASK Transmitter :

The block diagram of a QASK transmitter is shown in Fig. 6.14.4.

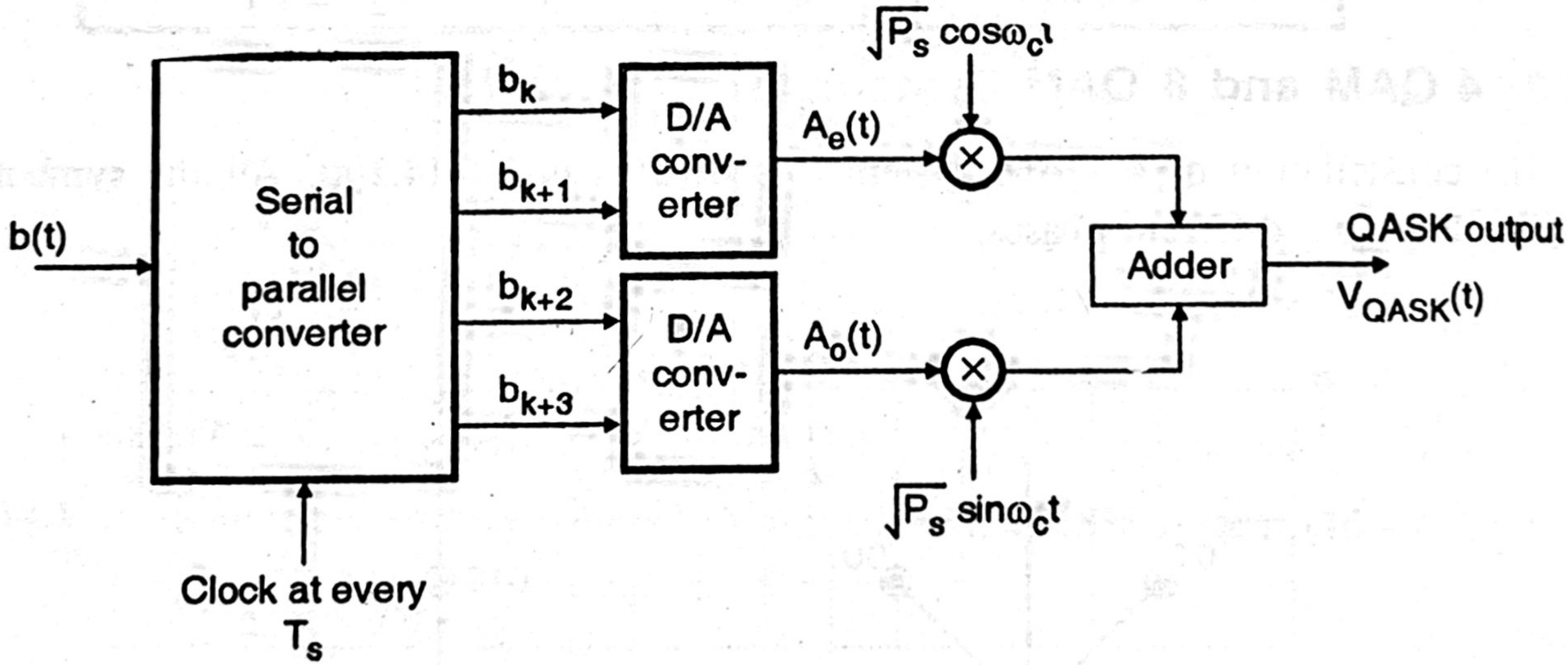


Fig. 6.14.4 : QASK transmitter

Operation :

- The QASK signal shown in Fig. 6.14.2 can be mathematically represented as,

$$V_{QASK} = k_1\, a\, u_1(t) + k_2\, a\, u_2(t) \tag{6.14.7}$$

where k_1 and k_2 are each equal to ± 1 or ± 3.

