Mobile Communication – An overview

Lesson 03

Introduction to Modulation Methods

Modulation

- The process of varying signal, called *carrier*, according to the pattern provided by another signal (modulating signal)
- The carrier usually an analog signal selected to match the characteristics of a particular transmission system.

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…Modulation

- The amplitude, frequency, or phase angle of a carrier wave is varied in proportion to the variation in amplitude of the modulating wave (message signal)

Equation for signal amplitude at an instant *t*, *s*(*t*)

$s(t) = s_0 \sin [(2\pi \times c/\lambda \times t) + \Phi_{t0}]$

$= s_0 \sin [(2\pi \times f \times t) + \Phi_{t0}]$

- s_0 — the peak amplitude (amplitude varies between s_0 and $-s_0$)
- c — the velocity of the transmitted wave
- Φ_{t0} — the phase angle of the signal at t = 0 (a reference point with respect to which t is considered)
- f — the signal frequency

Modulation of the voice or data signal

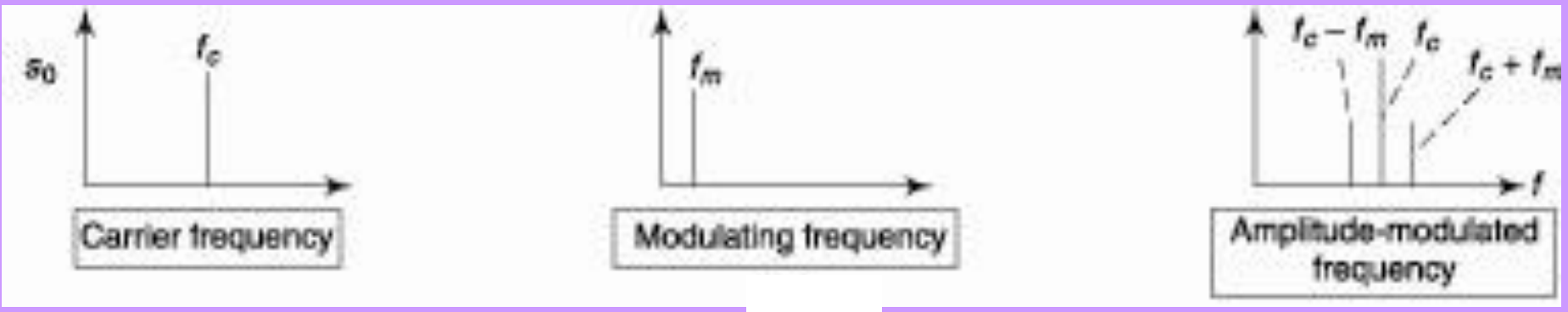
A technique by which f_c or a set of carrier frequencies used for wireless transmission such that

- peak amplitude, s_{c0}, or
- frequency, f_c, or
- Phase angle Φ_{ct0} varies with t in proportion to the peak amplitude of the modulating signal $s_m(t)$

