

XXI. MULTIPATH TRANSMISSION

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RESEARCH OBJECTIVES

Of major importance in this project is a basic understanding of the nature of the disturbances arising in radio reception under adverse conditions of multipath propagation and cochannel interference. At present, the primary objective is a revision of basic receiver design requirements with a view toward better meeting the signal channel requirements on the functioning and bandwidths, and toward coping successfully with the additional demands placed by multipath disturbance. This study should advance our knowledge of the interference rejection capabilities of frequency-modulation systems and increase our ability to make use of them.

A. CASCADED BANDPASS LIMITERS

In the Quarterly Progress Report of April 15, 1954, some ideas concerning the possibility of successively reducing the minimum required discriminator bandwidth by cascading several stages of bandpass limiting were derived from computed plots of required discriminator bandwidth vs. used limiter bandwidth. Those ideas were confirmed by direct computation for situations in which the desired capture ratio (ratio of strength of weaker undesired signal to the strength of the desired signal, α) was less than approximately 0.85. (Plots pertinent to two of these situations are reproduced, for convenient reference, in Fig. XXI-1.) We have now been able by direct computation to extend the validity of our ideas to cover situations in which the desired capture ratio is of the order of 0.85 and higher. Illustrative plots are presented in Fig. XXI-2.

In these plots, Ω_0 is the instantaneous frequency variation of the resultant two-path signal over one period of the frequency difference, r , between the two component signals.

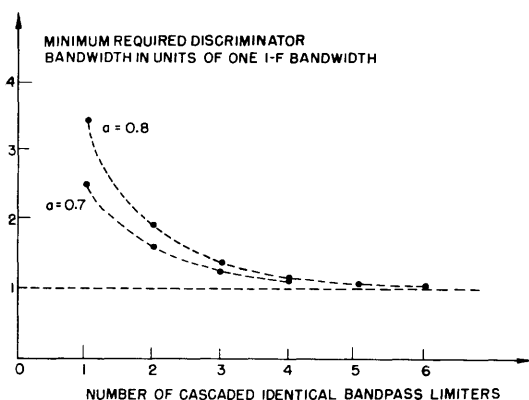


Fig. XXI-1

Variation of the minimum discriminator bandwidth requirement with the number of cascaded bandpass limiters. The ideal bandpass limiters are identical; the bandwidth of each is equal to the i-f bandwidth.

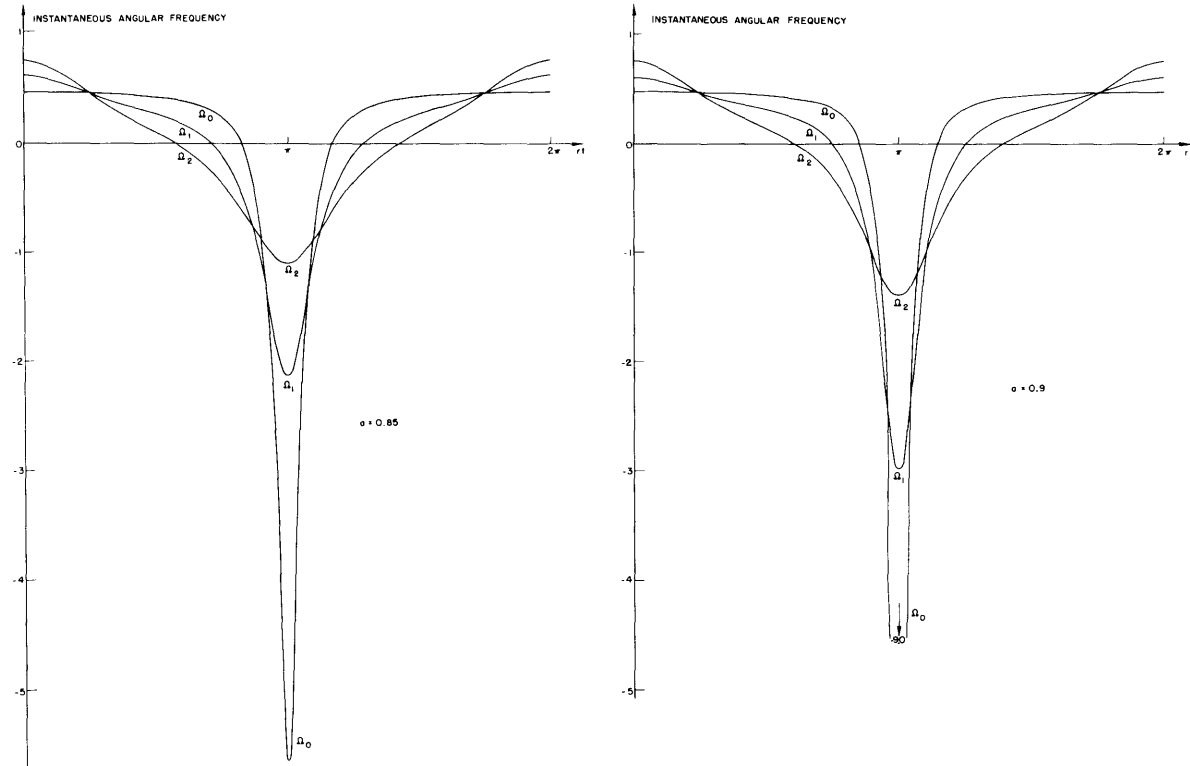


Fig. XXI-2

Plots of the variations from the frequency of the stronger signal in the instantaneous frequency of the resultant signal under two-path conditions, for two different values of the desired capture ratio, a .

