# P-M and Carrier Frequency

(1) In the vector representation of the p-m carrier, the carrier vector is speeded up or slowed down as the relative phase angle is increased or decreased by the modulating signal. Since vector speed is the equivalent of carrier frequency, the carrier frequency must change during phase modulation. A form of frequency modulation, knows as equivalent f-m, therefore, takes place. Both the p-m and the equivalent f-m depend on the modulating signal, and an instantaneous equivalent frequency is associated with each instantaneous phase condition.

(2) The phase at any instant is determined by the amplitude of the modulating signal. The instantaneous equivalent frequency is determined by the rate of change in the amplitude of the modulating signal. The rate of change in modulating -signal amplitude depends on two factors -- the modulation amplitude and the modulation frequency. If the amplitude is increased, the phase deviation is increased. The carrier vector must move through a greater angle in the same period of time, increasing its speed, and thereby increasing the carrier frequency shift. If the modulation frequency is increased, the carrier must move within the phase-deviation limits at a faster rate, increasing its speed and thereby increasing the carrier frequency shift. When the modulating-signal amplitude or frequency is decreased, the carrier frequency shift is decreased also. The faster the amplitude is changing, the greater the resultant shift in carrier frequency; the slower the change in amplitude, the smaller the frequency shift.

(3) The rate of change at any instant can be determined by the slope, or steepness, of the modulation waveform. As shown by curve A in figure 14, the greatest rates of change do not occur at points of maximum amplitude; in fact, when the amplitude is 0 the rate of change is maximum, and when the amplitude is maximum the rate of change is 0. When the waveform passes through 0 in the positive direction, the rate of change has its maximum positive value; when the waveform passes through 0 in the negative direction, the rate of change is a maximum negative value.

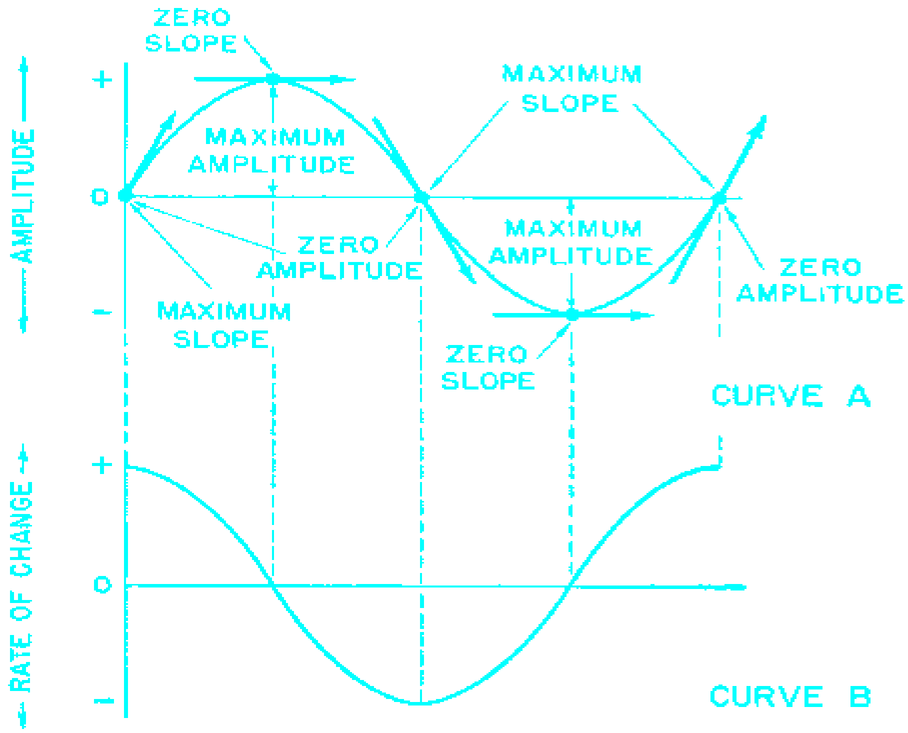


*Figure 14. Amplitude compared to rate of change of a signal.*

(4) Curve B is a graph of the rate of change of curve A. This waveform is leading A by 90°. This means that the frequency deviation resulting from phase modulation is 90° out of phase with the phase deviation. The relation between phase deviation and frequency shift is shown by the vectors in figure 15. At times of maximum phase deviation, the frequency shift is 0; at times of 0 phase deviation, the frequency shift is maximum. The equivalent-frequency deviation limits of the phase-modulated carrier can be calculated by means of the formula, $\Delta F = \Delta\theta f \cos(2\pi f t)$ where $\Delta F$ is the frequency deviation, $\Delta\theta$ is the maximum phase deviation, f is the modulating-signal frequency, $\cos(2\pi f t)$ is the amplitude variation of the modulating signal at any time, t. When $(2\pi f t)$ is 0 or 180°, the signal amplitude is 0 and the cosine has maximum values of +1 at 360° and -1 at 180°. If the phase deviation limit is 30°, or $\pi/6$ radians, and a 1,000-cps signal modulates the carrier, then $F = (\pi/6)*1000*+1$, F = +523 cps, approximately. When the modulating signal is passing through 0 in the positive direction, the carrier frequency is raised by 523 cps. When the modulating signal is passing through 0 in the negative direction, the carrier frequency is lowered by 523 cps.

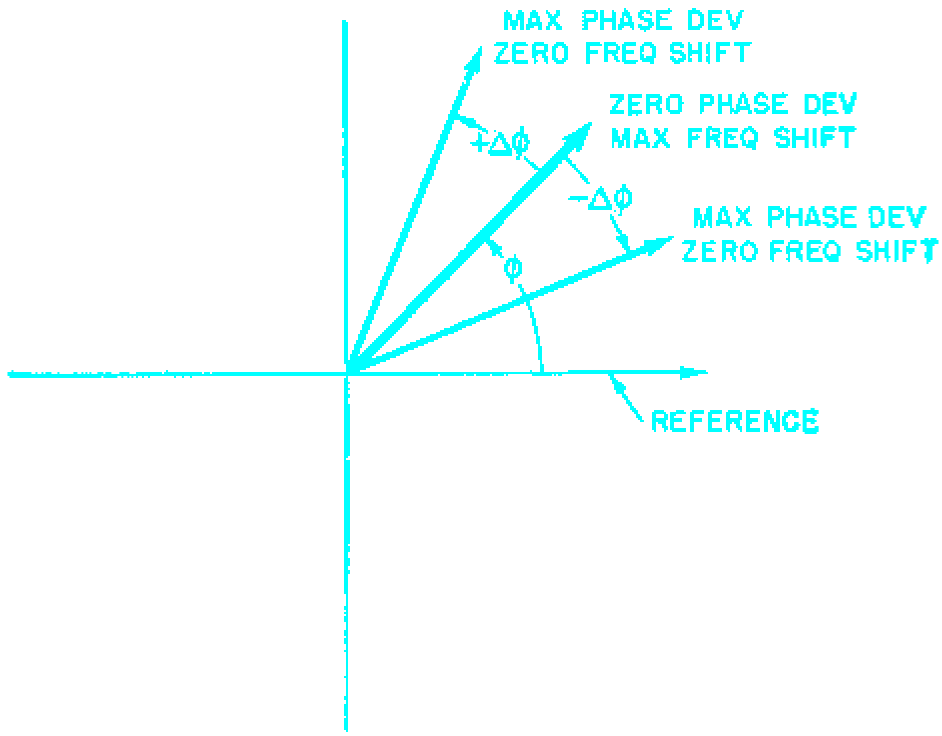


*Figure 15. Phase deviation and frequency shift.*

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