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THE STATISTICAL LOOP ANALYZER (SLA)[+]

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ABSTRACT

The Statistical Loop Analyzer is a new instrument for measuring acquisition, tracking and frequency stability performance characteristics of data acquisition and tracking systems.

1.0 INTRODUCTION

The Statistical Loop Analyzer (SLA) is designed to automatically measure the acquisition, tracking and frequency stability performance characteristics of symbol synchronizers, code synchronizers, carrier tracking loops, and coherent transponders. Automated phase-lock and system level tests can also be made using the SLA. Standard baseband, carrier and spread spectrum modulation techniques can be accomodated.

The SLA can be used to conduct tests during the initial design and checkout of breadboards, for conducting system level tests and acceptance testing. The tests can be performed on engineering breadboards thereby minimizing the risk of finding software (algorithm) and/or hardware problems during the manufacturing phase; thus the risk of schedule slips and associated increased costs are minimized. Utilizing the SLA in breadboards and system level test set ups eliminates the need for numerous monotonous and repetitive test procedures which require hand entry of test variables and hand recording of test results. The SLA approach to testing minimizes the changes for operator errors to enter into the experimental results as well as minimizing the time needed in the laboratory facility.

The test capability of the SLA is demonstrated in Table 1.1. The tests are automatically per-formed upon operator command so that manpower and laboratory test time requirements are minimized. The SLA can serve as a stand alone piece of test instrumentation (such as needed when testing breadboards) or it can be integrated into ground station test equipment and measurement laboratories via the SLA IEEE 488 and RS-232 interfaces.

The SLA is capable of collecting data and analyzing the statistics of discrete event indicators such as lock detectors, code sync detectors, frame sync detectors, etc. Through the SLA's phase-error jitter and cycle slip measurements the acquisition and tracking thresholds of the unit under test are determined; any false phase and frequency lock events are statistically analyzed and reported in the SLA output in probabilistic terms. Automated signal drop out tests can be performed in order to trouble shoot algorithms and evaluate the reacquisition statistics of the unit under test. Cycle slip rates and cycle slip probabilities can be measured using the SLA. These measurements, combined with bit error probability measurements, are all that are needed to fully characterize the acquisition and tracking performance of a digital communication system.

## 2.0 SLA TEST MENU AND SHUTTLE COMMUNICATIONS AND TRACKING TEST RESULTS

The test menu selectable by the test engineer is illustrated in Table 1.1. Four types of acquisi-tion tests can be performed. Typical results obtained from performing the acquisition tests on the Space Shuttle's Payload Interrogator-Payload Signal Processor Unit is shown in Figure 2.1. Here the joint carrier, subcarrier, bit sync and frame sync probability distribution of acquisition is plotted for four different PSP-PI channels within the 100 MHz band. Similar SLA output data from RF signal drop out experiments is depicted in Fig. 2.2 for the Shuttle PSP-PI frame sync circuit. The RF signal drop-out time interval was one second.

Figures 2.3 through 2.6 illustrate typical test results obtained by performing the SLA's Tracking Test. Measured phase error jitter in the Shuttle PSP-PI bit sync and subcarrier sync loops is illustrated in Figures 2.3 and 2.4 for Channel 1 and Channel 210. Similar test data obtained by perform-ing the SLA's tracking threshold test is depicted in Figure 2.5 to 2.6.

Figure 2.7 illustrates test data taken on the Frequency Stability of the Shuttle's Ku-Band high rate MUX clock. This data was taken using the SLA automated rms fractional frequency deviation test.

STATISTICAL LOOP ANALYZER
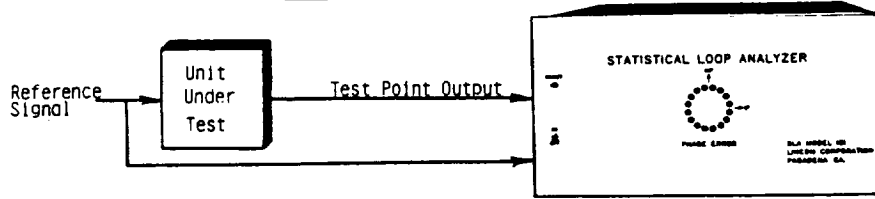
SLA FEATURES

- Automated Testing Under Microprocessor Control
- Automated Self Test and Calibration
- Automated Phase-Lock Tests
- Automated Phase and Frequency Stability Tests
- Automated Signal Drop-Out Tests
- Automated Testing of Acquisition and Tracking Algorithm Designs in Engineering Breadboards and at System Level
- Automated Data Reduction

- Compatible with Existing ATE via GPIB Interface
- Hard Copy Printing and Plotting via IEEE 488 Interface
- Visual Phase Error and Cycle Slip Transients
- Test Accuracy Selectable

Table 1.1. SLA Test Capability.

