FINAL REPORT FOR JUNE 1982 TO JULY 1983

ORBITER GLOBAL POSITIONING SYSTEM DESIGN AND KU-BAND PROBLEM INVESTIGATIONS

EXHIBIT B - REVISION 1

(NASA-CR-171699) ORBITER GLOBAL POSITIONING SYSTEM DESIGN AND Ku-BAND PROBLEM INVESTIGATIONS, EXHIBIT B, REVISION 1 Final Report, Jun. 1982 - Jul. 1983 (LinCom Corp., Los Angeles, Calif.) 12 p HC A02/MF A01

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PREPARED FOR

NASA LYNDON B. JOHNSON SPACE CENTER
HOUSTON, TX 77058

TECHNICAL MONITOR: WILLIAM TEASDALE

CONTRACT NO. NAS9-16097

TR-0783-0980

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LinCom

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1. Introduction

This report serves to document the LinCom effort under Exhibit B of Contract NAS 9-16097 for the period June 1, 1982 through July 22, 1983. The purpose of Exhibit B is to support JSC in its study of the use of the GPS navigation system on the Space Shuttle Orbiter and in Ku-band problem investigations.

2. Effort Related to GPS

No effrot related to GPS was made during this part of the contract performance period because such effort ceased in 1981 under instructions from JSC.

3. Effort Related to Ku-Band System

3.1 Introduction

In support of the Orbiter Ku-band System problem investigation, LinCom was tasked to provide independent technical evaluation of the system performance evaluations.

3.2 Description of Effort

To fulfill the task requirements, LinCom attended the monthly Ku-band program reviews at Hughes Aircraft Company and Communications Gropu in El Segundo, CA, and from the reviews and outside discussions LinCom became aware of many problem areas. A preliminary assessment of the problems was provided to the JSC person concerned and later the problems were followed up.

One exaple of such a problem is the forward-link Costas demodulator lock indicator blinking problem, documented in Attachment 1. In this case a detailed analysis was performed.

3.3 Recommendations for Additional Areas of Investigative Effort

LinCom should continue to provide the same type of timely, comprehensive support to JSC that it has been providing.

ATTACHMENT 1

LinCom Corporation

INTEROFFICE MEMORANDUM
TM-1080-1182
Date: November 29, 1982

From: C. S. Tsang, C. M. Chie

To: Jim Ratliff

Subject: Shuttle Ku-Band Forward Link Costas Demodulator Lock Indicator Blinking Problem

Summary

The Costas demod lock indicator blinking problem was verified on November 15, 1982 at the Hughes Baldwin Hills test facility. The receiver was visually observed (by monitoring the Costas lock indicator light) to acquire almost instantaneously 4 out of 4 tests. The carrier-to-noise ratio quoted was 60 dB-Hz. However, once the Costas loop had acquired, the indicator light then went on and off intermittently.

The sweep acquisition scheme was suspected to cause this problem and an analysis was performed to assess the sweep acquisition scheme. The results of this analysis, documented in this memo, show that the peak amplitude of the low pass filtered voltage input to the threshold detector during sweeping is about 1% of the in-lock amplitude. Therefore separate thresholds are needed for acquisition and tracking lock indications.

Examination of the reference print (DWG 3555201, Rev. J) showed that a dual threshold was used. In addition, a soft limiter is employed apparently to reduce this 1:100 variation in amplitude between acquisition and tracking.

It therefore appears that the blinking problem is a consequence of the desire to use the tracking threshold to indicate false side-lobe illumination condition. Apparently, the threshold was set to threshold at the highest expected side-lobe power level. This is different from the normal practice of employing the lock indicator to monitor excessive cycle slipping or drop-lock. The receiver was implemented in such a way that, unfortunately, when the tracking threshold is crossed, the receiver goes to sweep acquisition. This causes the blinking.

A simple solution to this problem is to use the present threshold detector for conventional out-of-lock indication but then add another threshold detector for false side-lobe lock monitoring.

1. Introduction

The Shuttle Ku-Band Costas Loop Lock Detector output signal appears to vary about the lock detection threshold (the lock detect flag is on and off) shortly after the carrier acquisition starts. It is the purpose of this memo to study whether this phenomenon is caused by the sweep acquisition algorithm. Real time computer simulation is performed to obtain the signal output from the low pass filter of the lock detector. Based on this simulation, it appears that the oscillation of in-lock and out-of-lock is related to tracking process and not to acquisition.