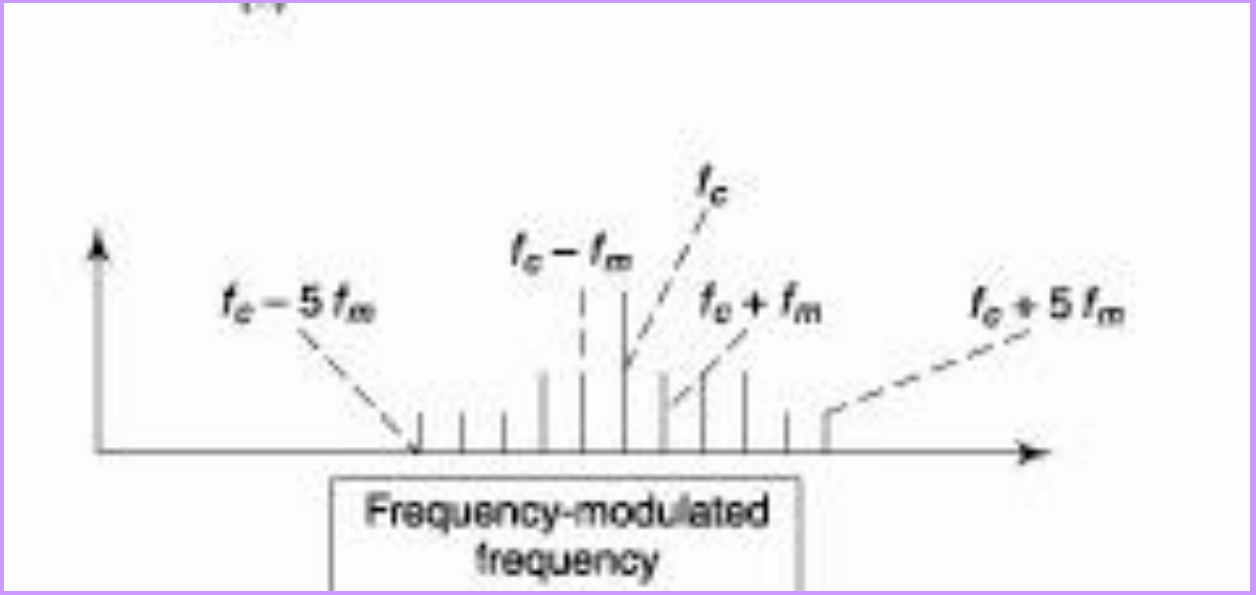
Modulation

- Amplitude modulation (AM) if amplitude s_{c0} of carrier varied
- Frequency modulation (FM) if frequency f_c varied
- Phase modulation if phase angle Φ_{t0} varied

Amplitude Modulation (AM)



Frequency Modulation (FM)



Digital Modulation

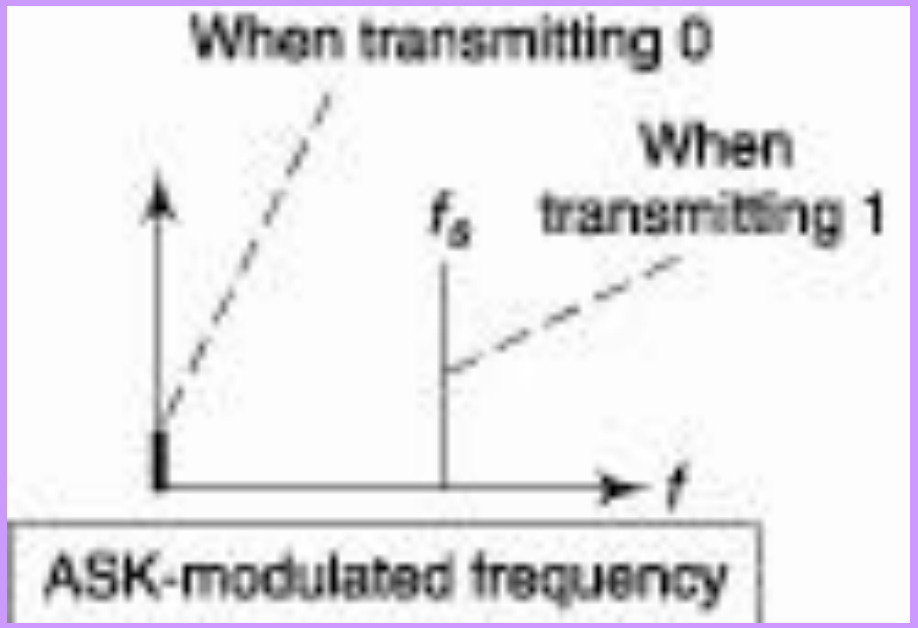
A technique by which amplitude, frequency, or phase angle parameters of carrier or sub-carrier frequencies varied according to the variation in the

- modulating signal bit 1 or 0 the or
- modulating bit-pair 00, 01, 10 or 11
- or set of 3 or 4 or more bits

