

Global Diagnostics and Detector Characterization

9th Marcel Grossmann Meeting Daniel Sigg, LIGO Hanford Observatory

LIGO-G000157-00-D



Organization

Detector Characterization Working Group

- Leader: Keith Riles
- Part of the LIGO Science Collaboration
- Development of software algorithms
 - Transient analysis
 - Performance characterization
 - Data set simulation
 - Reduced data sets
- Global Diagnostics Subsystem
 - John Zweizig, Daniel Sigg
 - Hardware and software infrastructure



Diagnostics Tasks

Detector Characterization

- Calibration
- > Detector response, inter-system dependencies & cross-couplings
- Machine artifacts
- Maintain Performance
 - System identification (Feedback control)
 - Continuous operation monitoring
- Detection Confidence
 - Understand the physical environment
 - Understand the auxiliary degrees-of-freedom
- \Rightarrow GW signal : 1% of data rate (3MB/s/ifo)



System Overview





Basic Approach

Diagnostics Test Tool

- Emulates a measurement instrument
- Interactive graphical user interface
- Stimulus-response tests
- Data Monitoring Tool
 - Maximum flexibility
 - Interactive command line interface & background processing
 - Simultaneously look at all channels



Diagnostics Test Tool

Supported tests

- > Fourier tools: power spectra estimates, coherence, etc.
- Swept sine measurements
- Multiple sine response measurements
- Triggered time series measurements
- Supports many excitations & measurement channels
- □ Site-wide & GPS/UTC synchronized
- □ Interfaces digital feedback controllers
- □ Off-line capabilities



LIGO	 Diagnostics test tools – /opt/CDS/e/dtt/daniel/lock_000218_050748_mca.xml 	
	Ele Edit Measurement Utilities	Hela
	Measurement Excitation Result Iterator Synchronization Environment Defaults	
	Measurement Selection	
	P Fourier Tools C Swept Sine Response C Sine Response C Triggered Time Response	
	Channels 0 to 19 C Channels 20 to 39 C Channels 40 to 59 C Channels 80 to 79 C Channels 80 to 99	
	Measurement Channels	
	0 17 H2LSC-AS_0_TEMP V 5 1 V 10 V 15 1	
	1 1 H2LSC-AS_LTEMP V 6 1 V 11 V 16 1	•
	2 P H2100-MCA_OUT_MON Y 7 N Y 12 N Y 17 N	•
Satur		•
OCIUP	4 9 9 9 14 9 19	•
•	- Faurier Tools	
	Start D 취Hz Story SUD 취Hz BW: 0.072 취Hz Setting Time 0.0 취 %	
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	Measurement Information	
	Measurement Time: 15/02/2000 05:08:04 UTC	
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	Start Para	1
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	rejest rover tool	10



Diagnostics test tools - /opt/CDS/e/dtt/daniel/lock_000218_050748_mca.xml Elle Edit Measurement Utilities Halp Result Synchronization Environment Defaults Measurement Excitation Iterator 4 Power spectrum Style X-axis Y-axis Legend Paran H2100-MCA_OUT_MON Traces Range Units Cursor Config H2LSC-AS__TEMP 10 H2LSC-AS Q TEMP Graph: Power spectrum ٠ 10 0 1 2 3 4 5 6 7 Magnitude P Active 10 Channels A: H2100-MCA OUT MON ٣ 1 B: . 10-1 Style 🗹 Line 📃 💌 solid 1.0 ÷ 1.0 -🗆 Symbol 🗾 🖬 circle ۵ 100 200 300 400 500600700 800 900 💌 solid 0.10 E Bar Frequency T0-18/02/2000 05:08:04 Avg-17 BW-0.0937493 4 Coherence Style X-axis Y-axis Legend Paran Traces Range Units Cursor Config Trace: 0.8 0 1 2 3 4 5 6 7 0.7 Active -Style -Type: Coherence C None C Vert. 0.6 P 1 Œ Abs. ΠZ Cross C Hortz. C Deta 0.5 0.4 Values 0 🔹 V1: 0.00767307 🔹 X1: 0.3 H2LSC-AS_Q_TEMP / H2100-MCA_OUT_MON H2100-MCA_OUT_MON (H2LSC-AS__TEMP 900 🚔 V2: X2: 0.271356 0.2 H2LSC-AS_Q_TEMP / H2LSC-AS__TEMP H2100-MCA_OUT_MON (H215C-AS_G_TEMP 0.1 Statistics H2LSC-AS__TEMP (H2LSC-AS_Q_TEMP • 900 0.263682 X/Y diff U, 200 300 °d 100 400 500 600 700 800 900 Frequency T0-18/02/2000 05:08:04 Avg-17 BW-0.0937493 Zoon Active New Options. Export. Print. Start Fourier tools Payneed

Plot

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Data Monitoring Tool

Multi-processor SUN workstations

- □ Input:
 - High bandwidth distribution of on-line data (1000baseSX broadcast)
 - Alternatively: Frame files from disk
 - Shared memory partitions (~10 sec of data)

Output:

- Triggers/veto to event database
- Alarms to control room
- Trend channel recording
- □ C++ class library
 - Container objects for time and frequency series, etc.
 - Signal processing library: FFT, etc.
 - Interactive environment & graphics based on ROOT

LIGO Micro-Seismic Monitoring

Channel **Statistics**



Flag	Channel	Frames	On	Off	Repeat	Avg	Sigma	Minimum	Maximum
	H0:PEM-MX_TILTT	28793	1000	ee00	19	4319.97	19.04	4298	4383
	H0:PEM-MX_SEISZ	28793	0000	0000	9	-97.57	46.52	-1117	939
	H0:PEM-MX_SEISY	28793	0000	0000	7	-106.64	32.65	-737	481
	H0:PEM-MX_SEISX	28793	0000	0000	7	-257.45	62.06	-1717	1225
	H0:PEM-MX_TILTY	28793	0800	£400	30	2478.16	67.30	2199	2971
	H0:PEM-MX_TILTX	28793	c000	0000	28	-8842.84	70.82	-9563	-7929
	H0:PEM-MY_TILTT	28793	0000	e000	17	4012.75	36.57	3967	4107

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Frequency Noise Measurement

Power spectrum estimate: Frequency Noise





Seismic Displacement





Alignment Fluctuations





Auto-Alignment: Step Response

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Conclusions

Combination of

- High performance data acquisition system
- 24 hour disk cache
- New software and analysis tools

has enabled

- Fast learning curve
- Emphasis on analysis rather than data gathering
- Greatly enhanced remote diagnostics