Acquisition Tests

    A - Probability Distribution of Acquisition Time

    B - Probability of Acquisition for a Fixed Time

    C - Probability Distribution of Reacquisition

    D - Signal Drop Out

Tracking Tests

    Phase Error Jitter-Slip Rate Tests

        A - Phase Noise Jitter

        B - Phase Error Jitter and Slip Rate

        C - Range Jitter

    Threshold Tests

        D - Tracking Threshold

        E - Slip Rate

Phase and Frequency Stability Tests

    A - Doppler Accuracy

    B - RMS Phase Deviation

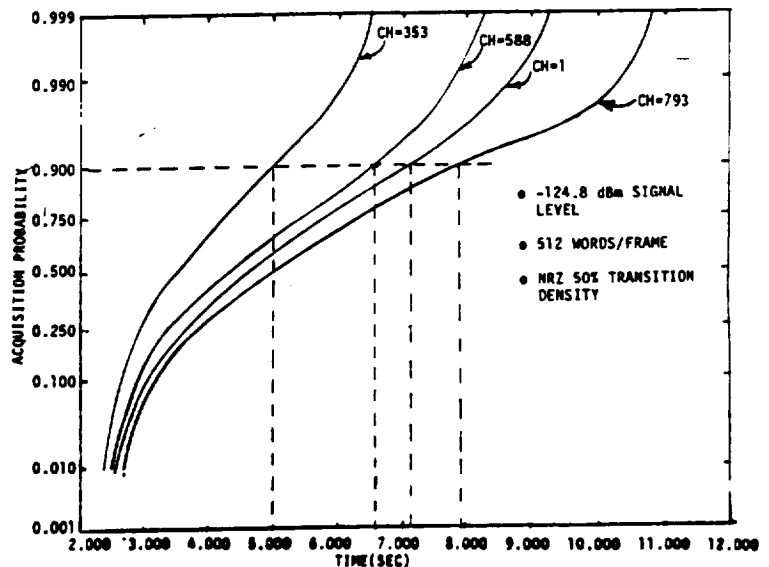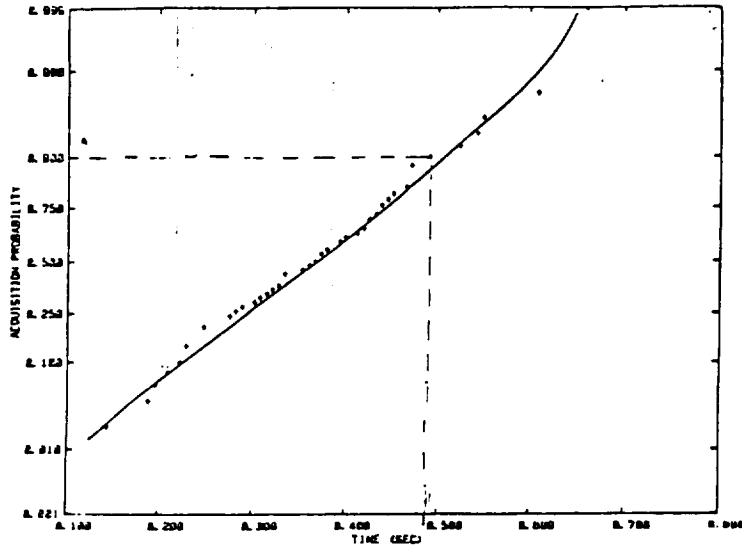   C - RMS Fractional Frequency Deviation

    D - Allan Variance

Figure 2.1. Shuttle PSP-PI Acquisition Test Result Comparison.

Figure 2.2.   Joint Probability of Carrier, Subcarrier, Clock and Frame
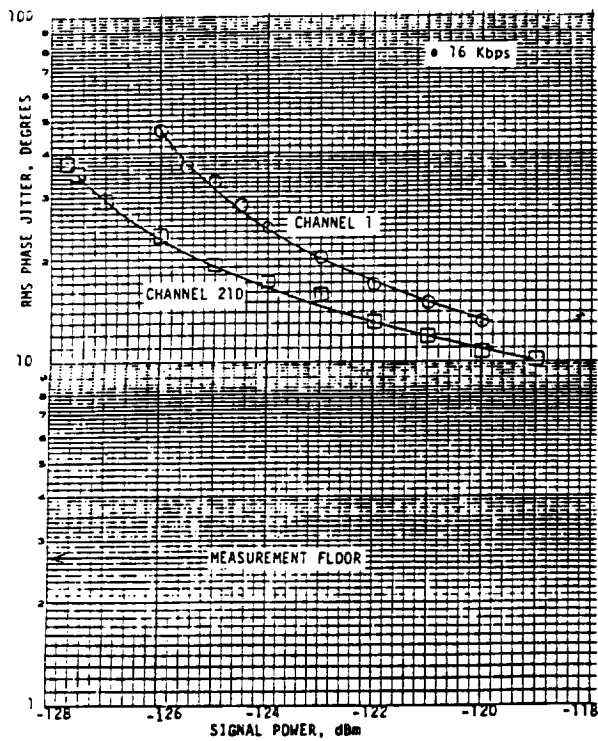Sync Acquisition vs Time for the Shuttle PSP-PI.