2. Simulation

The signal x(t) input to the low pass filter is of the form I^2-Q^2, where I(t) and Q(t) are respectively output of the in-phase and quadra-phase arm filters of the Costas Loop, Fig. 1. During acquisition the signals I(t) and Q(t) is of the form

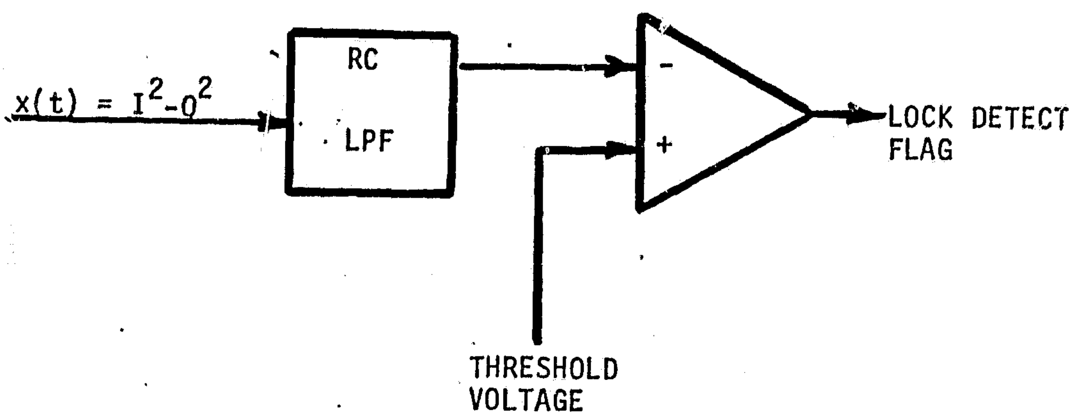

Figure 1. Costas Loop Lock Detector.

$$I(t) = A\cos(2\pi \frac{a}{2} t^2 + \phi)$$

$$Q(t) = A\sin(2\pi \frac{a}{2} t^2 + \phi)$$

where a = 4.4 MHz/sec is the sweep rate of the sweep circuit, and ϕ is a random phase error. Therefore x(t) is of the form

$$x(t) = A\cos(2\pi a t^2 + 2\phi)$$

For simplicity, the low pass filter is taken as a RC low pass filter of 3 dB frequency 3.25 Hz.

Figs. 2 to 4 are simulations output for $\phi = 0$, $\pi/4$ and $\pi/2$ radians. For all cases, the output signal peak is in the order of 6×10^{-3}A. This signal amplitude is much less than the tracking threshold and will not cause any on-off oscillation of the lock detector flag. Therefore, it appears that the on-off oscillation is due to the fluctuation of tracking signal about the tracking threshold.

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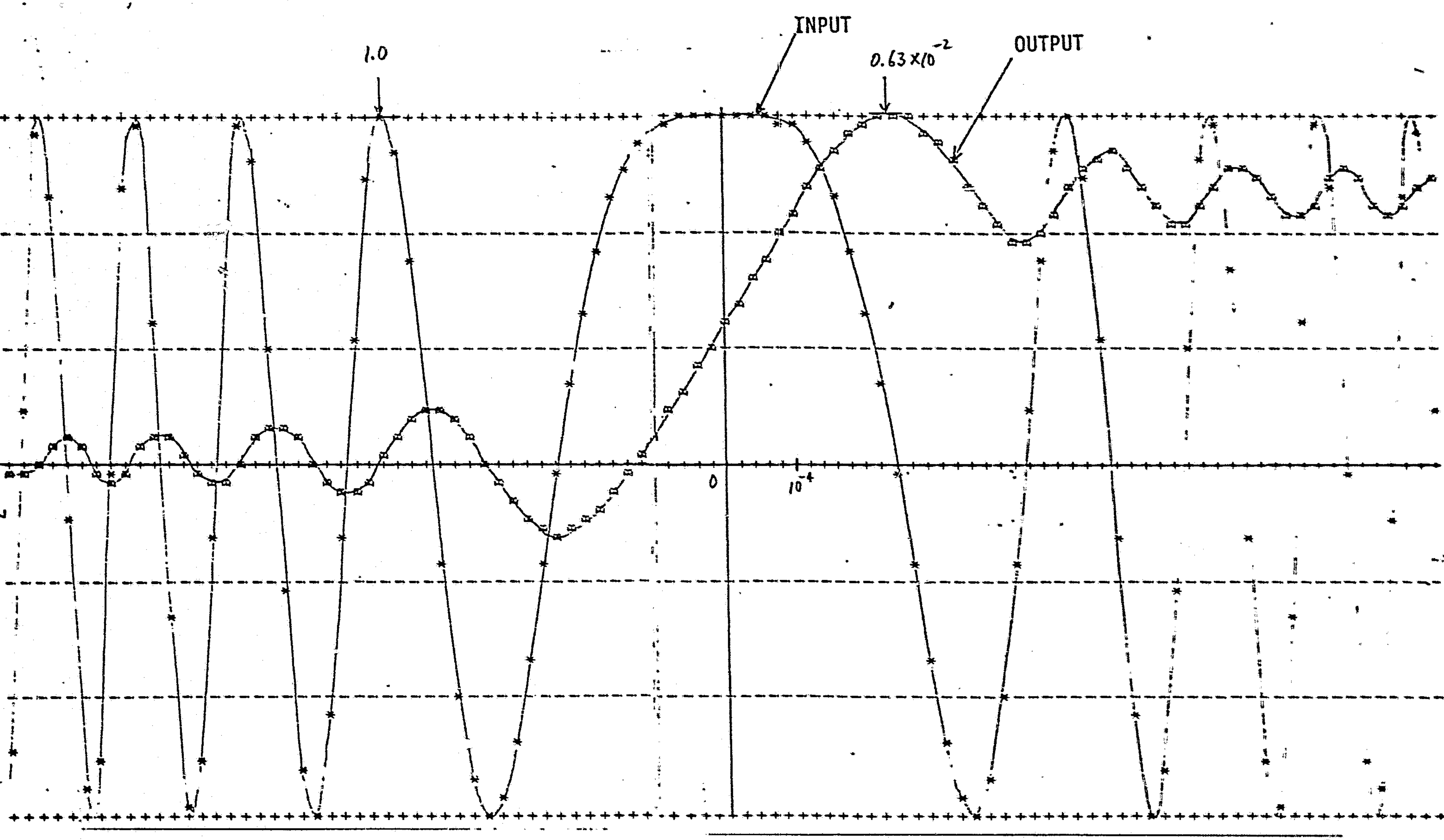

