A Space Communications Study

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Principal Investigator

Donald L. Schilling
Donald L. Schilling
Associate Professor

Co-Principal Investigator

Kenneth K. Clarke
Kenneth K. Clarke
Professor

Raymond L. Pickholtz
Raymond L. Pickholtz
Associate Professor

Department of Electrical Engineering
Polytechnic Institute of Brooklyn

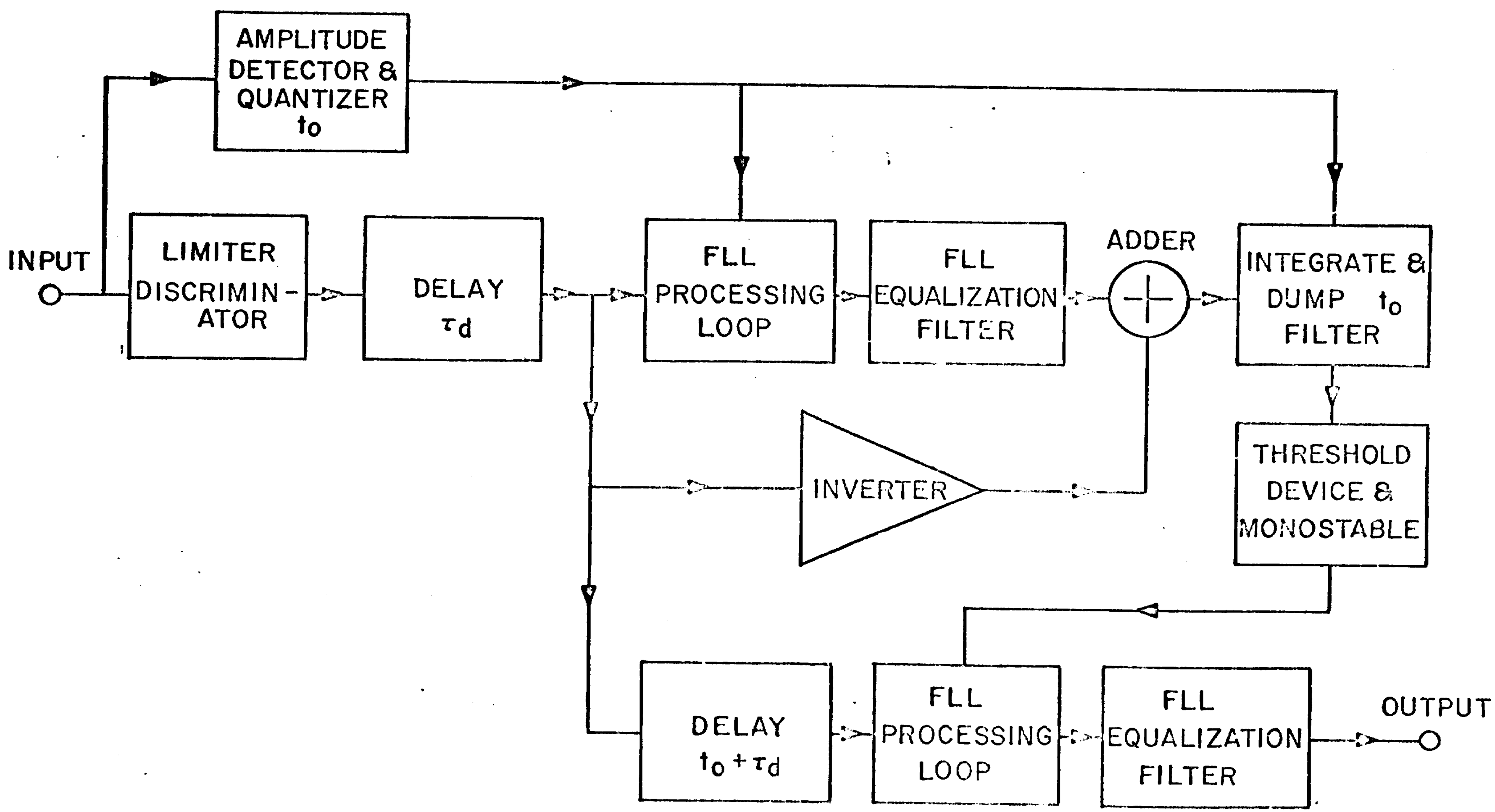

Fig. II. 1 Schematic of Double Order Frequency Locked Loop

II. The Frequency Locked Loop

An analysis has been made of the improvement to be expected from a double order Quantized Frequency Locked Loop as shown in Fig. II. 1. Such a loop essentially contains a "false hold" detecting circuit that prevents the basic or lower Quantized Frequency Locked Loop from holding on low amplitudes that do not correspond tc "clicks".