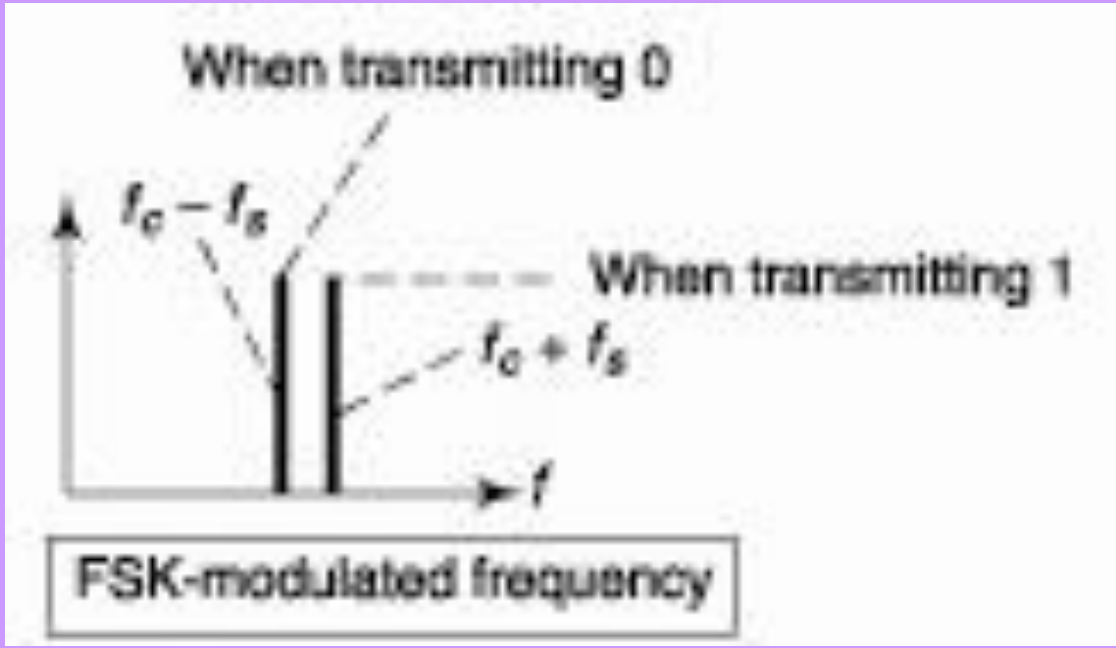
Digital Modulation of 1s and 0s

- Amplitude Shifted Keying (ASK)– if as per 1 or 0, the amplitude s_{c0} of carrier varied
- Frequency Shifted Keying (FSK)– if as per 1 or 0 the frequency f_c varied

Amplitude Shifted Keying Modulation (ASK)



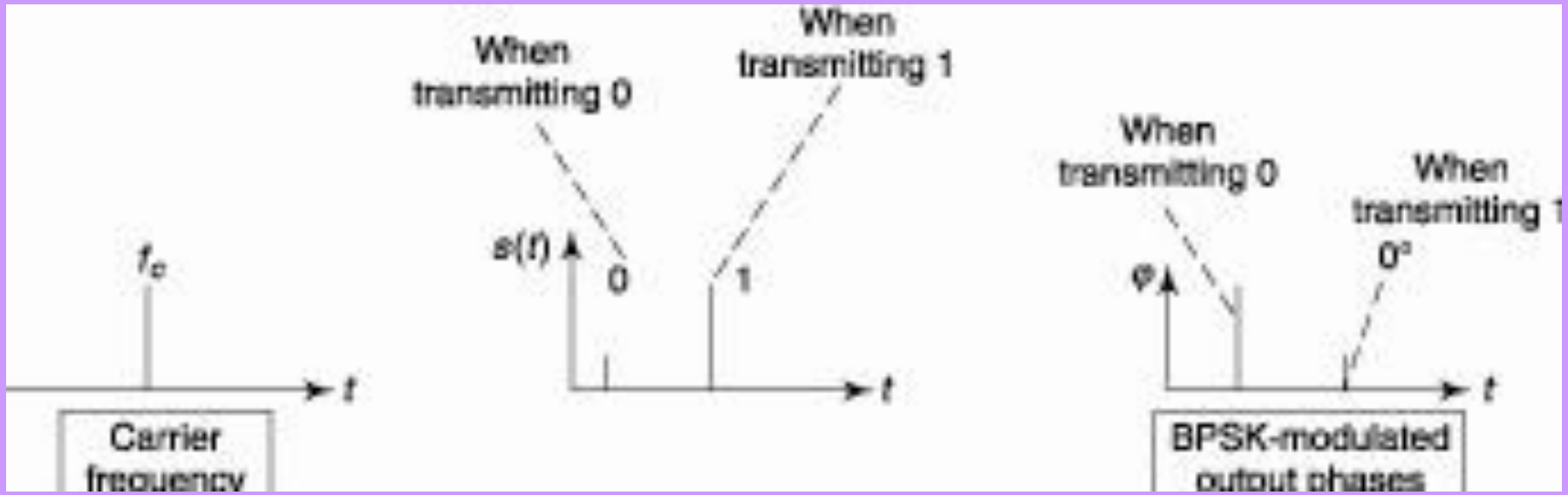
Frequency Shifted Keying Modulation (FSK)