Figure 2. Lock Detector Response for $\phi = 0$.

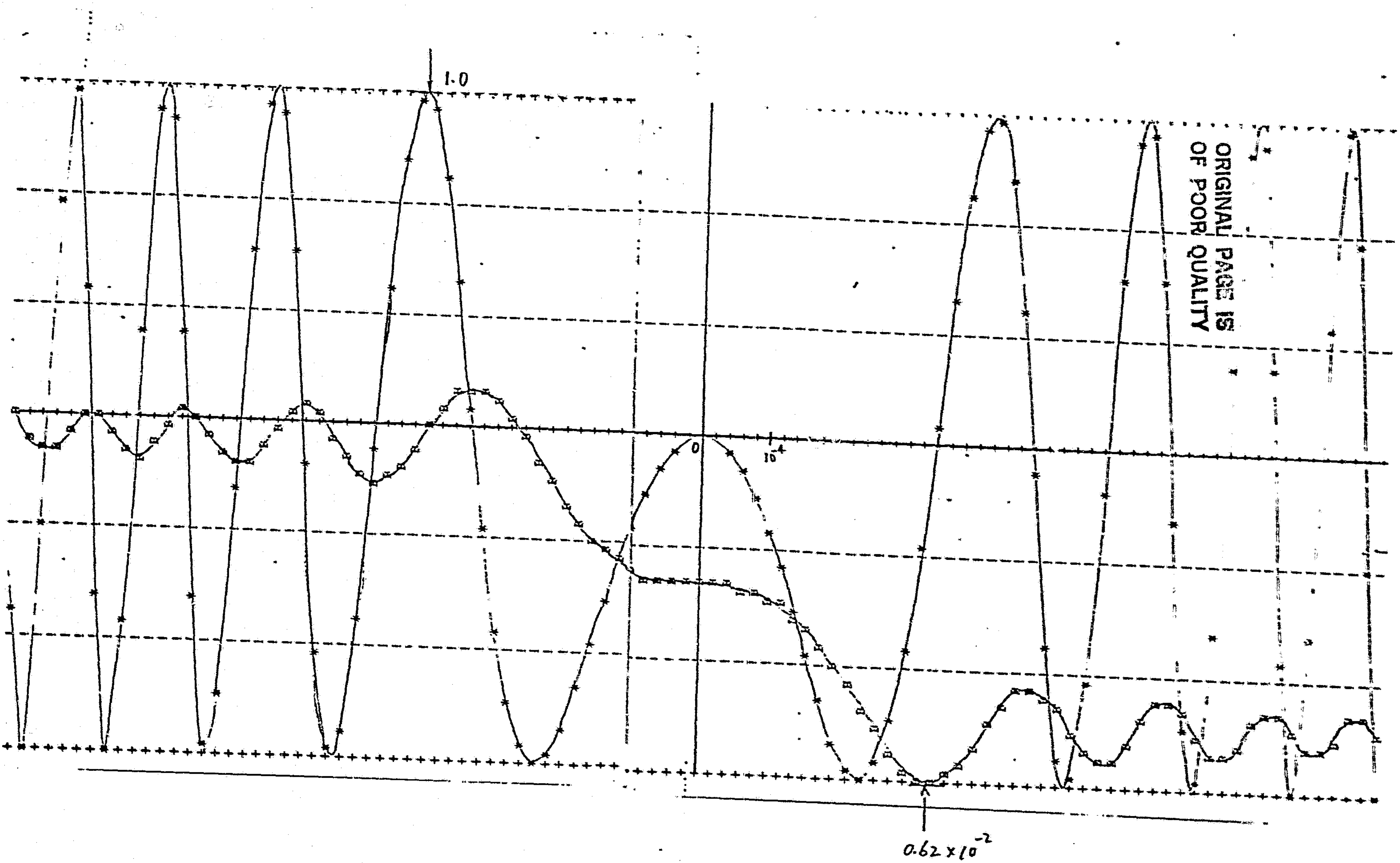

Figure 3. Lock Detector