The operation of this "false" hold removal system, illustrated in Fig. II. 1, is as follows: During the original holding interval, the area of the difference between the FLL output and the discriminator output is obtained. If a click had occurred, the area of the difference at time, $t_i + t_o$, (neglecting the Gaussian noise and signal distortion), would be $\pm(1-\mu)2\pi$, where $(1-\mu)$ is the percentage of the click area suppressed by a hold. If, however, a "false hold" or a doublet had occurred, the expected value of the area would be zero. Thus, if the magnitude of the output of the integrate-and-dump filter exceeds a pre-set threshold at $t_i + t_o$, a click is assumed to have occurred. The threshold device then triggers a monostable which generates a second holding pulse to operate a second (properly delayed) quantized FLL (the lower FLL in Fig. I. 1.).

Theoretical calculations have been made which indicate that further improvements in threshold performance can be obtained by such circuitry over the conventional discriminator or over a single quantized second order loop without the false hold detecting circuitry. Figure II. 2 indicates such a theoretical improvement curve. This curve might be compared to I-3. 2. 3, Page 81 of the FINAL REPORT PIB EE 68-0012, September 15, 1968 which shows similar data both for a single FLL and for a phase locked loop. The improvement at "full" deviation shown (in S/N at a C/N = 6dB) by Figure 2 over the prior FLL is approximately 4dB and over the Phase Locked Loop is approximately 8dB. Work is now underway to construct such a loop and to find out how much of these theoretical improvements can be realized in practice.

