LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY

LIGO Laboratory / LIGO Scientific Collaboration

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Electro-Optical Link Test Plan

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ELECTRO-OPTICAL LINK TEST PLAN

1.0 INTRODUCTION

This test plan shall document the in situ performance of the existing LIGO timing system joined by copper wires as well as the newly designed Electro-Optical Link (EOL) using fiber optics. Jitter describes the effect of timing noise on a signal similar to signal-to-noise ratio (S/N) describes the effect of voltage noise on a signal. The voltage noise that reduces the S/N ratio doesn't just cause amplitude fluctuations, it also causes timing fluctuations. One thing to remember is that jitter and voltage noise are not independent. By measuring and analyzing jitter in its entirety, a better understanding on the timing system requirement in the future can be achieved.

2.0 DEFINITIONS

Eye Pattern	Superimposed "1's" and "0's" of a serial data stream to aid visual inspection on the quality of data transmission. Typical mask has an "eye" in the center in addition to regions at the top and bottom to test for overshoot/undershoot as shown in Figure 1 below.
Bit Error Rate (BER)	The BER is calculated by counting the number of erroneous bits output by a receiver dividing by the total number of transmitter bits over a specified transmission period.
Jitter	The mis-position of the significant edges in a sequence of data bits from their ideal positions.
Deterministic Jitter	Jitter with non-Gaussian probability density function. Deterministic jitter is always bounded in amplitude and has specific causes.
Random Jitter	Jitter that is characterized by a Gaussian distribution. Random jitter is defined to be the peak-to-peak value equal to 14 times the standard deviation of the Gaussian distribution for a BER of 10^{-12} .
Total Jitter	The sum of all random and deterministic jitter components.
Duty Cycle Distortion (DCD)	Difference in the mean pulse width of a "1" pulse compared to the mean pulse width of a "0" pulse in a clock sequence.