Response for $\phi = \pi/4$.

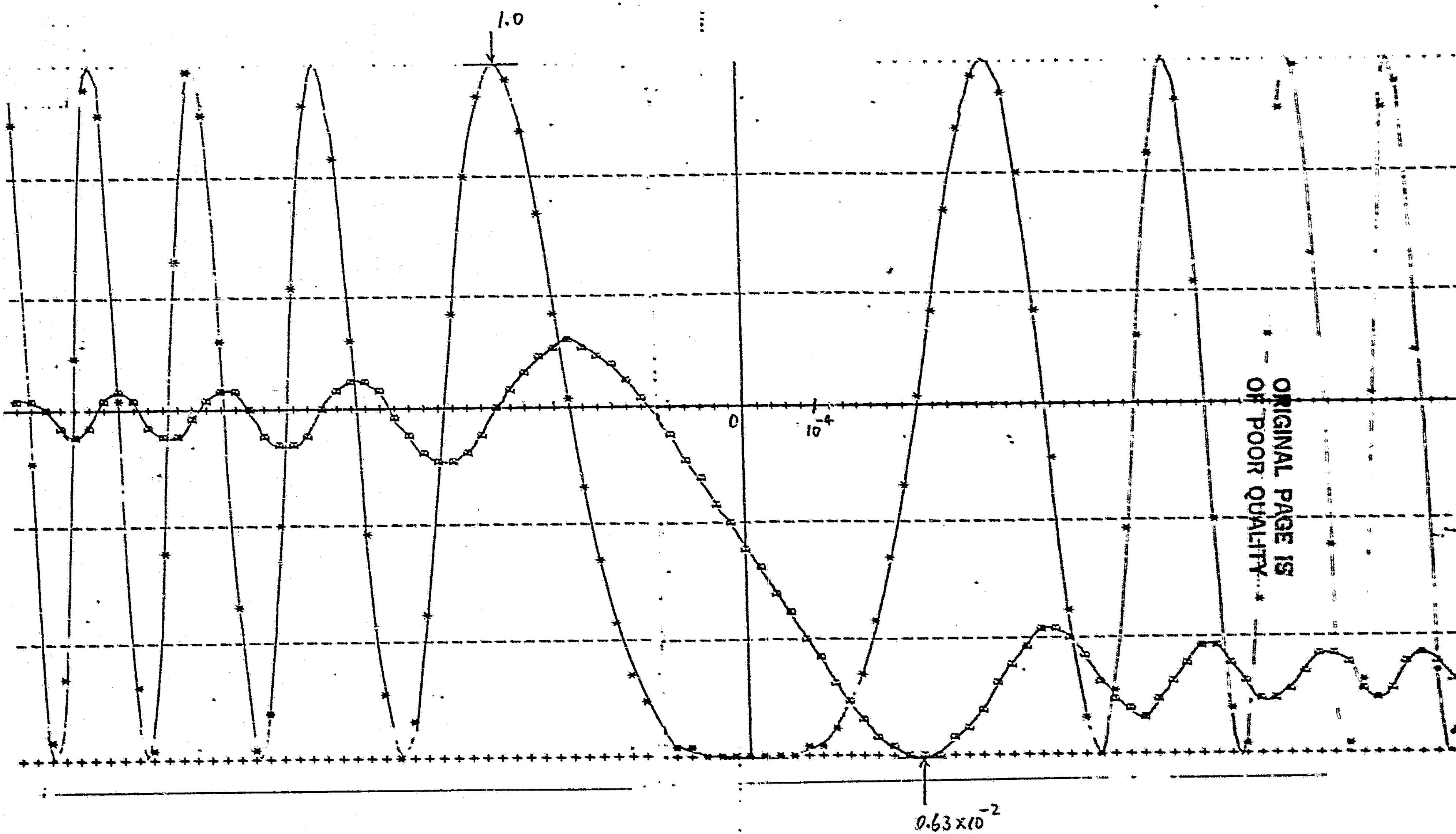

Figure 4. Lock Detector Response for $\phi = \pi/2$.