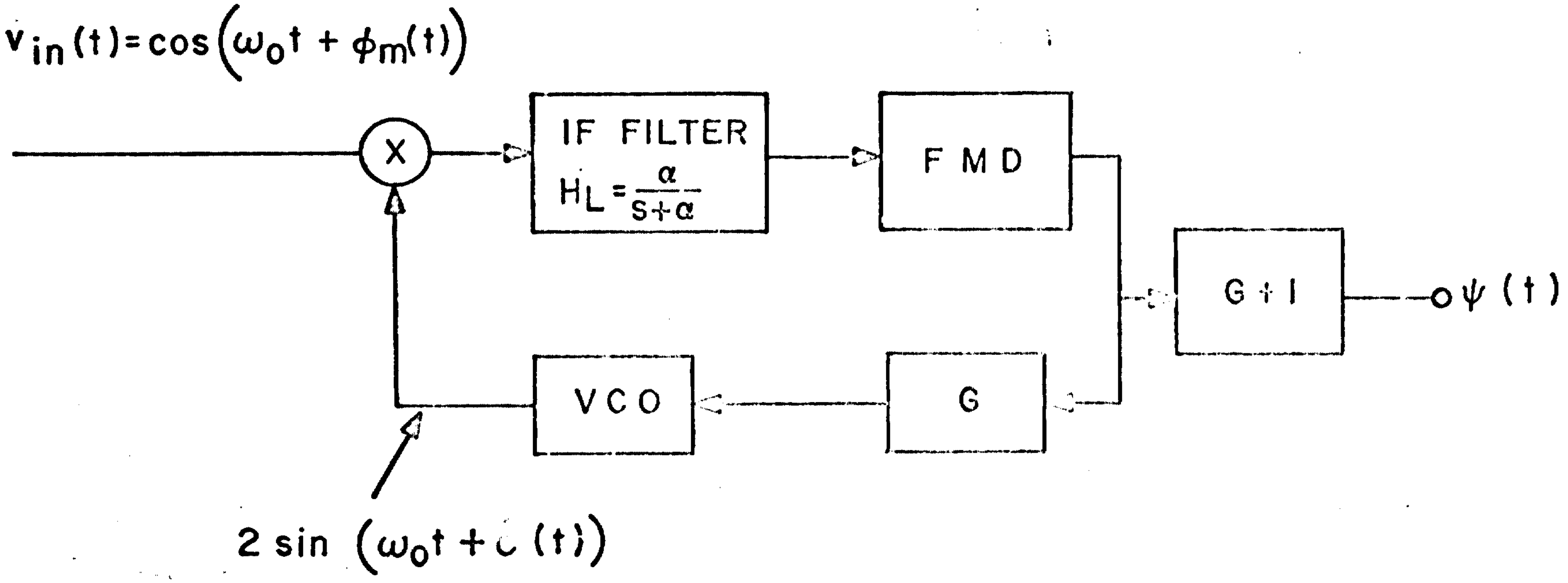

Fig. I. 1 FMFB "Baseband" Model

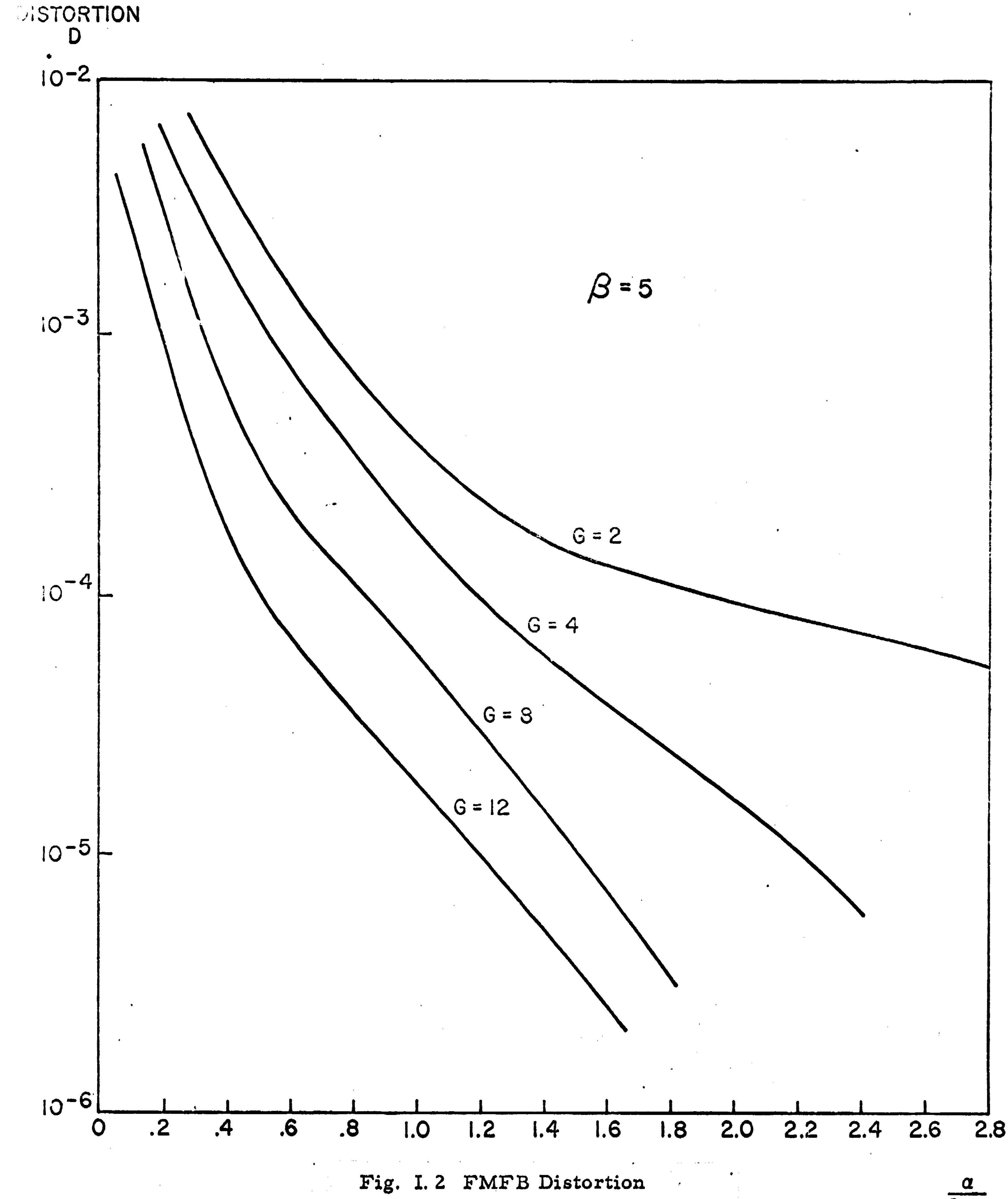

Fig. I. 2 FMFB Distortion