- We know that,

$$u_1(t) = \sqrt{2/T_s} \cos \omega_c t$$

and $$u_2(t) = \sqrt{2/T_s} \sin \omega_c t \text{ and } a = \sqrt{0.1\,E_s}$$

We can substitute these expressions into Equation (6.14.7) to get,

$$V_{QASK} = k_1 \times \sqrt{(0.2\,E_s/T_s)} \cos \omega_c t + k_2 \times \sqrt{(0.2\,E_s/T_s)} \sin \omega_c t \quad ...(6.14.8)$$

- But $E_s/T_s = P_s$ hence equation for QASK is given by,

$$V_{QASK} = k_1 \sqrt{0.2\,P_s} \cos \omega_c t + k_2 \times \sqrt{0.2\,P_s} \sin \omega_c t \quad ...(6.14.9)$$

- The QASK generator is as shown in Fig. 6.14.4. The bit stream $b(t)$ is applied to a serial to parallel converter operating on a clock which has a period of T_s sec. which is the symbol duration. The bits $b(t)$ are stored by the converter and then presented in the parallel form. The four bit symbol is $b_{k+3}\, b_{k+2}\, b_{k+1}\, b_k$.

- Out of these four bits, the first two bits are applied to a D to A converter and the other two bits are applied to the second D to A converter.

- The output of the first D/A converter is $A_e(t)$ which is used to modulate the carrier $\sqrt{P_s} \cos \omega_c t$, whereas the output of the second D/A converter i.e. $A_o(t)$ is used to modulate the carrier $\sqrt{P_s} \sin \omega_c t$ in the balanced modulators.

- The balance modulator outputs are added together to get the QASK output signal, which is expressed as follows :

$$V_{QASK}(t) = A_e(t) \times \sqrt{P_s} \cos \omega_c t + A_o(t) \times \sqrt{P_s} \sin \omega_c t \quad ...(6.14.10)$$

- Comparing Equations (6.14.10) and (6.14.9) we get,

$$A_e(t) \text{ and } A_o(t) = \pm\sqrt{0.2} \text{ or } \pm 3\sqrt{0.2} \quad ...(6.14.11)$$

depending on the input to D/A converter.

6.14.5 QASK Receiver :

The block diagram of QASK receiver is as shown in Fig. 6.14.5, which is very much similar to the QPSK receiver discussed earlier.

Operation :

- Like QPSK this is also a synchronous demodulation which requires a locally generated set of quadrature carriers i.e. $\cos \omega_c t$ and $\sin \omega_c t$.

- These quadrature carriers are recovered from the received QASK signal. The input QASK signal is first raised to the fourth power and using a bandpass filter with a centre frequency of $4\,f_c$ alongwith a frequency divider ($\div 4$), the required quadrature carriers are recovered.