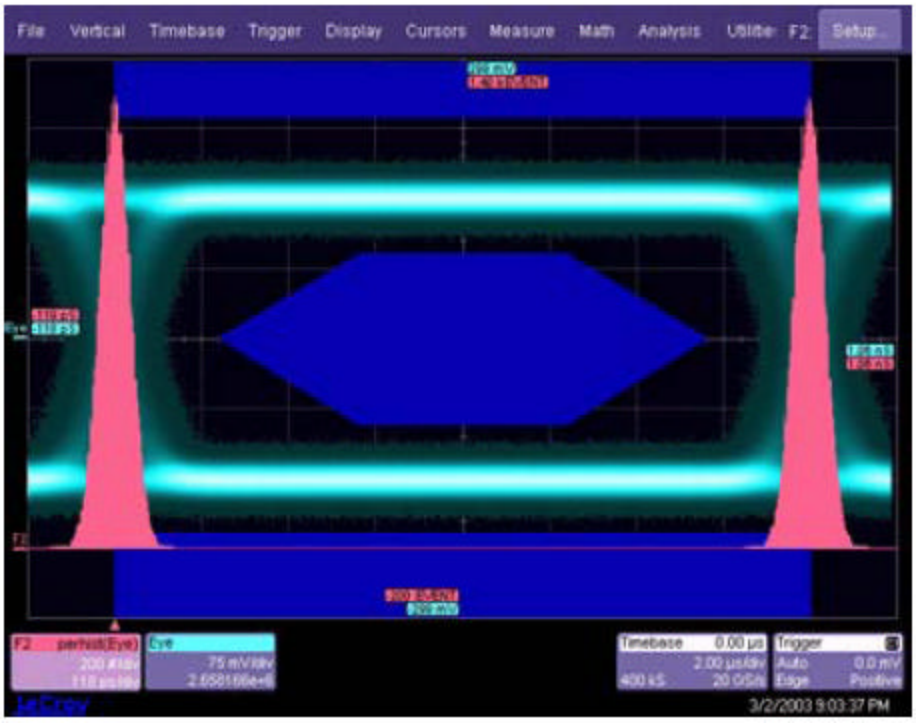


Figure 1. Typical Eye Diagram Measurement Showing Jitter Distribution

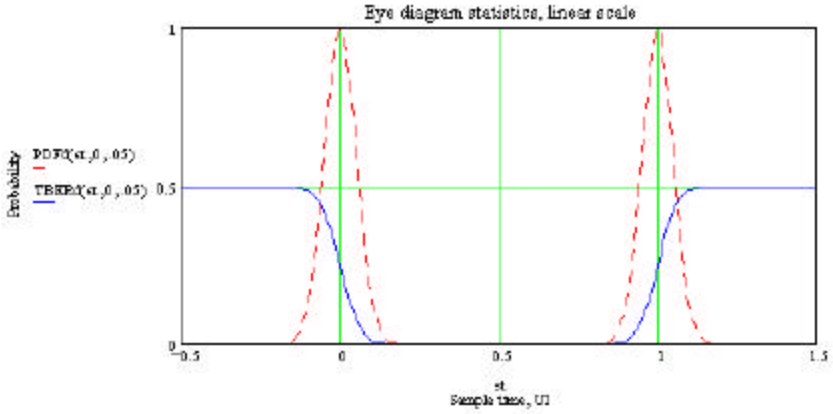


Figure 2. Typical Eye Diagram Statistics, Linear Scale

3.0 EQUIPMENT

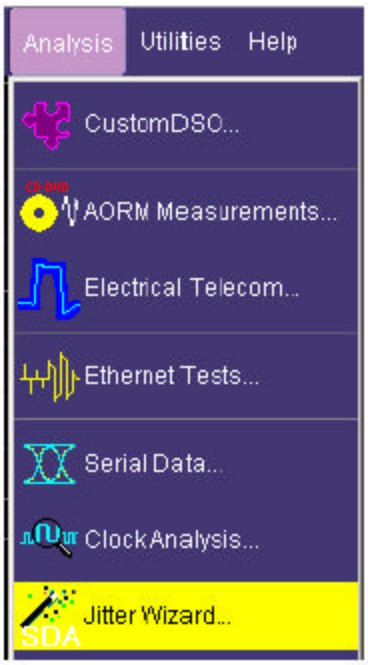
The Lecroy SDA-3000A with their ASDS-J software or its equivalent shall be used for the above measurements. Table 1. below lists the measurement capabilities of the instrument:

Table 1. Measurements Available in SDA, ASDA-J, and SDM.

AVAILABLE MEASUREMENTS			
Single-Signal Measurements	SDA (std.)	SDA w/ ASDA-J	SDM option
Data Stream			
Mask testing w/ software PLL clock recry	X	X	X
Mask violation locator		X	
Jitter Rj, Dj, Tj, ISI, DCD (DDj), Pj	X	X	
Filtered jitter		X	
ISI plot		X	
Edge-to-edge jitter		X	
Effective and MJSQ jitter breakdown		X	
Bit error testing with error map		X	
N-cycle jitter parameter (data)	X	X	
Eye Pattern Measurements			
Average power	X	X	X
Bit rate	X	X	X
Extinction ratio	X	X	X
Eye amplitude	X	X	X
Eye bit error rate	X	X	X
Eye crossing	X	X	X
Eye height	X	X	X
Eye width	X	X	X
One level	X	X	X
Zero level	X	X	X
Q factor	X	X	X

The followings are the basic steps in setting up the SDA:

A. On the Serial Data Analyzer (SDA), the jitter wizard is accessed from the analysis drop-down menu:

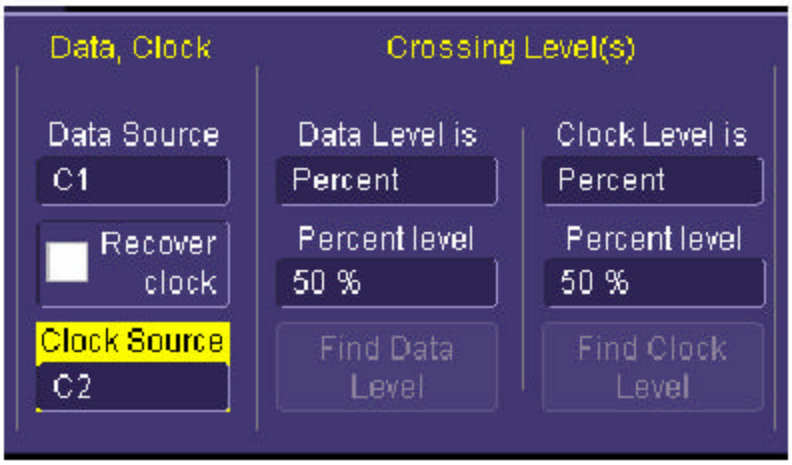


The remainder of the jitter setup guides one through a series dialogs concerning signal type and measurement method desired. Each dialog has a default selection representing the most common configuration. One can accept the defaults by simply touching the NEXT button in each dialog.

B. To access the SDA dialogs, press the Serial Data front panel button, or, touch ANALYSIS in the menu bar, then SERIAL DATA in the drop-down menu. Select Edge-Edge mode of operation.

C. Touch inside the Data Source field to select a data source, then touch inside The Clock Source and select a clock input.