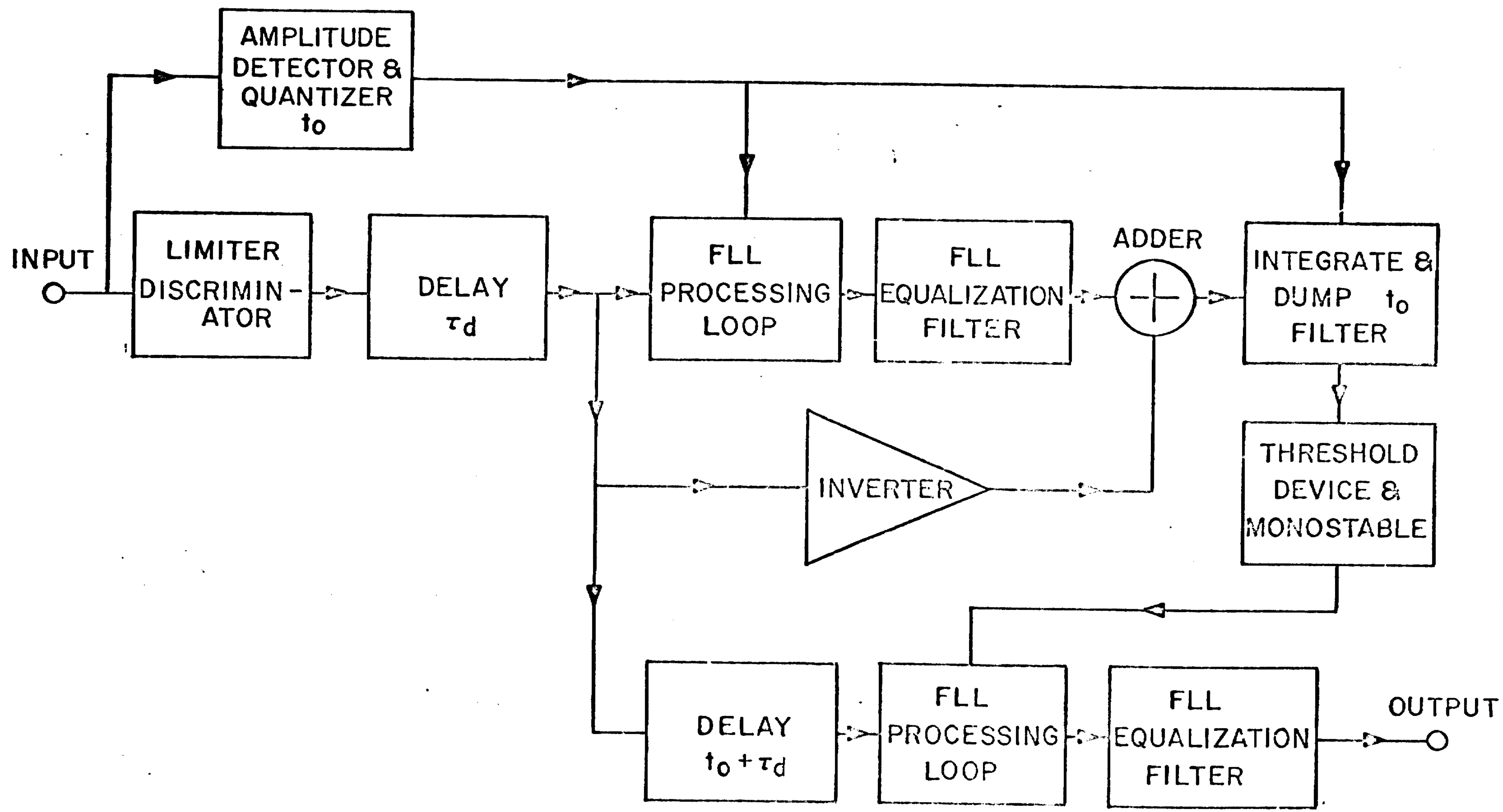

Fig. II. 1 Schematic of Double Order Frequency Locked Loop

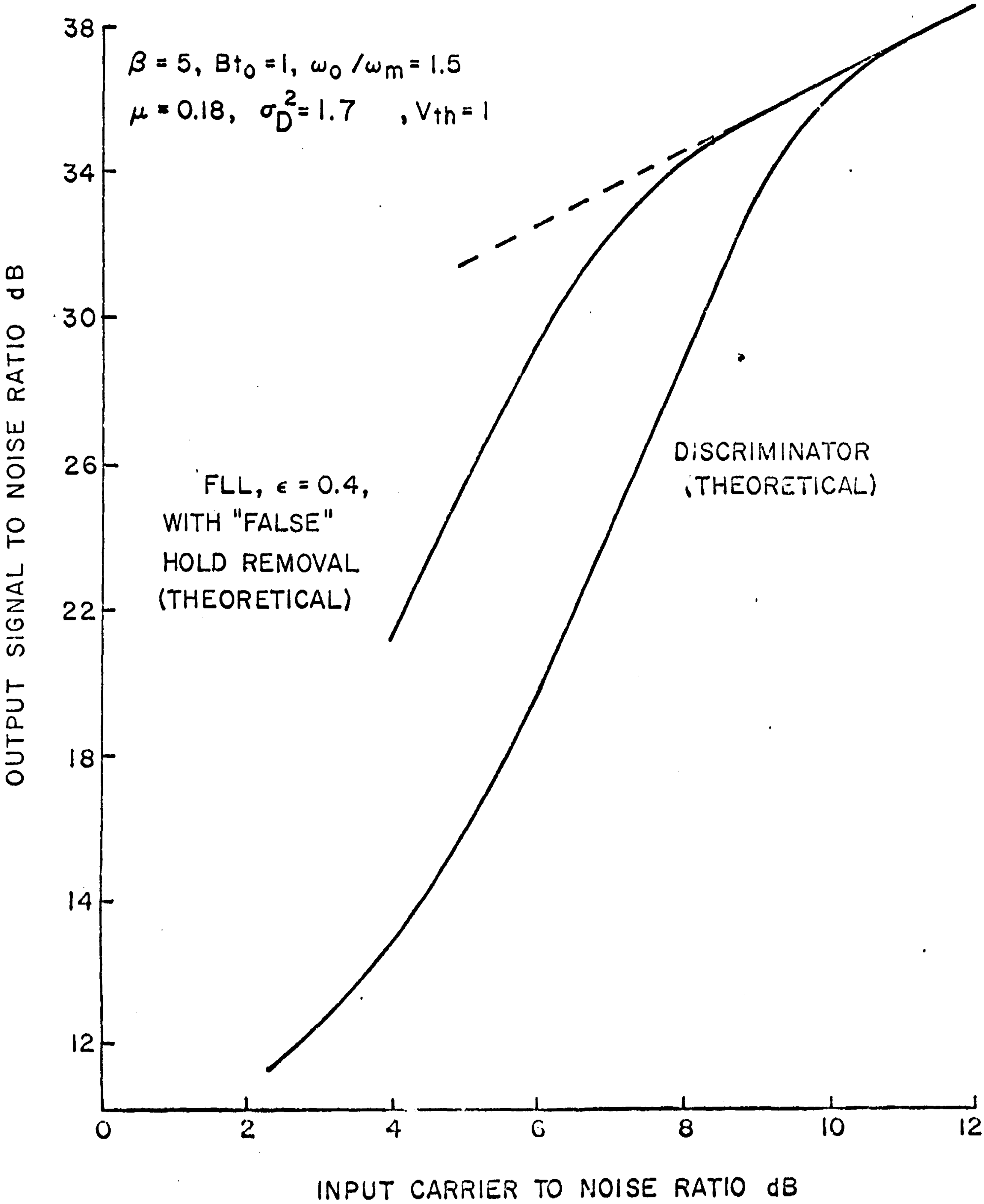

FIGURE II. 2. THRESHOLD EXTENSION PERFORMANCE OF A DOUBLE ORDER, QUANTIZED FREQUENCY LOCKED LOOP WITH SINUSOIDAL MODULATION TO $\Delta f = 5f_m$, $BW_{IF} = 6f_m$