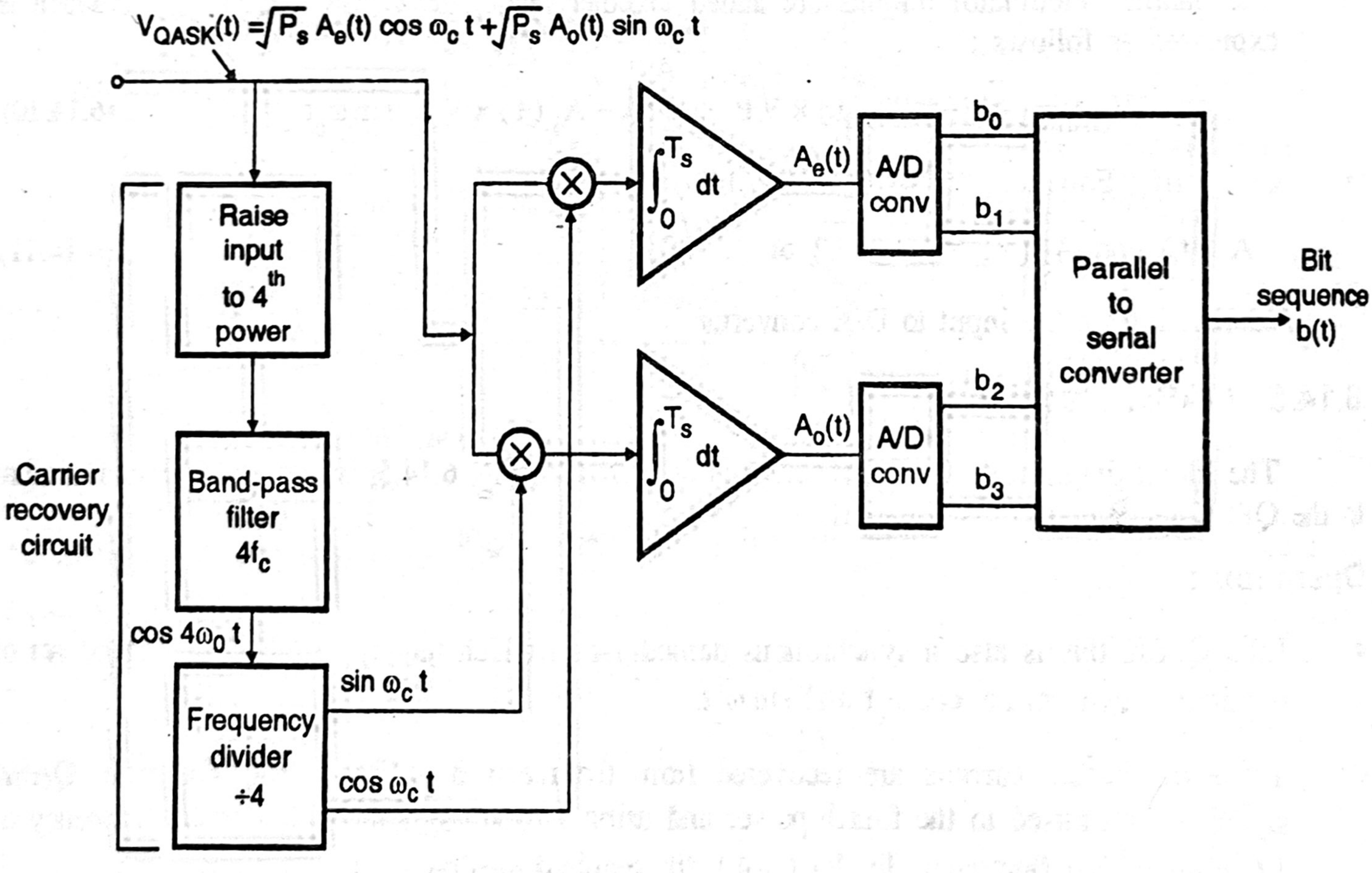
- Remember that the values of A_e and A_o are not constant and equal in the QASK system. Therefore it is not sure if we can really recover the quadrature carriers or not. Hence let us check whether we can really recover the carriers correctly.
- The input signal $V_{QASK}(t)$ is raised to fourth power as,

$$V_{QASK}^4(t) = P_s^2 [A_e(t) \cos \omega_c t + A_o(t) \sin \omega_c t]^4$$

- This signal is then passed through a bandpass filter with a centre frequency $4 f_c$, therefore we neglect all the other terms except for those at frequency $4 f_c$.

$$\therefore \quad V_{QASK}^4(t) = \frac{P_s}{8}\left[A_e^4(t) + A_o^4(t) - 6 A_e^2(t) A_o^2(t)\right] \cos 4 \omega_c t$$
$$+ \frac{P_s}{2}\left[A_e(t) A_o(t) [A_e^2(t) - A_o^2(t)]\right] \sin 4 \omega_c t \qquad ...(6.14.12)$$

- The average value of the coefficient of $\cos 4 \omega_c t$ is not zero but the average value of the coefficient of $\sin 4 \omega_c t$ will be zero. Thus at the output of the bandpass filter and frequency divider combination we get the quadrature carrier components $\cos \omega_c t$ and $\sin \omega_c t$.
- Then two balanced modulators (multipliers) are used together with two integrators to recover the signals $A_e(t)$ and $A_o(t)$. Both the integrators integrate over one symbol interval T_s. The symbol time synchronizer which is not shown in Fig. 6.14.3 is actually used alongwith each integrator.



- Finally the original bits are obtained from $A_e(t)$ and $A_o(t)$ by using two A to D converters. The outputs of the two A to D converters are then applied to a serial to parallel converter to obtain the sequence $b(t)$.

6.14.6 Bandwidth of QASK System :

- The expression for the QASK output is very similar to that of a M-ary PSK. Therefore the plot of power spectral density also will be same as that for the M-ary PSK.
- The spectrum of QASK is shown in Fig. 6.14.6, which is quite similar to that of a M-ary PSK.