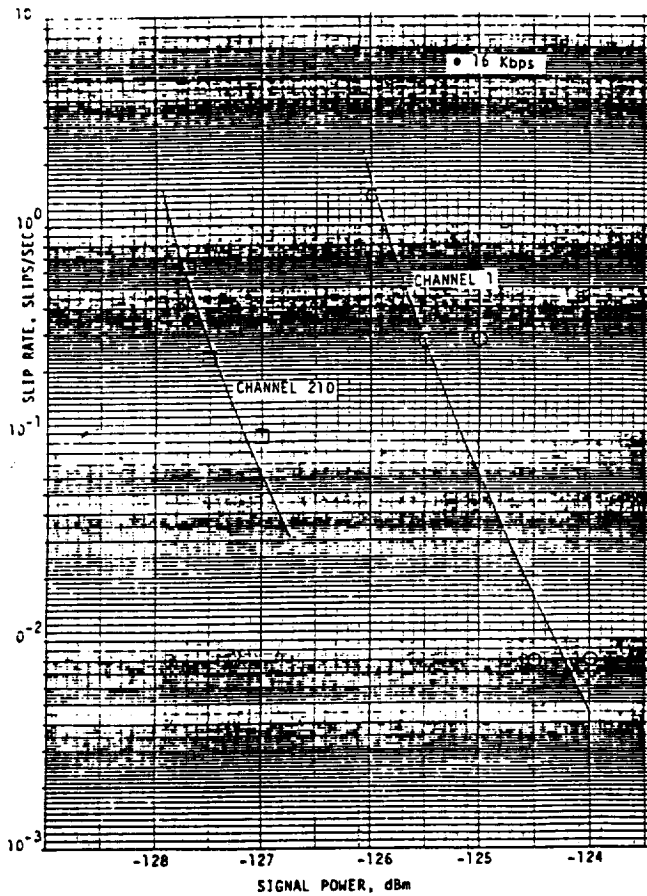Figure 2.3. Shuttle PSP-PI Subcarrier Loop Phase
Jitter Performance.

Figure 2.4. Shuttle PSP-PI Subcarrier Loop Slip Rate
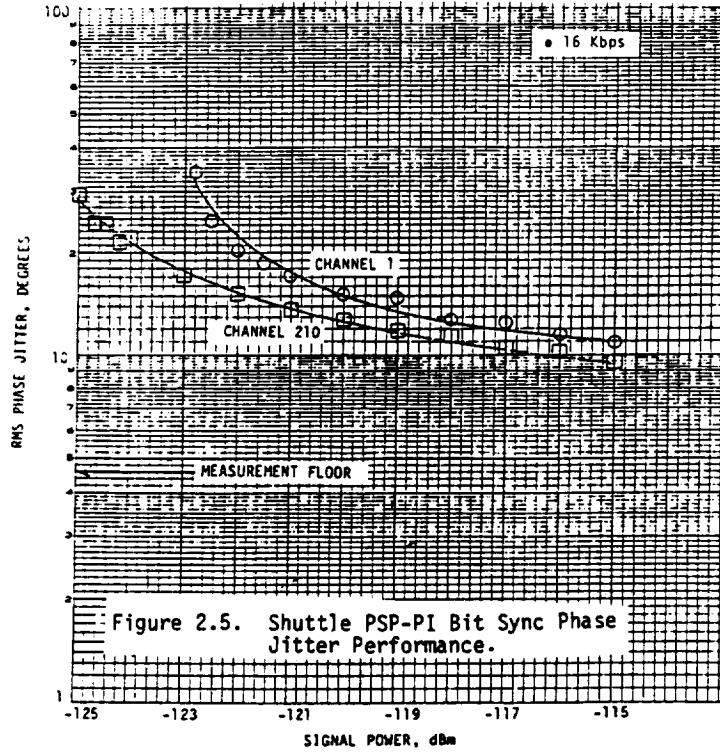Performance.

