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Description of the ServoMon DMT Monitor

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1 Function

The `ServoMon` DMT monitor watches over key servo control channels for particular known pathologies that indicate excess noise due to unintended gain changes, imminent servo instability or growth of a narrow-band excitation. Triggers are sent to the MetaDataBase when these pathologies are detected.

2 Algorithm

The algorithms for detecting pathologies are relatively simple. Power spectral densities are estimated every 20 seconds and excesses over nominal expectations in specified frequency bands are flagged. The expectations are defined in the configuration file read by the monitor at start-up. The conditions defined in the configuration file are a subset of the standard DMT operational state conditions[1]. While those conditions allow monitoring of shape changes, independent of total power in a data channel, we have chosen in the pathology monitors implemented to date to threshold on absolute band-limited powers. The normalization convention used obeys Parseval's Theorem in that the sum of all power from zero frequency up to the Nyquist frequency equals the mean square value of the corresponding raw time series (in ADC counts squared).

At present, monitoring is carried out only when both arms of an interferometer are locked, defined by the same criteria used in the `LockLoss` DMT monitor[2]. `ServoMon` is meant to evolve with time, as more pathologies to flag come to light. This document describes the pathologies monitored to date and itself is expected to evolve with time as a "living document". The following subsections describe the presently monitored pathologies.

2.1 Mode Cleaner power excess at high frequencies

In the E2 engineering run using the Hanford 2K interferometer, it was observed that power at frequencies above 3 kHz underwent occasional, sustained broadband enhancments, indicating increased noise, presumably from drifting, non-optimal gains in that servo controls system. A simple monitor was set up during E2 and later applied to the Livingston 4K Mode Cleaner feedback signal for the E3 and later engineering runs.

Specifically, `ServoMon` monitors power in the `XX:IOO-MC_F` channel in the frequency range $3000Hz$ to $7000Hz$, where the `XX` in the channel name is to be replaced by `H1`, `H2`, or `L1`, for the Hanford 4K, 2K, and Livingston 4K interferometers, respectively. In general, thresholds used must be tuned from time to time as interferometer conditions change (*e.g.*,, laser power, photodiode gains) and are set to approximately 20% above what is believed to be nominal power in that bandwidth.

2.2 Violin mode fundamental and 1st harmonic excitation

In the E4 engineering run using the Livingston 4K interferometer, it was observed that the 1st harmonic of a large optic violin mode was at one point strongly excited at a frequency near 686 Hz. The excitation was strong enough to dominate the dynamic range of both the common and differential mode arm servo control channels. A similar phenomenon was seen repeatedly in the E5 engineering run using the Hanford 2K inteferometer. The `ServoMon` monitor has consequently been enhanced to monitor power excesses in the 680-690 Hz band (to be conservative in finding other, so-far-unseen large optic violin harmonics).

Similarly, the fundamentals of some violin modes were seen in the E7 engineering run at both observatories and more monitored bands added, as a result.

Specifically, `ServoMon` monitors power in the `XX:LSC-DARM_CTRL` channel in the frequency ranges 340-345 Hz, 345-350 Hz, and 680-690 Hz. In general, thresholds used must be tuned from time to time as interferometer conditions change (*e.g.*,, laser power, photodiode gains) and are set to approximately 20% above what is believed to be nominal power in that bandwidth .

3 Triggers & Alarms

The monitor sends a trigger to the MetaDataBase whenever the threshold defined for a given pathology condition is exceeded while both arms are locked. An alarm is also set which can be seen via the DMT alarm summary page. The following table lists the presently defined trigger labels:

4 DMT Viewer Interface

The `ServoMon` monitor also serves data for display in the DMT Viewer program. At present, the data served are 12-hour histories of the power in the monitored

Trigger Name
XX:MC_3kHz-7kHz
XX:DARM_340Hz-345Hz
XX:DARM_345Hz-350Hz
XX:DARM_680Hz-690Hz

Table 1: Trigger set

bands. The power is non-zero for only those periods when both interferometer arms are locked.

5 Trend Files

The `ServoMon` monitor also produces 1-minute trend files of the same data every hour which can be displayed via the control room data viewer.

6 Summary web page

ServoMon also provides a summary page giving unthrottled trigger rates over the preceding 2-hour, 6-hour, 12-hour and 24-hour periods. (Note that the actual trigger rate for triggers sent to the database is throttled to no more than one trigger each 5 minutes, but the summary page will report all 20-second intervals for which the trigger condition is satisfied.) The summary page can be reached via the "spi" links, for example,
`http://blue.ligo-wa.caltech.edu/gds/dmt/Monitors/spi.html`.

7 Implementation

`ServoMon` uses the `OperStateCondList` DMT class to define conditions. For illustration, the configuration file used to monitor excess Mode Cleaner noise at high frequencies during the E5 engineering run for the Hanford 2K is shown below (taken from the standard LockLoss config file on sand at `/export/home/ops/pars/ServoMon.conf`):

```
H1:MC_F_peaking  abspowerabove "H1:IOO-MC_F"  freqlo=3000 freqhi=7000 thre
shold=950.
H1:MC_problem    boolean       "H1:Both_arms_locked & H1:MC_F_peaking"
```

8 Known Bugs

ServoMon trigger entries in the MetaDataBase through the end of the E5 engineering run have time stamps that are exactly one second later than intended. The bug was corrected in the source code after E5.

References

[1] D. Chin and K. Riles, "Defining and Testing Operational State Conditions in the Data Monitoring Tool", LIGO-T-010104-00-Z (September 2001).

[2] D. Chin and K. Riles, "Description of the DMT LockLoss Monitor", LIGO-T-010105-00-Z (September 2001).