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If an amplitude-insensitive discriminator is used immediately following the i-f section, the FM-to-AM conversion characteristic of the discriminator must be linear over the whole range of variation of $\Omega_0(t)$. However, if one stage of ideal bandpass limiting is inserted between the i-f section and the amplitude-insensitive discriminator, the most serious variations in the instantaneous frequency of the resultant signal delivered to the discriminator follow the curve denoted by $\Omega_1(t)$ when the ideal limiter bandwidth is three times the i-f bandwidth. The effect of cascading two such identical stages of limiting between the i-f and the discriminator is that the most serious variations in resultant signal frequency now follow the curve for $\Omega_2(t)$. Reference to Fig. VIII-2 in the April report shows that the value chosen here for $(BW)_{lim}$ corresponds to the value that dictates the smallest minimum required discriminator bandwidth for $a = 0.9$; the second smallest for $a = 0.85$.

Table XXI-1 shows the values of minimum required discriminator bandwidth under the conditions of each of the plots of Fig. XXI-2. These values are also plotted in Fig. XXI-3. Clearly, the same type of action will be duplicated by further stages of ideal bandpass limiting until, after a sufficient number of them has been cascaded, the minimum required discriminator bandwidth becomes effectively that of the i-f section.

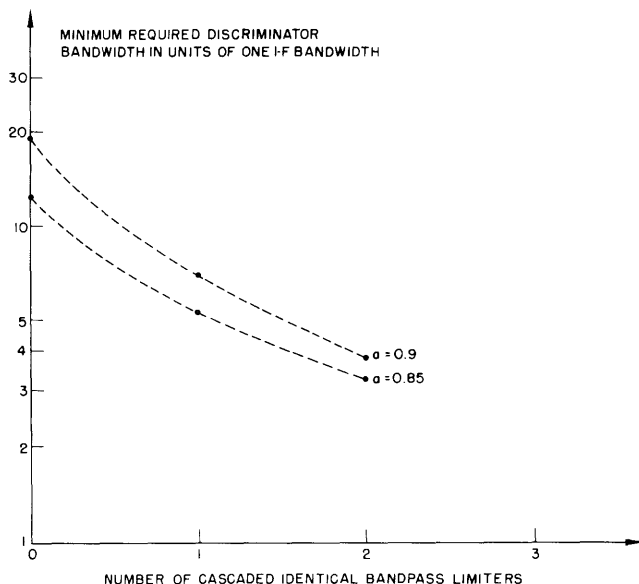


Fig. XXI-3

Variation of the minimum discriminator bandwidth requirement with the number of cascaded bandpass limiters. The ideal bandpass limiters are identical; the bandwidth of each is three times the i-f bandwidth.

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Table XXI-1

Capture Ratio, a	Frequency Spike Magnitude at the Output of the			Minimum Required $(BW)_{disc}/(BW)_{if}$ after n Identical Bandpass Limiters		
	i-f section	first bandpass limiter [†]	second identical cascaded bandpass limiter	n = 0	n = 1	n = 2
0.85	$5.667r^*$	2.1395r	1.1099r	12.333	5.2790	3.220
0.9	9r	$2.9883r \approx 3r$	1.3913r	19	$6.9766 \approx 7$	3.7826

* r is the difference frequency (in radians/sec) between the desired and undesired carriers.

† The bandwidth of each ideal bandpass limiter used is three times the i-f bandwidth.

B. NARROW-BAND LIMITING

A recheck on the value of $k(a)$ for $a = 0.7$ has revealed that the value used in the plot of $k(a)$ vs. $\ln a$ in Fig. IX-3(a), Quarterly Progress Report, October 15, 1954 (p. 44), was in error. The more exact value is $k(0.7) = 0.1401$, which increases the excellence of the agreement between the plotted points and the straight line in the region of $a = 0.7$ in the figure. This correction encourages us to claim that the equation

$$k(a) = -0.395 \ln a$$

holds for all values of a . Consequently, the relation

$$\psi(a) = 1 - \zeta(a) e^{-k(a)x}$$

appears to describe the variation of the minimum required discriminator bandwidth with the odd values of ideal limiter bandwidth used, at least for all $a \leq 0.95$, with $k(a) = -0.395 \ln a$ and $\zeta(a) = 0.30a + 0.44$ (see the October report).

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