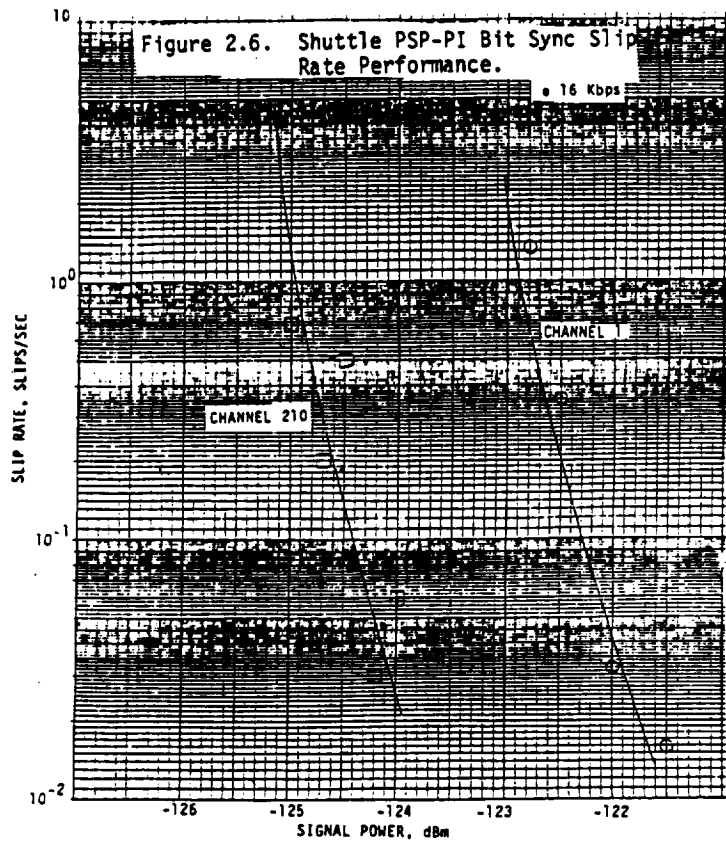Figure 2.5. Shuttle PSP-PI Bit Sync Phase Jitter Performance.

Figure 2.6. Shuttle PSP-PI Bit Sync Slip Rate Performance.

Fig.2.7. rms Fractional Frequency Deviation vs Count Interval for High Rate Clock.
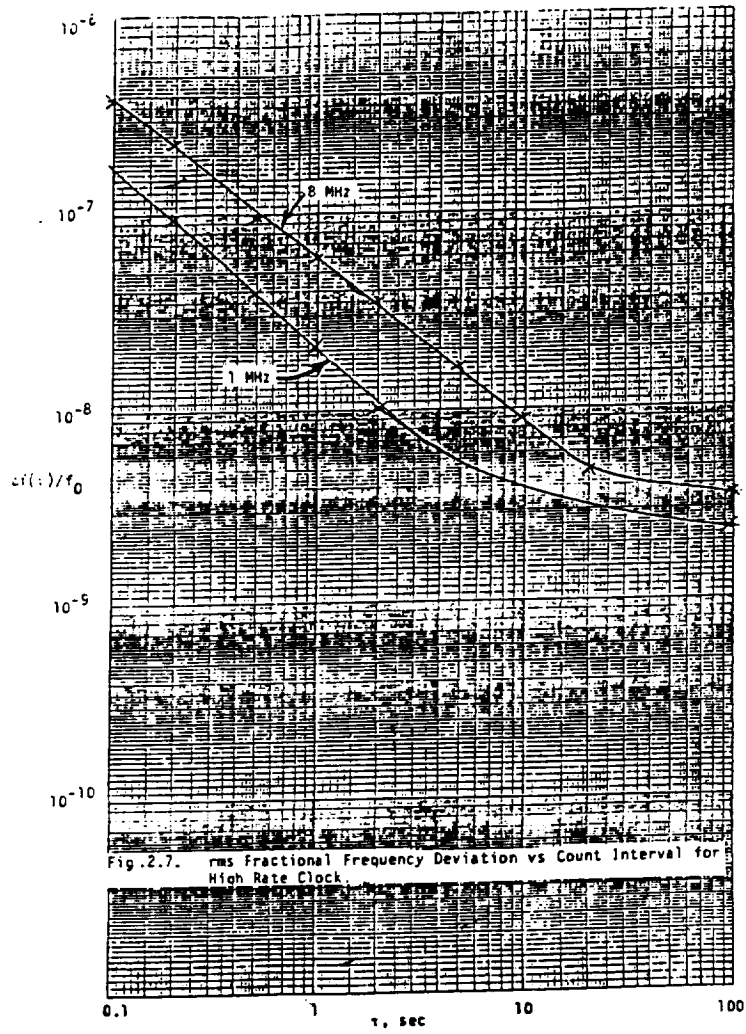
Figure 2.7. rms Fractional Frequency Deviation vs Count Interval for High Rate Clock.