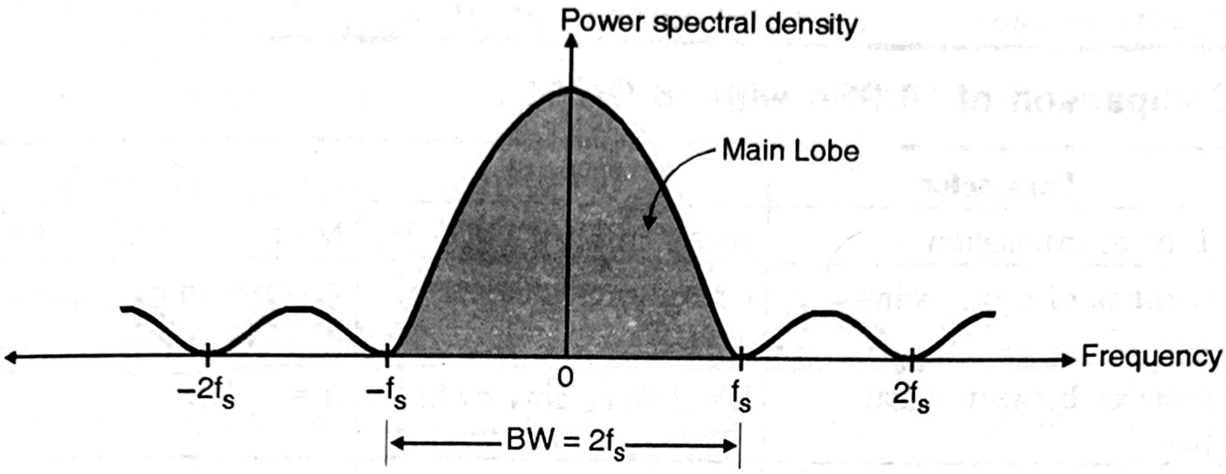


Fig. 6.14.6 : Frequency spectrum of QASK

- From the Fig. 6.14.6, it is evident that main lobe of the frequency spectrum extends from $-f_s$ to $+f_s$. Therefore the bandwidth of QASK is given by,

$$BW = f_s - (-f_s) = 2 f_s \qquad ...(6.14.13)$$

$$= \frac{2}{T_s} \qquad ... \text{As} \quad f_s = \frac{2}{T_s}$$

$$= \frac{2}{N T_b} \qquad ... \text{As} \quad T_s = N T_b$$

$$\therefore \quad BW = \frac{2 f_b}{N} \qquad ... \text{As} \quad f_b = \frac{1}{T_b} \qquad ...(6.14.14)$$

Thus the bandwidth of QASK system is same as that of an M-ary PSK system.

6.14.7 Comparison of QASK and QPSK :

[Asked in Exam : May 08 !!!]

New Syll. MU - Dec. 2009

Table 6.14.1

Sr. No.	Parameter	QPSK	QASK
1.	Type of modulation	Quadrature phase modulation	Quadrature amplitude and phase modulation
2.	Location of signal points	On the circumference of a circle	Equally spaced and placed symmetrically about origin

Sr. No.	Parameter	QPSK	QASK
3.	Distance between the signal points	$d = 2\sqrt{E_b}$ for $N = 2$	$d = 2\sqrt{0.4\,E_b}$ for $N = 4$ or $M = 16$
4.	Noise immunity	Better than QASK	Poorer than QPSK
5.	Probability of error	Less than QASK	More than QPSK
6.	Type of demodulation	Synchronous	Synchronous
7.	System complexity	Less complex than QASK	More complex than QPSK

6.14.8 Comparison of 16 PSK with 16 QASK :

Sr.No.	Parameter	16 PSK	16 QASK
1.	Type of modulation	M-ary PSK with M = 16	M-ary QAM with M = 16
2.	Location of signal points	On the circumference of a circle	4 points in each quadrant
3.	Distance between signal points	$d = 2\sqrt{4\,E_b}\,\sin(\pi / M)$	$d = 2\sqrt{0.15\,E_b}$
4.	Noise immunity	Poorer than 16 QASK	Better than 16 PSK
5.	Number of symbols	$M = 16$	$M = 16$
6.	Number of bits per symbol	$N = 4$	$N = 4$
7.	Detection method	Coherent	Coherent
8.	Symbol duration	$T_s = 4\,T_b$	$T_s = 4\,T_b$
9.	Bandwidth	$B = \dfrac{2\,f_b}{N} = f_b/2$	$f_b/2$
10.	System complexity	Less than 16 QASK	More than 16 PSK

Binary Frequency Shift Keying (BFSK) :