D. Adjust the voltage level at which the signal timing is measured with the "Crossing level" adjust.



E. Touch inside the Signal Type field and select a standard signal type fro the pop-up menu.

F. Touch the Find Pattern Length button to automatically find the pattern length.

Consult LeCroy's Operator's Manual for detail instructions.

4.0 TIMING SYSTEM CHARACTERIZATION

The existing LIGO timing system uses copper wiring for distribution of the 1 PPS and CLOCK pulses to various racks as shown in Figure 3 below.

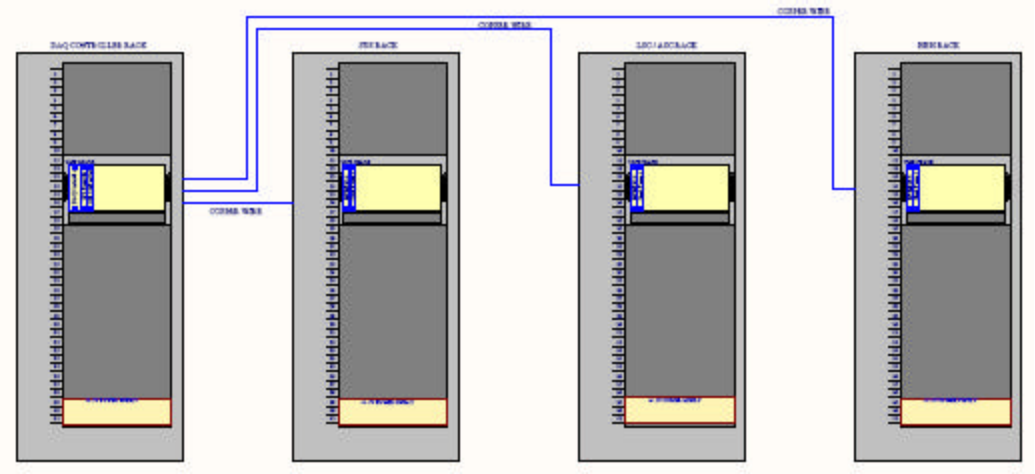


Figure 3. Existing LIGO Timing Distribution System

This Test Plan shall first measure all of the following parameters on the existing timing system at every Clock Fanout points in every rack to establish a baseline for a comparision study between the existing system and the new one joined by the EOL as shown in Figure 4.

(A) Total Jitter

(B) Random Jitter

(C) Deterministic JItter

(D) Timing Interval Error

(E) Eye Pattern

(F) Bit Error Ratio

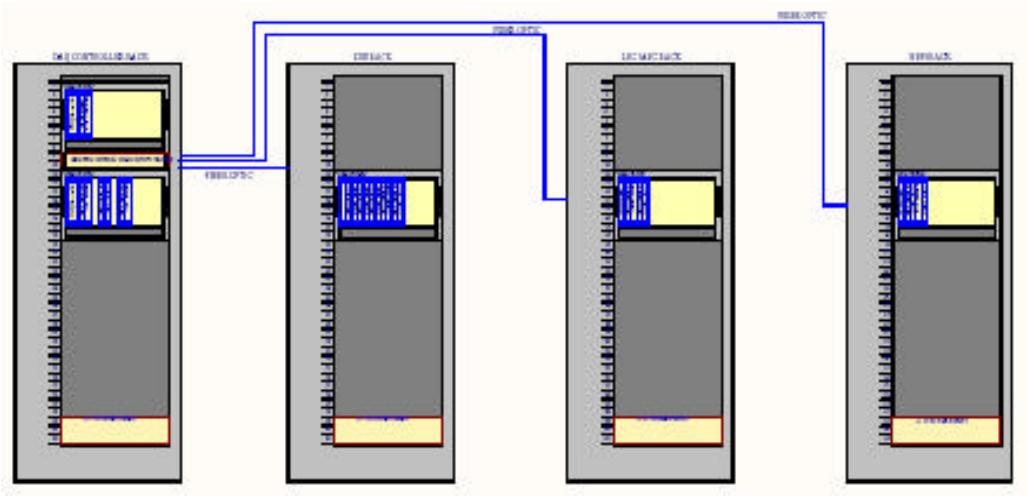


Figure 4. Configuration of New EOL Timing Distribution System

5.0 REFERENCES

T-040142-00-C Electro-Optical Data Link

T-040193-00-E 40M Electro-Optical Link Test Result

T-040216-00-C Electro-Optical Link Design Requirement

T-050045-00-C Electro-Optical Link Acceptance Test Procedure

D-050054-00-C Electro-Optical Link Transmitter

D-050055-00-C Electro-Optical Link Receiver

D-050056-00-C Electro-Optical Fanout Receiver

D-050057-00-C Electro-Optical Link Fanout Transmitter