Phase Modulation of 1s and 0s

- Binary Phase Shifted Keying (PSK or BPSK) 0° or 180° if as per 1 or 0 phase angle varied
- Gaussian Minimum-phase Shifted Keying (GMSK) 0° – if change from 1 to 0 then angle change by 180°, and if change from 0 to 1 then angle change by –180° and then use a minimizing technique for filtering of high frequency components introduced using PSK

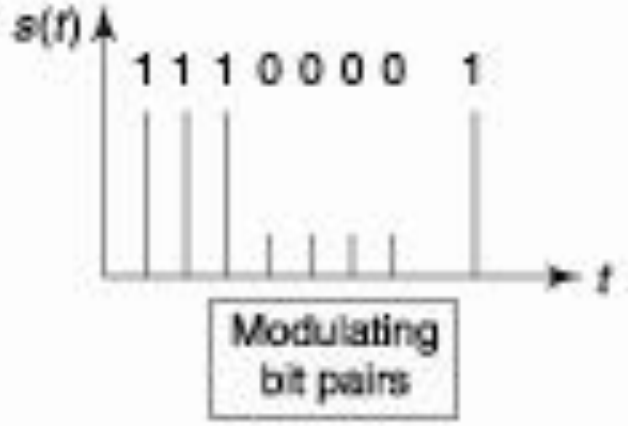
BPSK

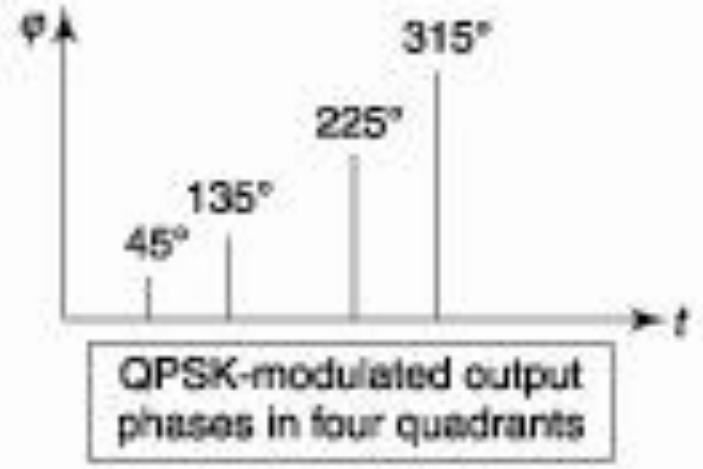


Phase Modulation of 1s and 0s

- Quadrature Phase Shifted Keying (QPSK or BPSK) as per 10, 00, 01 or 11
- QPSK Phase angle shift = Φ of the transmitted signal s(t) will be $3\pi/4$, $-3\pi/4$, $-\pi/4$, $+\pi/4$ ($\equiv 135^\circ, 225^\circ, 315^\circ, 45^\circ$) after each successive time interval T when bit pattern is 10 00 01 11. [T = 1/f]

QPSK





8-PSK MODULATION

- Bit pattern is 101 000 110 011 100 111. The phase angle of the transmitted signal $s(t)$ will be $-5\pi/8$, $\pi/8$, $-3\pi/8$, $7\pi/8$, $-7\pi/8$, and $-\pi/8$, after each successive time interval of T. [T = 1/f]

Quadrature Amplitude Modulation (QAM) modulation

- Quadrature amplitude modulation quadrature phase shift keying
- 16-QAM– The 4 PSK with 4 combinations of 3-discrete values of amplitudes A0, A1 and A2 modulation

Quadrature Amplitude Modulation (QAM) modulation

- Quadrature amplitude modulation quadrature phase shift keying
- 64-QAM– The 8 PSK with 8 combinations of 4-discrete stage amplitudes A0, A1, A2 and A3 in modulation

Summary

- Amplitude, frequency and phase modulations
- AM of analog signals
- FM of analog signals

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...Summary

Digital modulation

I. BPSK
II. GMSK digital modulation
III. QPSK digital modulation
IV. ASK and FSK digital modulations
V. 8-PSK
VI. 16-QAM
VII. 64-QAM

End of Lesson 03
Introduction to Modulation Methods